The magical lantern of Edgerton – the electronic flash tube GE FT-403

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This essay aims to introduce the GE FT-403, recently bought by the Deutsches Museum Munich, and to investigate its inherent potential as a museal artifact by analyzing and interpreting it in a photographic context. Developed and produced in the second half of the 20th century, the FT-403 is part of the recent history of physics. The flash tube was invented and subsequently established by a group of engineers around Harold E. Edgerton (1903-1990) in the 1930s. It was the first flash tube in series-production and was part of the Kodatron, a market launched electronic flash photography unit in 1940.
I want to highlight its symbolic meaning in the cultural context of photography by focusing on the history of the electronic flash, where the FT-403 finds a prominent place as reference for the interrelations between scientific, artistic and societal development. By allowing the FT-403 to be a multi-dimensional item in a museal exhibit, it is a great example for the material culture as well.

Keywords: flash tube, Harold E. Edgerton, high-speed photography, history of physics, material culture

Material Culture in the History of Science and Technology

(Hi)stories usually are written accounts of the past or in other traditions passed down by oral testimonies to younger generations. Yet in the last decades a new trait of examination has come into focus and infiltrates the history of science and technology. The study of material culture with a long tradition in archaeology and ethnology links not only the intellectual approach directly with practical skill, it also embodies and identifies empathetically through our senses and makes it possible to gain knowledge from new levels by studying and handling artifacts in the same way its inventors, manufacturers and former users did. Material culture can help to understand different cultures and to discover non-explicit or even unconscious beliefs, values, and assumptions, which are captured within (Prown 1993, 1). The power of the past lives on in its things, giving us the opportunity to experience "the shock of connection to an impersonal past through the magic of the haptic," as Miller describes it in his recently published book (2017, 20). By analyzing 3d-objects, historians may be able to access their time period in a more direct way and bring scientific experience and innovation in connection to cultural history and maybe even cultural anthropology. Scientists and historians equally are biased by their own unconscious beliefs related to their culture and their time period. Therefore, an analysis of another time period becomes a lot more difficult and objective interpretation impossible. But this “problem is [only] a problem of mind,” as Prown puts it (1993, 17) and the perspective of material culture studies might be able to diminish the partiality of the investigator. Miller agrees and amplifies by arguing, that material culture in history “obliterates so many of the false walls that partition off our experience of living” and “getting this relationship right will help us, finally, make history work for life” (Miller 2017, 20).

By its definition, material culture is the study of material expression in artifacts. In material culture the research is started by physically engaging with the object, rather, than to approach it intellectually. By putting ourselves in the same place as the person, who handled the object originally, and since we live in the same realities of the physical world, we all have access to the same tremendous body of experience through our shared human neuro-physiological apparatus, which is common and transcultural and, in our specific case, timeless (Prown 1993, 17f). For the historian, the embodiment of the person who originally worked with the artifact, is the closest way possible to access the time, the person, or culture in question. This is especially valuable for the history of physics, since scientific instruments have been part of the scientific work from the time of the ancient Greeks and the gain of knowledge was enormous throughout the centuries. Especially in the 20th century the infiltration of new and counterintuitive ideas have accompanied the physicists constantly, which separated them from the general public, the applied arts and even other academic disciplines. New approaches were needed to reduce the gap and to reconnect the different mindsets. The material turn in the history of science is one of them (Fors et al. 2016).

Accessing through the senses brings all humans closer together even scientists, the common (wo)men on the street, and artists. This essay is a case study of material culture in the history of physics to illustrate one of various different ways of unraveling the past through the methodological approach of an unknown artifact. In addition to that the object in question will be placed at the above-mentioned interface by relating to the disciplines of electrical engineering, photographic art, common technological acceptancy and, finally, the museal exhibit.

A case study of Material Culture in the History of Physics

This essay is part of the *IV. International Seminar Material Culture in the History of Physics* generously funded by the Wilhelm & Else Heraeus Foundation. The seminar was held at the Deutsches Museum Munich (DM) in March 2020. The aim of the seminar included the exploration of an unknown object in the history of physics by applying the study of material culture. The written result is now in your hands and serves as final examination of the seminar.

The model originally developed by E. McClung Fleming in the context of his teaching at the Winterthur Museum-University of Delaware became widely known as *Winterthur Model*, which was later refined by Prown, Pearce, and Gessner amongst others (Fleming 1974; Prown 1982; Pearce 1994; Lourenço and Gessner 2014). Fleming’s methodological framework was originally formulated for artifacts from the early American decorative arts and therefore bears a special interest and orientation towards the cultural history. The general wording and basic structure of the model make it widely applicable for other study areas and offer an equally great foundation for artifact analyses. On that account Fleming's universal approach is my model of choice for the investigation of the unknown museal object in this essay.

