


PRINCIPLES OF PHYSICS IN THE USE OF THE FARADAY CAGE¹ <https://doi.org/10.63330/aurumpub.043-010>

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Abstract

The Faraday Cage is an electrical shield, whose conductive surface surrounds a given region of space to block the entry of radiation from electric and electromagnetic fields. It was developed during the 19th century, but needs to be better used, demonstrating that its potential goes beyond what is currently used. It is especially recommended in physiotherapy clinics to neutralize the effects of electric and electromagnetic waves produced during the operation of DOCs - Shortwave Diathermy, widely used for the therapy of patients in these clinics. Professionals in the field of physiotherapy demonstrate that they are not aware of the importance of the security that the Faraday Cage provides. The objective of this work is precisely to know the use of the Faraday Cage in establishments that need it and to evaluate the potential market that can absorb it, including as part of the lightning rod capture system. As a result, physiotherapy professionals are unaware of the need for this safety equipment in their establishments and the greater use of the Faraday Cage in buildings as part of the Lightning Protection System.

Keywords: Faraday cage, Construction, Short Waves, SPDA.

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INTRODUCTION

The Faraday Cage is an apparatus developed to neutralize the effect of electric and electromagnetic discharges caused by natural causes such as lightning and by artificial factors resulting from equipment that generates electric or electromagnetic fields, such as SWD devices—Shortwave Diathermy—used in the recovery of patients in physiotherapy clinics.

The operating principle of the Faraday Cage is more widely disseminated than its use in specific enterprises where there is electromagnetic radiation that places at risk the workers who operate the devices.

Are professionals in the field of physiotherapy properly informed, and do they prioritize safety measures through the installation—preferably during the construction phase—of systems for neutralizing electric and electromagnetic fields in the vicinity of SWD devices? This question constitutes the research problem.

The general objective of this research is to understand the use of the Faraday Cage as well as to consider the potential market for its application in systems for capturing electric and electromagnetic fields.

Regarding the methodology used, this work follows the theoretical research methodology defined by Demo (2000) as research dedicated to the reconstruction of theory, concepts, ideas, and ideologies with the purpose of producing theoretical foundations.

According to the methodology, this study is classified as descriptive in terms of its objectives, because it describes characteristics of a specific object of study. By the nature of the data, it is classified as qualitative because it seeks the understanding and interpretation of phenomena. (Gonsalves, 2012)

Köche (2011) conceives various forms of knowledge; however, modern science has introduced a practical and effective method in the search for truth, understood through experimentation, by formulating hypotheses, repeating the experimentation to verify the hypotheses, and formulating generalizations, laws, or theories.

CONCEPTS AND CHARACTERISTICS OF THE FARADAY CAGE

The Faraday Cage is an electrical shield whose conductive surface surrounds a given region of space in order to block the entry of radiation originating from electric and electromagnetic fields. It was developed during the nineteenth century, but it needs to be used more effectively, demonstrating that its potential goes beyond its current applications. It is especially recommended in physiotherapy clinics to neutralize the effects of electric and electromagnetic waves produced during the operation of SWD devices—Shortwave Diathermy—widely used in the therapy of patients in such clinics. Professionals in the field of physiotherapy demonstrate that they are unaware of the importance of the safety provided by the Faraday Cage. According to Ferraz Netto (2011), the Faraday Cage is an electrical shield, “a conductive surface that surrounds a given region of space and that may, in certain situations, prevent the entry of disturbances produced by external electric and/or electromagnetic fields.”

For Melo (2011), the tendency of a conductor, when charged, is to disseminate its charges uniformly over the entire surface; however, if it is a hollow sphere, the charges will be restricted to the external surface, where they will remain as far apart from one another as possible due to the effect of repulsion. Meanwhile, on the inside, a neutral field will occur because the effects of the electric field generated internally cancel each other out.

The same occurs when the conductor is not charged but is located in a region that has an electric field caused by an external agent. Its interior is free from the action of this external field; it is shielded. This effect is known as electrostatic shielding.

