



MTT Society News

Toby's Statue

■ By James C. Rautio

Maxwell's Home Preserved, His Statue Unveiled, but the Final Word Is from a Child

When James was a little boy of two years and a half old, I had given him a new tin plate to play with. It was a bright sunny day; he held it to the sun, and the reflection went round and round the room. He said 'Do look, Maggy, and go for papa and mamma.' I told them both to come, and as they went in James sent the reflection across their faces. It was delightful to see his papa; he was delighted. He asked him, 'What is this you are about, my boy?' He said, 'It is the sun, papa; I got it in with the tin plate.' His papa told him when he was a little older he would let him see the moon and stars, and so he did."

This is a recollection about the youthful James Clerk Maxwell reported by Maxwell's biographer, Lewis Campbell [1] from a servant, Meg, of the Maxwell household. Maxwell was always exploring his universe, encouraged by his parents and often with



The new statue of Maxwell in Edinburgh.

his beloved dog, "a terrier of the mustard kind," as described by Campbell. Maxwell's youthful environment at his home in the country, Glenlair, and in Edinburgh (pronounced, "Ed-in-burr-ah") with relatives was critical in guiding "Jamsie" along the path that would change the world.

Although not widely recognized among the general population, Maxwell is well known among scientists and engineers. Maxwell's equations,

just one of his many accomplishments, are where I have personally spent my professional career. About 20 years ago I started wondering just who Maxwell was. I started taking occasional day trips, as a tourist, into the field of history. I found an absolutely amazing story, a story that just had to be told. So, I started telling it. I had help along the way, most notably from the IEEE Microwave Theory and Techniques Society (MTT-S) Distinguished Microwave Lecturer (DML) program. In fact, with in and in addition to the DML program I have given a lecture on the life of James Clerk Maxwell almost 100 times all over the world. It has been an amazing ride, especially seeing so many others who share such strong interest in Maxwell.

Maxwell's life was full of happiness...and tragedy. One tragedy occurred after Maxwell's lifetime. His home, Glenlair, where he had played with the "new tin plate," caught fire in 1929. The firemen came but they had no water. All they could do was help carry things out of the house. Figure 1 shows Glenlair the first time I saw it, in July 2005. The large, left portion was built by Maxwell and the right portion by Maxwell's father. The last remaining roof is threatening to collapse. Grass

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and small trees are growing on top of walls. Mortar holding stones in place is washing away.

Maxwell is considered to be one of the three most important physicists of all time, along with Newton and Einstein. He deserves better than this. At the June 2007 meeting of the MTT-S AdCom, I proposed that the MTT-S and I split the cost. They agreed. Actually, they did more than just agree, they agreed *unanimously*, an amazing consensus for a group as intelligent and as diverse as AdCom! Significant funding was also provided by the European Microwave Association (EuMA), and by the IEEE Antennas and Propagation (AP) Society. With transfer of U.S. funds to Scotland handled by the IEEE Foundation, we were on our way.

The preservation is being overseen by the most recent owner of Glenlair (Glenlair is now owned by the Maxwell at Glenlair Trust [2]), Captain (Royal Navy, retired) Duncan Ferguson, Figure 2. We are most fortunate to have Duncan's skilled services available. He has substantial experience managing large projects in the Navy and he is also trained as an electrical engineer. In fact, as a young boy he did not fully realize the importance of Maxwell until, during college, he was introduced to Maxwell's equations. After class he told his disbelieving professor that he lived on Maxwell's estate (in the restored former farmer's cottage) next to the Glenlair mansion itself. It is here at Glenlair that Maxwell wrote his *Treatise on Electricity and Magnetism*, the founding document of our field. Of all the students that have ever been taught Maxwell's equations, the future Capt. Ferguson is unique!

Unknown to me until recently was work by a dedicated group in the



Figure 1. Glenlair as it appeared in July 2005.

United Kingdom lead by Sir Michael Atiyah, president of the Royal Society of Edinburgh (now immediate past president) to erect the first major public statue honoring Maxwell. I was most honored to be invited to attend the statue unveiling. Sir Michael is also a past president of the Royal Society in London. Having been president of both Societies is a feat previously achieved (to my knowledge) only by Lord Kelvin. Sir Michael is a world class researcher in mathematics and nuclear physics. He is exceptionally modest (like Maxwell himself), and even insisted that no special mention of his efforts be indicated on the statue. However, I am very pleased to make special mention of his efforts here.

To make it possible for Americans to attend, the statue unveiling was moved up to two days prior to a major U.S. holiday (Thanksgiving), near the end of November. That did make things a

most kindly invited me along. In Maxwell's youth, Edinburgh to Glenlair in extreme south western Scotland was two days by horse and carriage. For us, it was two hours by car. (GPS is helpful, even if you have a local driver!)