Study of the Artifact

Within the scope of the Material Culture Seminar, selected museum artifacts were handed out to the participants. The assignment was to describe, identify and evaluate the unknown objects. This essay concerns the object illustrated in figure 1, which only very recently became a part of the DM collection in 2019.[1]

Figure 1: This "mystery object" is the main topic of this essay. Source: Deutsches Museum Munich © Nana Citron.

I applied the original *Winterthur Model* (Fleming 1974) in order to methodologically describe, identify and evaluate the given artifact. The model provides a framework relating different approaches to the object with each other. The model incorporates two conceptual tools: (A) a five-fold classification and (B) four operations performed on the findings from (A). The classification contains the material, construction, design, history and function of the artifact. The operations are supplemented by supporting information of the artifact, which I summarized under (C) in figure 2.

Identification and Classification

The identification includes the classification of the artifact by material, construction and design. The detailed description and the orderly delineation of the physical aspects from the object result in a body of distinctive facts about the artifact in order to identify it accurately. Looking at the object, the first impression is, that it is some kind of electronic lighting device and therefore a part of the recent history of physics in the 20th century. To confirm or refute this observation, first, a detailed factual description of the object at hand is made.

[1] That is why the artifact is not listed in the inventory catalog of the museum by the time of this essay's emission.

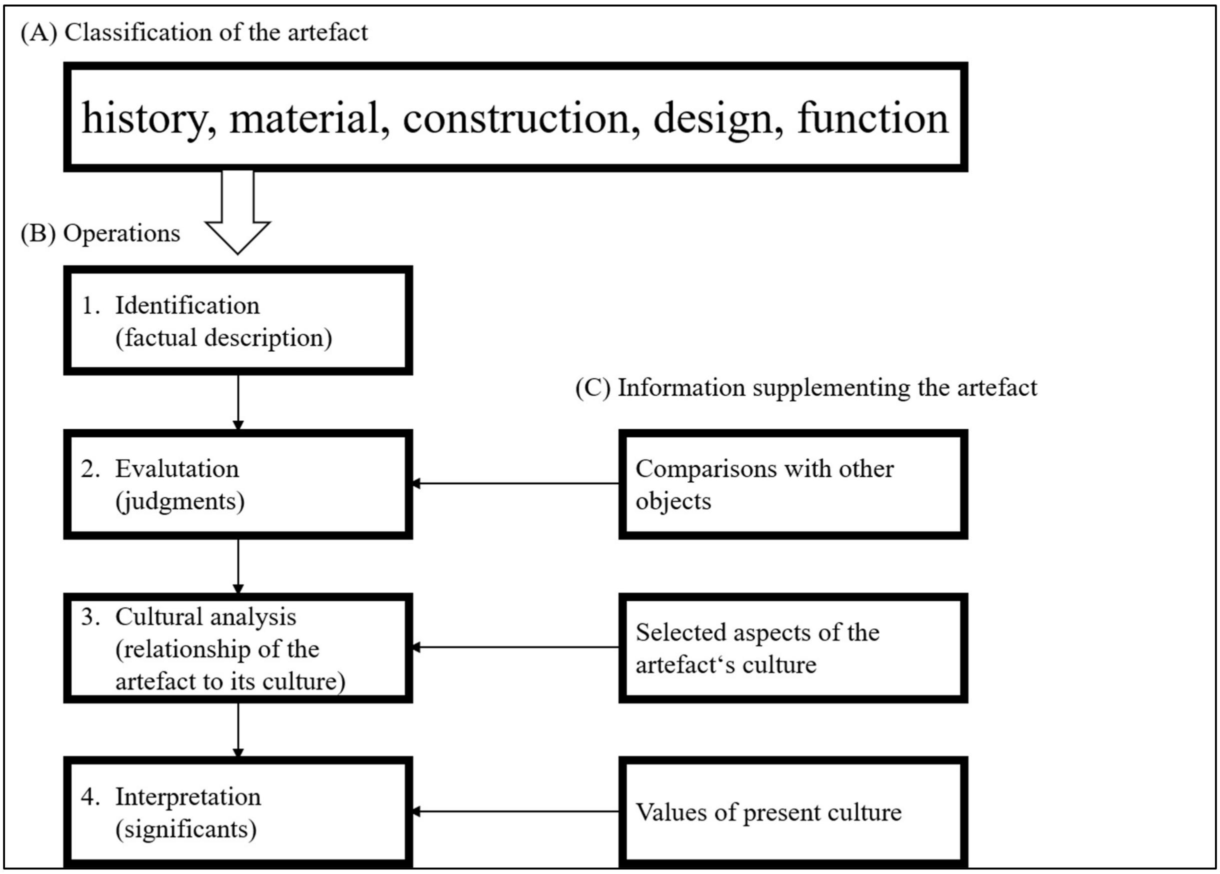

Figure 2: The model by Fleming (1974, p. 166), slightly altered by the author to fit the artifact of concern.