To prove this effect, the British physicist Michael Faraday conducted, in 1836, an experiment to demonstrate the effects of electrostatic shielding. He built a metal cage charged by a high-voltage electrostatic generator and placed an electroscope inside it to prove that the effects of the electric field generated by the cage were null. Faraday himself entered the cage to prove that its interior was safe. This experiment became known as the “Faraday Cage.” (Melo, 2011, p. 1) (Figure 1)

Faraday cages are used to obstruct electric fields and electromagnetic radiation; this is why they are essential in clinics that use shortwave resources. “Thus, electrostatic shielding also became known as the Faraday cage, and this effect is widely used in our daily lives.” (Melo, 2011, p. 1)

Figure 1

Operation of the Faraday Cage



Source: Melo, 2011

The principle is always the same: the Faraday Cage neutralizes electric discharges because they dissipate on its exterior without penetrating it. In this case, the worker at the top of voltage networks will remain unharmed because his suit—stainless steel clothing containing 25% to 75% Nomex, which is a derivative of Kevlar material—acts as a Faraday Cage, provided that he does not come into contact with the ground. (A Vida, 2011)

Figure 2

Clothing that acts as a Faraday Cage



Source: A Vida, 2011

COMMERCIAL VIABILITY OF THE FARADAY CAGE

A study conducted by Silva et al. (2007) surveyed knowledge and use of the Faraday Cage among professionals in the field of Physiotherapy in the city of Niterói, in the State of Rio de Janeiro. The research results made it possible to conclude that none of the establishments visited had a Faraday Cage, demonstrating that there is widespread lack of knowledge regarding the harmful effects of radiation caused by the Shortwave device frequently used in ultrasound sessions for patient recovery.

Despite the indiscriminate use of shortwave, its operator is not aware of the deleterious effects of this resource on his or her own health when used without a protective measure. Although the professionals approached most often referred to the contraindications of the device for its application to the patient, they neglect measures for their own protection. We also found that most of the interviewees use the resource almost daily, and several times a day, representing a possible imminent risk to the health of those who are exposed to the daily radiation of shortwave. (Silva et al. 2007)

Since 1890, the biomedical field has used high-frequency electric currents; in recent years there has been greater concern regarding the possibility of health damage due to exposure to various types of radiation.

Another study conducted by Messias; Okuno; Colacioppo (2011) aimed to measure the radiation exposure of physiotherapy professionals to 17 shortwave diathermy (SWD) devices used in clinics in Presidente Prudente/SP in order to “compare the measured values with the exposure levels recommended by the ICNIRP (International Commission on Non-Ionizing Radiation Protection). To observe the effectiveness of Faraday cages as a protective measure against physiotherapists’ exposure to oscillating electric and magnetic fields.” (Messias; Okuno; Colacioppo, 2011, p. 309)

Through the study, the authors sought to measure the level of knowledge (information) that professionals in the field of physiotherapy in Niterói/RJ have regarding the harm caused by frequent exposure to the electromagnetic field of the Shortwave device, and the consequent need to install the Faraday Cage in this type of establishment, due to the presence of certain therapeutic-resource devices. (Messias; Okuno; Colacioppo, 2011)

The authors of the research, based on the data collected, recognized the existence of levels “above the limits recommended by the ICNIRP (International Commission on Non-Ionizing Radiation Protection), mainly near the cables and electrodes of the equipment analyzed” and suggested the installation of a Faraday Cage as a safety measure for the physical health of those professionals, who remain exposed throughout the workday, since SWD devices are common tools in the work of rehabilitating physiotherapy patients.