Figure 3 shows Glenlair during our visit there on Sunday, 23 November. Many of the walls have been repointed (the mortar holding the stones in place has been renewed) so that the walls are no longer in danger of collapsing. (What an obituary it would have been, for a scientist or engineer: "Killed by a collapsing wall at Maxwell's home, Glenlair!") The roof over the main part of the building was a special problem. The framework supporting the slate shingles was found to have sagged about 20 cm. This required the replacement of the entire wooden supporting structure. All the shingles were removed, the framework replaced, and then the shingles put back in place. Although not easily seen in Figure 3, this task was performed with incredible skill. The restored roof looks as though it has not been disturbed for the last century!

The foyer (Figure 4) on the side of the main building has received special attention. While we are interested in preservation for most of Glenlair, we have pursued restoration for the foyer. It will serve as a small visitor center for the occasional visitors who find their way here. Of special interest in the foyer is the beautiful tile



Figure 2. Overseeing the Glenlair preservation is Capt. Duncan Ferguson (right) chatting with Bobbie and Lew Terman (2008 IEEE president).



Figure 3. *Glenlair nearing the completion of our preservation efforts, November 2008.*

floor (Figure 5). The tile floor might have been designed by Maxwell himself. When I first saw the floor in 2005, there was a considerable amount of debris. All I could see was tiles of white, red, green, and blue. With the floor now clean and clear, it turns out there are also two shades of brown, and the red (perhaps with age?) could also be called brown.

The question that entered my mind in 2005 was why would Maxwell pick red, green, and blue? That seems really odd. But then I recalled that Maxwell is the person who first experimentally determined that red, green, and blue are the primary colors of light. (Artists and printers have a different set of primary colors because they work with subtractive colors. Red, green, and blue are the primary additive colors. Take, for example, the light coming out of your RGB computer monitor.)

In fact, Maxwell even did considerable research in color blindness. One approach he took was to peer into the eyes of dogs (he loved animals and had a special skill in working with them) and people (who might have been more difficult!) using a homemade ophthalmoscope to explore the causes of color blindness. He also made the world's first color photograph using three negatives with three filters and projected with three projectors. The original negatives, along with many other Maxwell artifacts, are on display



Figure 4. *The side foyer has been almost completely restored.*

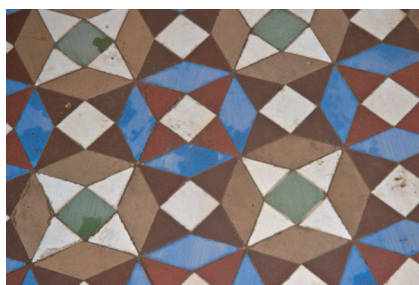


Figure 5. *The floor of Glenlair's foyer is an unusual pattern including (brownish) red, green, and blue tiles.*

at the James Clerk Maxwell Foundation, 14 India Street, Edinburgh, Maxwell's birthplace. Visitors are most welcome, but they should call ahead [3]. We do color imaging pretty much the same way today; it is just that our three projectors are all in one box. I like to think that Maxwell included red (?), green, and blue in the tile floor because of his work with color.

The steps on the foyer entrance, Figure 6, have also been carefully restored. The top step is original. The others were moved here from the garden. Again, the restoration is incredible, the lichen and color look like the steps have always been there. Maxwell undoubtedly climbed these steps and passed through this door many times. Einstein, whose work was directly inspired by Maxwell, usually declined offers to lecture. However, he made an exception once for the Royal Society, provided he would be allowed to walk on the same floor boards (at the Royal Society) that Maxwell himself had walked upon. At Glenlair, we can walk on the floor of Maxwell's own home.

The intensity of the experience of visiting Glenlair is lost on those who have not worked with Maxwell's equations, or some other aspect of Maxwell's many contributions to physics. We realize that Maxwell's work on electricity and magnetism, his *Treatise on Electricity and Magnetism*, which he wrote right here at Glenlair, founded our entire field. But, it was more than that. It was 23 years after his initial publication of his electromagnetic theory before the rest of the world realized that Maxwell was right. When they caught up, everything in physics opened up. We were no longer bound to Newton and $f = ma$. We could set down any equations we want with no need to build a mechanical contraption to justify it. As long as the equations allow us to predict the outcome of experiments, that is good enough. The door was now open to relativity, quantum theory, and all of twentieth century physics. It was right here, at Glenlair, where 20th century physics started.

We hope to restore the large windows (Figure 7) on the front of Glenlair if we can find an appropriate donor.