It is the matter of a cylindrical shape with a dome on top and an opening at the bottom, measuring 18.8 cm in length and 6 cm in diameter. The constituent material of the cylinder is frosted glass. The border of the opening is some kind of black synthetic material, probably hard plastic, which has three small reinforced cut-outs. There are three metal pins passing through the cut-outs. Inside the cylinder metal wires are attached to the pins. There is another body inside the glass, which can be clearly recognized in backlighting (fig. 3, top). This intrinsic object embodies a spiral of 4.5 turns. It is obvious, that one of the metal wires has the function to hold the spiral in its place. The other two are connected to the ends of the spiral, which has an approximate length of 58 cm and a diameter of approximately 0.8 cm. The material of the helical structure is transparent glass and its center is hollow. The spiral is a closed system, only connected through the attached wires. This observation justifies the assumption that the spiral is filled with a gaseous substance other than air. The metal pins give the impression of contacts because they have alterations, probably, through the usage as plug-in device. The dome comprises several inscriptions: A company name “General Electric”, the corresponding emblem, a letter-number combination “FT 403”, and another number with a different inscription type “31” (fig. 3, bottom left). The latter seems to be a serial number. Along with the fact, that there are no adornments, nor other individual or outstanding marks, whatsoever, the following assumption is nearby: We are dealing with a series-produced object primarily owning an inherent functional purpose.