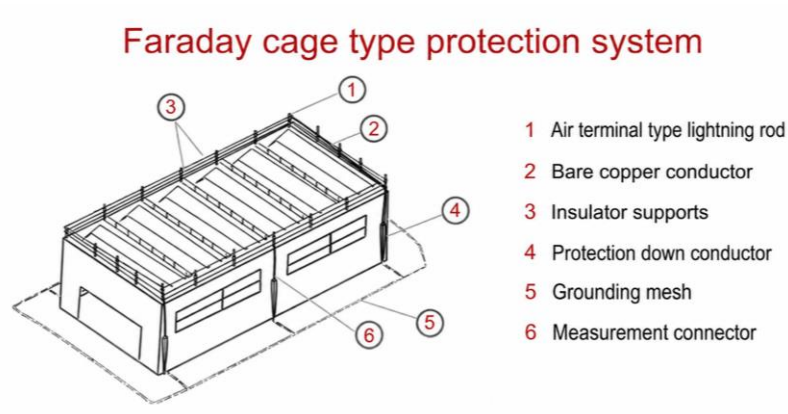
FARADAY CAGE – AN EFFICIENT METHOD FOR LIGHTNING ROD CAPTURE

The lightning rod capture system is necessary on buildings in order to attract electric discharges and must observe the regulatory guideline of ABNT to compose a safe and efficient system. According to standard NBR 5419:05, there are basically two lightning rod capture systems: “Franklin-type air terminals

mounted with masts and the Faraday cage system, which is composed of a capture mesh that may be executed with bare cable, aluminum cables, or aluminum strips over the building.” (Sistema, 2011, p. 1)

Figure 3

Faraday Cage-type protection



Source: Adapted and translated from Sistema , 2011

In studying the LPS—Lightning Protection System, Coutinho; Altoé (2003) dismiss the Faraday Cage method, stating that around it, the current must circulate uniformly, since the field will only be null at the center of the cage; however, in the “vicinity of the conductors there will always be a field that may induce voltages in conductors of electrical installations that are parallel to the mesh conductors.” They dismiss the method because they understand that the protection area is very broad, which rules out the use of the cage for this purpose. “Maximum protection in the case of the Faraday method is obtained when the structure is enclosed by a metallic box with welded walls and sufficient thickness to withstand the thermal effect of lightning at the point of impact,” conclude Coutinho; Altoé (2003, p. 25)

The following position is contrary to that of the authors cited above, because the Faraday Cage appears as part of a system for lightning rod capture, making the installation quite safe, since it neutralizes the propagation of electromagnetic waves (preventing their entry and blocking their exit).

The Faraday Cage, according to the technical standard for lightning rods NBR 5419:05⁹, constitutes an effective way to achieve lightning rod capture by installing “bare copper cables with a cross-section of 35 mm² around the entire perimeter of the building, plus transverse cables, forming a large Faraday cage, or by means of aluminum strips with a minimum cross-section of 70 mm². The Faraday cage has the characteristic of better shielding the volume to be protected, and if we consider the reinforcement bars of the reinforced-concrete structure or metallic structures, several Faraday cages will naturally exist, reinforcing the lightning rod system. The principle of the Faraday cage is that the volume to be protected will have shielding against the entry of electromagnetic waves, as well as the exit of electromagnetic waves, provided that the Faraday cage is properly grounded to the lightning rod system (LPS). For calculation and design purposes, we consider lightning as components of strong electromagnetic waves, in the megahertz range. (Instalação, 2010, p. 1)

It is known that a large portion of currently existing new technologies are products developed and tested for military purposes¹⁰. According to Gomes (2006), in 1941, grounding began with the use of reinforcement bars (rebars) in reinforced concrete. During the Second World War, engineer Herb Ufer devised a system for storing bombs kept in the warehouses of the American Davis Monthan Air Base, in Tucson, Arizona.

Figure 4 illustrates the Faraday Cage that must be interconnected with the entire grounding system for lightning rod capture.