Maxwell's bedroom was on the second floor. The main living area was on the first floor. When I work difficult equations, I frequently look out a window, focus my eyes in the distance, and day-dream. Perhaps Maxwell occasionally did the same, looking out these very windows. If so, Figure 8 shows the view he would have seen, essentially unchanged in over 100 years, an idyllic pastoral countryside that influenced Maxwell his entire life. Sheep and cattle are still raised here, just as in Maxwell's day. Maxwell might easily have seen a scene like Figure 9, where the Fergusons' dog (who is named after Maxwell's dog) is greeting cattle.

One thing you will notice if you visit Glenlair is several large barrels mounted high in the unroofed portion of the house, Figure 10. These are owl houses. In the attic, under the original roof there was a nesting owl. In the interests of the environment, work on the roof was performed after nesting season and the replacement habitat was put in place. Special consideration was also given to bat habitat.

Our visit to Glenlair was on Sunday. The day went by all too quickly and with sunset approaching, we did not visit Maxwell's grave. It is just a few minute's drive from Glenlair and most of us had seen it on a previous trip. Figure 11 shows the grave as I saw it in 2005. It is within the ruins of a small Scottish church (kirk) that is in the side yard of a much larger church that Maxwell's father had built. That church is for sale, if you are in the market!

On the way back to Edinburgh, we made one final stop at Lockerbie right at sunset. It is indeed a small world.



Figure 6. The top step (on which Capt. Ferguson is standing, in front of Dick Gowen, president of the IEEE Foundation) and the door are original to the foyer.



Figure 7. Detail of Maxwell's bedroom windows (second floor) and main living area windows.

Turns out Captain Ferguson's wife, Henrietta, spent her entire Christmas holiday in 1988 preparing meals for the first-responders to the Pam Am 103 disaster where a terrorist bomb took down a 747 killing 288 people including 35 Syracuse University students. I had just finished two years as a visiting professor at Syracuse when this happened. There is a small visitor's center staffed by volunteers. They even devote an entire room to Syracuse University. It is very much worth spending a few moments, Figure 12. Hatred, in any and all forms, is evil.

The next day, Monday, we spend visiting Wolfson Microelectronics (a major sponsor for the IEEE/RSE Maxwell Medal) and University of Strathclyde, Glasgow as guests of Prof. Tariq Durrani. Both visits are simply amazing and deserve detailed descriptions of their own, but I limit my scribblings.

Tuesday is the big day for the statue. The Royal Society of Edinburgh planned a full day of events including a number of presentations by world class experts. My annotated photographic record of the event (as well as of our visits to Glenlair and Strathclyde) is available online [4]. Papers by the presenters are also published [5] with illustrations in full color. A copy of [5] should be in every Maxwell oriented library, supplies are limited.

The statue location is simply amazing. At first, it was thought they would have to settle for some quiet out-of-the-way place. However, Sir Michael has some very good friends who advised proposing whatever would be the best



Figure 8. Pastoral view from the front of Glenlair.



Figure 9. Ferguson's dog greeting cattle, very much as Maxwell would have seen. Glenlair is in the background.

possible place in all of Edinburgh, and then they would go from there. Shortening the story considerably, they proposed the best possible place and it was immediately approved!

Edinburgh is divided into “The Old Town” and “The New Town.” The New Town is 200 years young and was developed after it was no longer an advantage to remain behind the city walls. Unlike The Old Town, The New Town streets are laid out in a more-or-less rectangular grid (like Manhattan), a radical idea at the time. The central axis of The New Town is George Street. The statue is located on the eastern end of George Street right next to St. Andrew Square, only 100 m from the Royal Society itself.

We are fortunate to have a gifted sculptor to do the statue, Alexander “Sandy” Stoddart [6]. He has done several recent statues in Edinburgh (David Hume, Adam Smith). In fact he has just been appointed Queen’s Sculptor in Scotland. Most importantly for this work, he also has a good grasp of the scientific significance of Maxwell’s work. The process of creating a large sculpture is intense and demanding. After numerous models of increasing size, the final full-size sculpture is first done in clay. Then a plaster cast is formed (destroying the original clay model). The plaster is then used to form the sculpture in wax. The wax allows the final sculpture to be cast. Full details are provided by Mr. Stoddart in [5].



Figure 10. An owl home replacing the previous attic habitat.



Figure 11. Maxwell’s tombstone with his father and mother listed first and his wife listed last.

Maxwell is sitting, as is customary for philosophers, holding his “color wheel,” the simple apparatus that allowed him to experimentally determine the primary colors of light. It works by varying the percentage of colors in the inner and outer circles until, when the wheel is spun rapidly, the color of each region appears the same. This gives an equation relating the percentages of each color in both regions. Do a few cases, form a set of equations, then find an orthogonal basis that spans the space (modern terminology). The orthogonal basis is red, green, and blue.