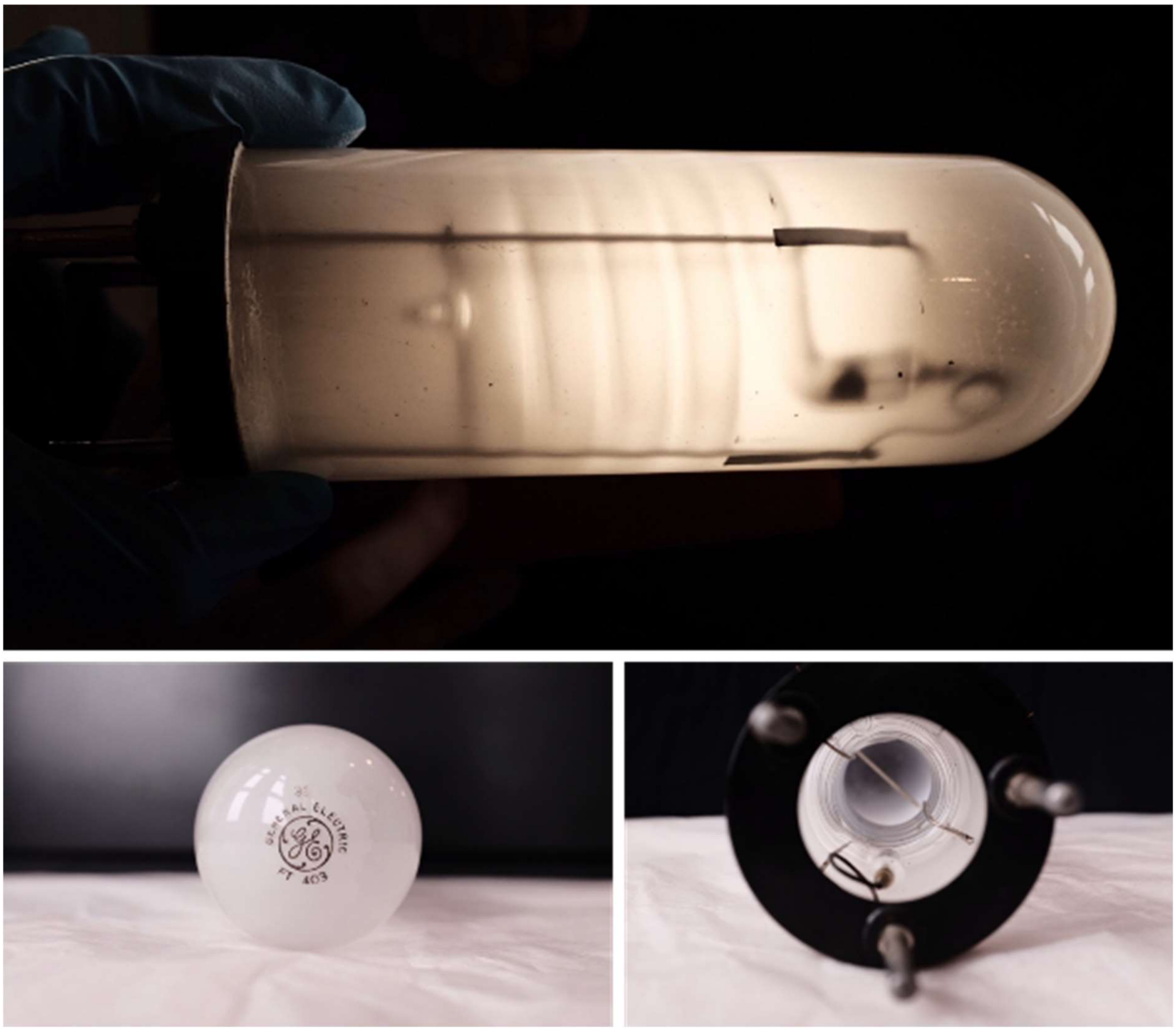

Figure 3, top: The artifact shown in backlighting. **Bottom:** The inscriptions of the dome of the artifact (left) and the bottom with a glance inside the cylinder (right), the different type of metal pins for stabilization and contact are clearly visible. Source: Deutsches Museum Munich © Nana Citron.

Nonetheless the inside of the device seems to be a rather complex and precise manufacture. To get a better insight, a scheme was sketched (fig. 4), which also enlists the exact measures of the object in question.

The object is compact, seems to be intact and might eventually be functioning. There are no obvious missing parts, nor fractures or holes, which would require restoration. Still it is obvious, that there must be a connecting device, which we did not have for further investigation. Therefore, the accurate state of conservation and the actual functioning are unknown and only can be assumed.

The mentioned inscription and the close resemblance to contemporary electrical devices simplifies the identification enormously. The object of investigation is a flash tube with the name FT-403 produced by General Electric.

Finally, the material, construction and design have been sufficiently described, which allows an exact identification of the object as the first operational step of the *Winterthur Model*. In the following operational tools, I will concentrate on questions towards the function and the history of the FT-403. Concerning the biography of the specific artifact, it is rather short. Although the FT-403 has an individual serial number, which makes it unique, there are usually no records for specific flash tubes in use, since they belong to the category of expendable goods. This is a common issue concerning objects from series-production and therefore known in material culture studies from artifacts of recent history. The DM only just bought the FT-403 (serial no. 31) from an online auction platform in 2019.[2] Other biographical facts of the individual FT-403/31 are not available at the moment. It is assumed that the object might be significant in its cultural and historical context in a diachronic point of view. In addition to that, the fact that the FT-403/31 was bought by the DM is a starting point for its individual biography, which will attach additional significance and value to it in the future.