⁹ NOTE: Any structure to be protected by a lightning protection system and measuring more than 10 m in height from ground level must have a cable installed around its entire perimeter as a complement to the lightning protection system, as required by NBR 5419:05, the technical standard for lightning protection systems. (Instalação, 2010. p. 1)

¹⁰ It was developed during the early period of the Cold War under the name ARPANET to maintain communication among United States military bases, even if the Pentagon were erased from the map by a nuclear attack. Once the Cold War threat had passed, ARPANET became so unnecessary that the military no longer regarded it as important enough to keep under their control. Access was then granted to scientists, who later transferred the network to universities; these institutions subsequently shared it with universities in other countries, allowing local researchers to access it, until more than 5 million people were connected to the network and, with each new user, four more joined the vast web of global communication. (Bogo, 2000)

Figure 4

The Faraday cage is formed by the enormous quantity of reinforcement bars in precast structures



Source: Gomes, 2006

THE USE OF THE FARADAY CAGE IN CIVIL CONSTRUCTION

German standards served as a source of inspiration for the development of guidelines in other countries, but considering the use of the grounding method initiated by Ufer, Germany has already used this system for more than 70 years.

Gomes (2006) warns that in the construction method that uses precast structures, the interconnection points¹¹ must already be prepared to ensure continuity of the entire insulation; therefore, they must be prepared during the reinforcement phase, before receiving the concrete, leaving the points on the external part of the structure in order to allow full interconnection with the Faraday Cage.

¹¹ These points must be provided externally on the various precast components, so that they can be interconnected—usually by exothermic welding—after final assembly, thereby forming a Faraday cage.(Gomes, 2006)

Figure 5

Interconnections made with exothermic welding (electrical continuity for the Faraday cage)



Source: Gomes, 2006

In Gomes's study (2006), two case studies are presented to show the use and demonstrate the need for and installation of a grounding system containing the reinforcement bars of the columns associated with a Faraday Cage: a railway shelter (house) and a DPC—Data Processing Center.

In both undertakings, the SRG—Signal Reference Grid—is used; however, while the Faraday Cage is used in the railway shelter, in the DPC an additional grounding reinforcement with complementary electrodes is used.

In DPCs, obtaining a constant signal reference is even more justified, which is normally achieved with an SRG conveniently dimensioned to equalize frequencies over a wide range. The grid must be interconnected to the local equipotential bonding bar (LEB), and this must be interconnected to the reinforcement bars of the pillar foundations (preferably in the central pillars), which in the case reported here are used as complementary grounding electrodes. (Gomes, 2006, p. 62)

In general, the safety systems during the construction of the undertakings listed here and other similar ones include grounding and follow the guideline of ABNT Standard NBR 5419:05.

CONCLUSION

The invention of the Faraday Cage dates back to the nineteenth century; however, there are many sectors that should make use of it and do not, either due to lack of awareness of its necessity, fear of excessively increasing the costs of the enterprise's installations, or the absence of regulatory standards for its use.

This work concluded that many physiotherapy professionals still do not know the extent of the harmful effects of using SWD devices—Shortwave Diathermy—daily and for many hours. The solution indicated was the existence of the Faraday Cage to neutralize the effects of radiation from SWD devices and the suggestion, as an occupational health safety standard for professionals, of installing a complete system, including the Faraday Cage.

A lack of regulatory standards requiring the installation of the Faraday Cage in all physiotherapy clinics as a condition for approving their operation was detected. Thus, owners would have to provide, a priori, for the installation of this system in order to safeguard, above all, their health.

In civil construction, it was observed that undertakings using precast structures adopt as a criterion Ufer grounding with reinforcement bars connected to the other iron structures, and may, in certain cases, include the Faraday Cage fully interconnected with the structural reinforcement bars.

Faraday Cages are also used in railway shelters within the grounding system, demonstrating that there is viability for the use of this equipment, which is essential for the safety system against electric discharges and electromagnetic radiation.

DECLARATION OF AUTHORSHIP

I declare that the work presented is my own authorship, containing no plagiarism or unreferenced citations. I inform that, should the work be failed twice for containing plagiarism, I will pay a fee of R\$ 250.00 for a third correction. If the work is failed, I will not be able to request exemption, pursuant to Clause 2.6 of the Service Provision Agreement (referring to *lato sensu* postgraduate courses, with the

exception of Occupational Safety Engineering. In Pedagogical Complementation and Second Licensure courses, the presentation of the Course Completion Work is mandatory).

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