At Maxwell’s feet is his trusted dog, Figure 14. We do not know the exact breed; an Irish Terrier was used as a model. Stoddart refers to “inter-species sympathy,” the empathy a member of one species can have for a member of another. In a conversation with Dr. William Duncan (chief executive of the Royal Society and who had significant responsibility for the day’s events and for the statue itself), I was told, “we had to find out what the dog’s name was. That’s important for the children, in case they ask. We simply have to have an answer; we have to draw the children in.” I agree with Dr. Duncan’s observation completely. The children are so important. Without the dog, from their point of view, this is just some big old statue of some dusty old guy that grown-ups insist is important. Adding the dog draws in the children and makes the statue...more human.

In Figure 13, also notice the seat cushion just over the dog’s head. A few of the rivets have popped. The sculptor’s knowledge of science really shines here. The popped rivets (and worn shoe laces on one shoe) illustrate the second law of thermodynamics. While Maxwell did not invent the concept of entropy, he did work with it, and it fit well into the framework of his kinetic theory of gases. There appears, however, to be no sign of Maxwell’s Demon.

Figure 14(a) shows the frieze on the south side of the plinth, to your right as viewed in the opening photo. On the left edge is sun god Apollo having shot an “arrow” of light into a prism.



Figure 12. Lockerbie at sunset, a moment of reflection, Bobbie and Lew Terman, Fern Katronetsky (executive director IEEE Foundation and Awards).



Figure 13. Maxwell's faithful dog at his feet. Note the missing rivets in the chair cushion above the dog's head.

The red light portion of the rainbow is allowed to pass through a small window and into the second prism. Only red light emerges from the second prism. This showed Newton (who is pointing at the ground) that the rainbow of colors is not generated by the prism; rather light is intrinsically composed of these colors and the prism merely separates the colors. To the right, the goddess of red light, Eos

(rosy fingered dawn) symbolizes the color and a new day in physics.

The frieze on the left side of the plinth [Figure 14(b)] shows Einstein holding a rubber-sheet model of a body gravitationally distorting space-time. The boy-god Eros, the god of compelled attraction, on the right, stands in representing the god of gravity. Why a boy-god? Because gravity is the weakest of the four major known

Payback Time

Having personally worked with Maxwell's equations for a quarter century and having founded a successful company based on finding solutions to Maxwell's equations, I naturally picked up an interest in Maxwell himself. As I learned more about Maxwell, I found his life to be such a compelling story that I spent the last few years telling that story where ever I could, and many of you have listened. Thank you for that. As I learned that story, I came to realize we owe a great debt to Prof. Clerk Maxwell. By helping to fund the preservation of Glenlair and to help fund the erection of a statue in his honor, we are, in a small way, paying a part of that debt back. If you likewise have benefited from Maxwell's work and feel you would also like to pay back a portion of that debt, please make a donation to one or more of the charities listed below. I know the good professor would appreciate it.

- Maxwell at Glenlair Trust: <http://www.glenlair.org.uk/> (for U.S. tax deductability, contact donate@ieee.org).
- Royal Society of Edinburgh (for the Maxwell statue, funding is still needed!): <http://www.rse.org.uk/maxwell/> (for U.S. tax deductability, contact the U.S. 501c charity listed at this link).
- The Clerk Maxwell Foundation (promoting scientific research and history related to Maxwell, especially in maintaining Maxwell's birth place, 14 India Street): <http://www.clerkmaxwellfoundation.org/>.



Figure 14. Plinth friezes. (a) Newton's experiments with light and prisms. (b) Einstein holding a rubber-mat model of warped space-time.

forces. To illustrate, a small hand magnet can overcome the force exerted by the entire earth on a small piece of iron. Eros has planted an arrow in Apollo, on the left; gravity can influence light. The naked impoverished philosopher, Diogenes (of "looking for an honest man" fame) here looks on in horror, his begging bowl resembling a failed version of Einstein's model

and an idle warrior with an unstrung lyre at his feet both illustrate the outcome of the conflict between modern science and the ancient ways. Here, victorious modern science leaves the arts neglected. Standing back, I see a sweet irony, as art is most impressively enveloping science in the form of this monument.

Later, the starry night sky is bringing on a sharp chill as I leave the Royal Society. The statue beckons to my right; I cannot resist attempting some final night photography. Pressing my camera against a light pole for stability, I suddenly feel someone watching, a father and his young daughter.

"So, who is this Maxwell fellow?" he asks, lightly tapping his walking stick on the sidewalk.

"Why, this is James Clerk Maxwell, the Scottish physicist who, in the late 1800s, opened the door for all of 20th century physics; he is a very important person," I earnestly reply, pleased at their interest.


The young girl draws close to her father and points boldly at the statue, "But what is the name of his doggie?"

"His doggie?" I am momentarily startled. "Of course! Yes! His doggie's name is Toby."

She looks at the statue with bright, blue eyes. "Toby," she whispers and

smiles. A moment later her father nods thank you, and they walk away.

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