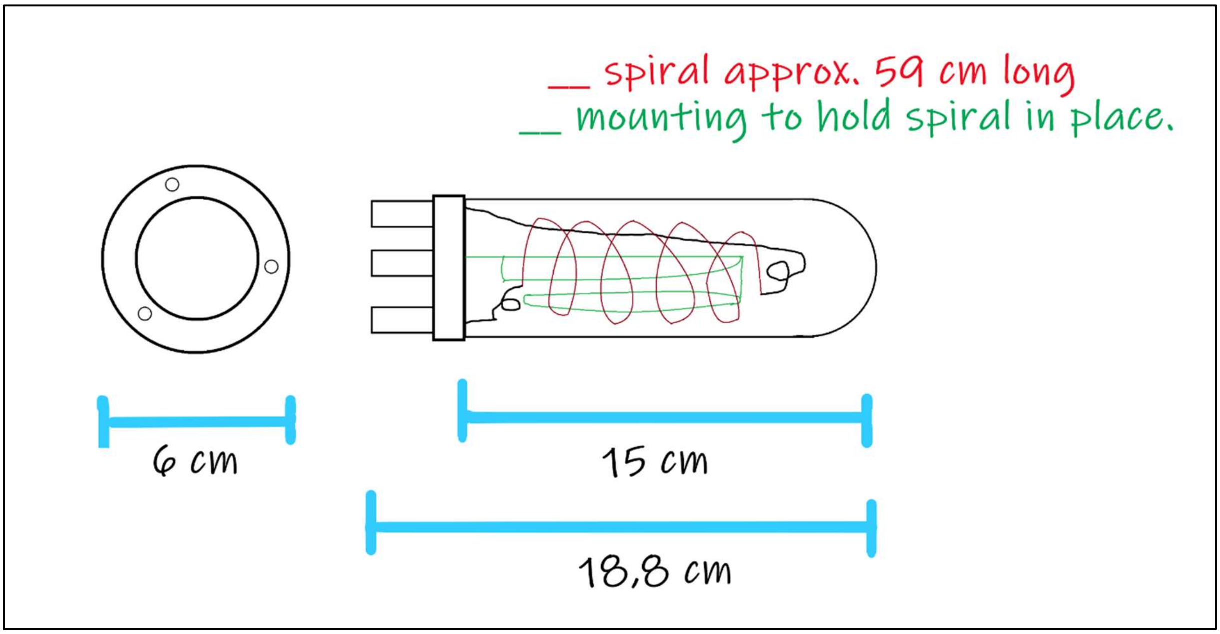

Figure 4: The scheme of the artifact's composition on the inside. The spiral is a closed system, which reasons the consideration of a specific gaseous filling © Lena Ulbert.

Evaluation with supplementing information on the FT-403

To evaluate the flash tube FT-403 questions concerning its provenance (through history) and application (through function), supplementing information through further research is required. Regarding the sales catalog of the GE lamp division from 1954, the FT-403 and other models of repeating flash tubes are presented in detail on page 11. It says, that the FT-403 is "designed for studio photographic use in large reflectors" and "recommended for black-and-white photography" (General Electric 1954, 11). The FT-503 has the same physical dimensions but a helix made from different material for higher energy input and corresponding increase in light output. The catalog recommends the FT-503 for color photography. In addition to that, a filament lamp can be mounted inside the helix of the FT-403/503 showing the exact appearance of the flash tube lighting on the subject (fig. 5, left). Here it becomes clear that the FT-403/503 is part of a system: the electronic flash photography equipment called Kodatron flash unit (fig. 5, right). Several patents in connection with electronic flash technology and stroboscopy were filed by Harald E. Edgerton[3] (1903-1990), a professor of electrical engineering at the Massachusetts Institute of Technology (MIT), and granted by the United States Patent Office in the 1940s. In his book *Electronic Flash, Strobe*, Edgerton

[2] The object was bought by Johannes-Geert Hagmann in 2019 on eBay in the context of enlarging and enriching the Museum's own Maiman-Laser and its historical background and cultural significance. Nonetheless, a completely different perspective will be the topic of this essay.
[3] Later in his career, Edgerton acquired the nickname *Papa Flash*.

gives detailed insight in the functioning of the new technology (Edgerton 1970, 108ff.), which was developed in close collaboration with the Eastman Kodak Company.

The new technology changed high-speed photography sustainably by using electrical gas discharge. Through its spectral distribution close to that of daylight or lightning flashes in natural events and its high efficiency, xenon became the noble gas of choice in series-production. The new flash technology was able to contain the flash in the controllable inside of the lamp on the one hand, and on the other, to arrange the instant of the flash within microseconds. Through a trigger signal the lamp was stimulated and the energy stored in the electrical circuit was instantly transformed into radiant light of very short flash duration with precise control of its release instant. Through the outer frosted glass, the light patterns caused by the lamp in a specular reflector were broken up to imitate optimal natural lighting.

That is how the electronic flash system can be handled by the operator to suit his or her exact intentions. Even today, it is possible to find the FT-403 for purchase on the internet. For example, there are still flash tubes of this specific type available in vintage camera and photography equipment stores. To elaborate the significance of the artifact, I will pose questions of reference (Miller 1994, 397), which set the FT-403 in a broader cultural context as a pivot between special laboratory equipment of scientists, and the institutionalization of the electronic flash in professional photography as contemporary state of the art. Let's indulge in the ramified and yet fascinating history of high-speed photography.

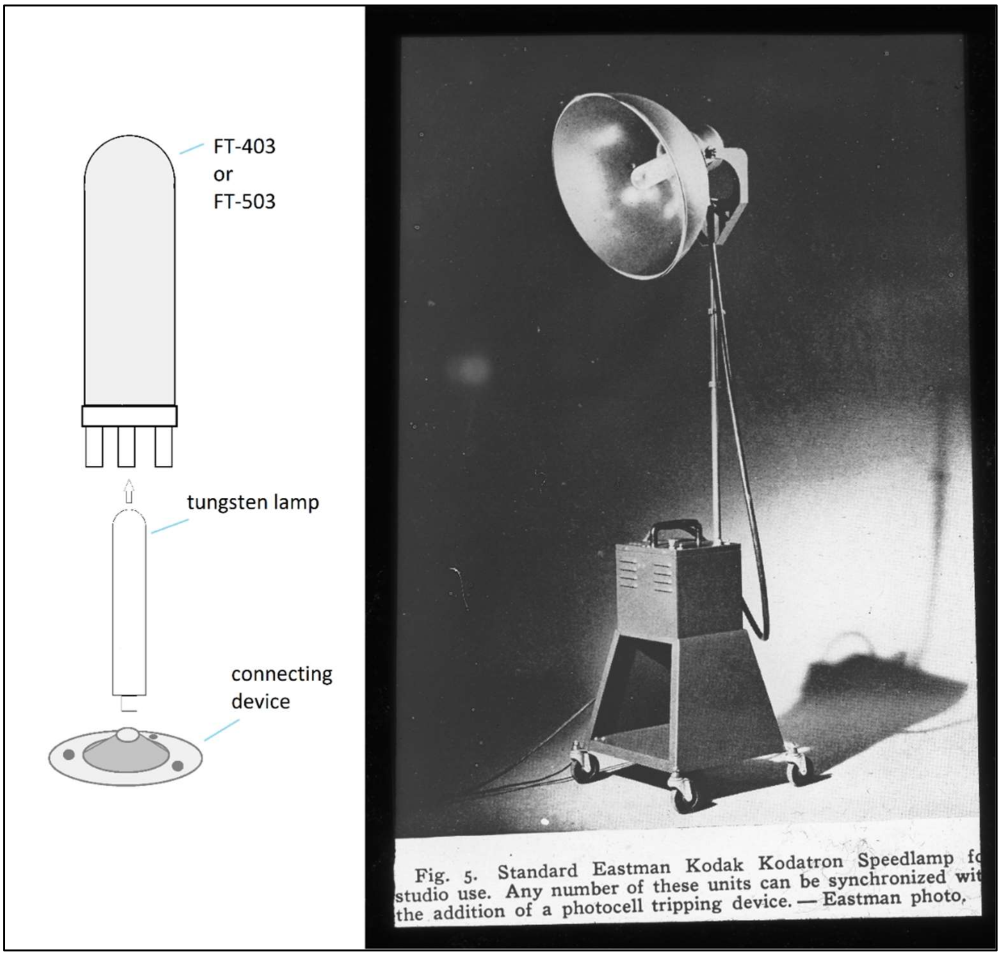

Figure 5, left: The FT-403 (glass spiral) and FT-503 (quartz spiral) are built to nest over a 100-watt tungsten lamp. Replacement of the tungsten lamp is accomplished by removing the flash lamp first © Lena Ulbert. **Right:** The 1940 Kodatron flash unit. The image is a reproduction from a book (PDM 1.0). Source: Unknown photographer / Tekniska museet. URL: https://digitaltmuseum.se/021016318671.

Cultural Analysis – the origins of the FT-403

The cultural analysis examines the various interrelationships of an artifact and its contemporary culture (Fleming 1974). Therefore, the history of the institutionalization of high-speed photography is regarded. Edgerton himself, summarized a few mile stones of the technology in his brief history of the strobe photography, which is excerpted from *Optical Engineering Reports* published in 1984 (Fleming 1990, 43ff.). His experiences with stroboscopy go back till the 1920s, when he engaged in finding a technical device to prove the theoretical solutions of electro-mechanical problems. A visual fast-recording device was needed as experimental prove, which he eventually pursued with strobe photography (Fleming 1990, 53). Although Edgerton started experimenting with mercury gas, he soon switched to experiment with noble gases, as e.g., argon or neon, because they wouldn't be as temperature-sensitive as the former and could be operated with high efficiency, when hot or cold. Finally, xenon was the element of choice because of its high efficiency and spectral properties. The flash tubes, which is operating with electrical discharge in xenon is the accomplishment of those findings (Edgerton 1941; Fleming 1990). Edgerton's strobe photography extended the human sight abilities by freezing the motions, which are too rapid to be detected by the unaided eye. His technology produced instantaneous images of fast-moving objects, like the humming bird (fig. 6). His photographs of speeding bullets and detailed breakdown of any kind of fast movement (e.g., sports) were widely published and famously recognized (Kemp 1997, 2003, 366).

Figure 6: A humming bird's wings flap up to 60 times per second. Source: Gift of Gus and Arlette Kavafas, 1987 / International Center of Photography. URL: https://www.icp.org.

Although, the Museum of Modern Arts displayed some of his photographs in the exhibition *The History of Photography: from 1839 to the Present Day* in 1937, Edgerton claimed never to have seen himself as an artist but as a scientist-engineer, who 'solely was after the facts' (Kremer 2012, 186). Still, this was the first time that a major art museum displayed photographs as art work and three year later established a new department: the Department of Photography (Hirsch 2017, 369). In the same year, 1940, the initial introduction of the first Kodatron unit was made at the photography convention in Chicago. The Kodatron unit including the flash lamps were engineered and designed by Kenneth Germeshausen, Herbert Grier and Harald Edgerton. The production was handled in collaborative effort by General Electric Company[4] (flash lamps) and Raytheon Company at Waltham, Massachusetts (electrical units) (Edgerton 1970, 108f.). George Eastman got interested in the up-coming flash technology by the wide success of printed photos in the newspapers. The composition and marketing process was carried out by his company, the Eastman Kodak Company. It engaged in popularizing the personal camera and leisure photography, systematically, for already 50 years before the series-production of the FT-403 (Munir and Phillips 2005).

In this cultural context, the FT-403 becomes an important part as pivot in the history of photography between science, art and society. This artifact can not only be referred to as a symbol for the electronic flash, but also as a peak reference for the development and progress in photographic practice. The stroboscopy extended its meaning tremendously, first only prominent in scientific laboratory, then emerging in artistic exhibitions and finally becoming the state of the art in contemporary professional photography. Edgerton expresses the success of electronic flash photography by refering to a picture, which shows a moment of the boxfight "Joe Louis versus Arturo Godoy" in 1940. It is a razor sharp image of Louis employing a left uppercut to Godoy's face.[5] He says:

> *"It was significant to me that this first fight photo was published widely and nothing was said about the strobe system that was used. Most previous strobe photographs, when published, had a mention of the system used. This meant to me that strobe (electronic flash) photography finally had become accepted as a standard system of photography."*
>
> Edgerton 1970, 47f.

As Hodder points out in his article, the interpreter can chose from an infinity of possible contexts constructed by inventors and users (Hodder 1994). In this respect, I want to point out a second interesting correlation of the FT-403 in the history of physics. The flash tube is closely associated with the invention of the first ruby-laser by the group around Theodore H. Maiman (1927-2007) (fig. 7). The helix is an image of the flash tube as is mentioned in the description of the figure from the filed patent in 1961 (Maiman 1961). Whereas, the original Maiman-Laser[6] was smaller and shorter, the schematic diagram has its origins from the flash tube design, which is pointed out in the figure description as well. The introduction of the laser-technology changed the field of optics in a lasting way.[7]

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[4] In 1940, for the first time, General Electric placed flash tubes on the market (p. 185). For further research, please refer to Keating 1954.

[5] URL: http://edan.si.edu/saam/id/object/1997.118.15.

[6] There are four existing original devices today, one of them is part of the DM collection.

[7] For further information on the FT-403 in the context of laser-technology, see Nana Citron's essay for this seminar.

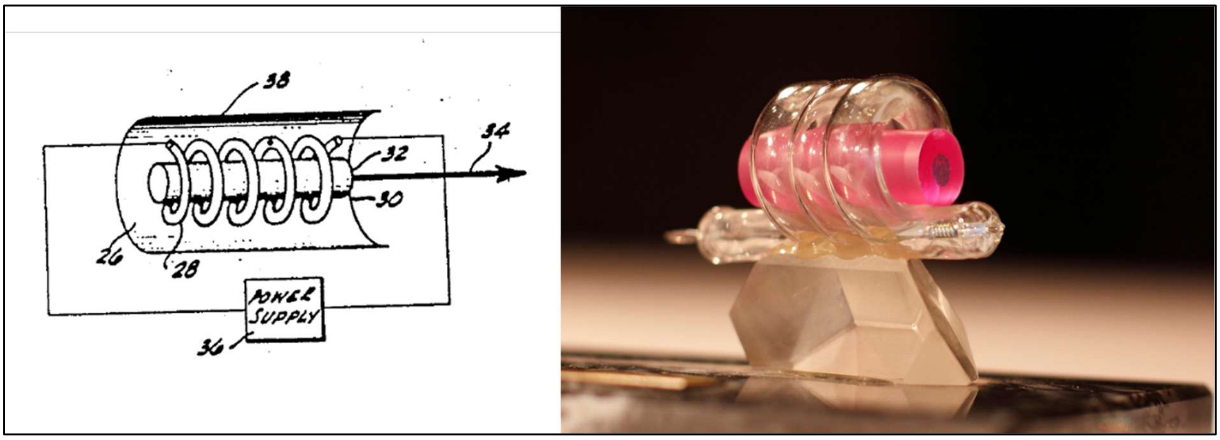

Figure 7, left: Sketch from Maiman's patent for a ruby laser system (Maiman 1961, p. 2). The description says: "A schematic diagram of one embodiment of the present invention which utilizes a helical gas-filled flash tube for optical pumping of the laser material." (p. 4) Source: US Patent Office. **Right:** Flashlight from the Maiman-Laser in DM. Source: Deutsches Museum Munich © R. Wengenmayr.
URL: https://www.deutsches-museum.de/presse/pressearchiv/presse-2015/laser.

Interpretation

The historiographical interpretation relates the artifact to the present culture. The FT-403 as museal artifact is the starting point in this essay and can be analyzed in several different ways as already indicated in the cultural analysis. I concentrated on the early history and the implementation of the FT-403. Not only is it a highlight of engineering mastermind, but it is also a powerful example of working endurance, transparency and collaboration. The FT-403 can be interpreted as a symbol of a wide-spread institutional change: After the implementation of the electronic flash lamps, the discipline of photography in general (not only high-speed) change substantially. And to top that, this transformation can even be put in a bigger cultural context: Looking at the fundamental change in societal behavior concerning the practice of photography all together. By joining everyday life of the common (wo)man, the caption of visual imagery and the personal story-telling, thus story-manufacturing, is introduced in the society with no possibility of return. In this respect, further investigation into the gender change from mainly male professional photography to widely female and personal snapshots in everyday lives can be done.[8] In addition to that, electrical engineering continued, paving the way to the Maiman-Laser, military surveillance technology, and further electronical observation and documentation in physics, only to mention a few possible scopes of interpretations. Edgerton never failed to emphasize his pure research interest and pursuit of the facts by highlighting the requirements of specialized knowledge in producing high-speed photographs (Fleming 1990, 46). Furthermore, it is obvious in his transparency and communication efforts of his inventions and scientific research, as well as in his teaching efforts.[9] Nonetheless he knew about the close relations to corporate and public affairs and used his achievements to spread his technologies.[10] In this respect, the FT-403 is not only a prominent example as part of the electronic flash, which slowly appeared in everyday life, but also a manifest for Edgerton himself, who told his students: "Work hard. Tell everyone everything you know. Close a deal with a handshake. Have fun!"[11]

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[8] See Munir and Phillips 2005.
[9] Furth further information, see https://edgerton.mit.edu/about [accessed 30.08.2020].
[10] For further information, see Kremer 2012.
[11] https://edgerton.mit.edu/about/doc-edgerton [accessed 30.08.2020].

Conclusion

Material Culture enriches the history of physics from a different perspective. It can play a major role in the connection of different disciplines through time and space. Especially in the curating work of the history of physics, the human side and the practical side are good approaches to engage the visitors, who are generally the ordinary interested persons. The FT-403 is a great example for the Material Culture Studies, despite the fact that it is a rather inconspicuous artifact, nor is it unique. This essay shows that it has a reasonable place in the museal collection because of its rich cultural background. That is why the FT-403 can be a framing artifact to supplement the Maiman-Laser but in addition to that, it is possible to explore further in the history of the electronic flash and let the FT-403 find a more prominent place in a possible exhibit by framing it with other artifacts from the history of high-speed photography. In this case it can refer to the interrelations between scientific, artistic and societal development to explore the recent developments from our own cultural background and its interrelations politics, economics, society and sciences. Therefore the FT-403 works at the interface of the two major kinds of images (Kemp 1997, 2003, 362): on the one side as the subject matter of scientific investigation in the MIT lab or as historical artifact in an material culture essay. And on the other side as iconography of science, reflecting human accomplishment and collaborative success in science as a social activity. The artifact of question in this essay intimately interconnects both aspects of visual imagery. Especially, in the case of photographs, the science behind the actual practice of taking and developing them, their symbolic representation in documentation, and, finally, their potential in emotional evocation interpenetrate and stimulate each other continuously, allowing the FT-403 to be a multi-dimensional item in an museal exhibit.

In my personal opinion, the obtained amount of historical information that can be associated with a quite unspectacular artifact (on first sight, please note), is baffling and rather impressive. That is something the FT-403 can stand for as well, and that is why it is such a great example for the material culture.

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