Summary

1. **Aim and thematisation.** The aim of this thesis is to highlight the tight connections that exist between the *technical* and the *aesthetic* aspects that characterise the production of instruments, tools, devices and machines of all sorts throughout history. We focus particularly on the modern era and the advent of industrial revolutions, which have brought about a technological explosion, and base our research on the relationship between *utility (function)* and *appearance (shape).* Our starting point is that the field we are tackling, namely design, stems from the natural characteristics of objects and especially from the shapes of animals, which are perfectly adapted to their environment, whether they are fish, birds or animals living on land. Careful observation of the shape of these creatures – in fact, flawless and perfectly-adapted mechanisms – and an attempt to imagine structures that can copy their shapes and mimick the way they are built and function, both lie at the basis of the whole philosophy of tools and machinery production. We emphasise the fact that an important tenet of our endeavour is to underline the existing *correlation between natural, live shapes and the technical shapes yielded by design.*

   Our thesis thus posits that technical intelligence is the ability to imagine mechanisms, devices or contrivances whose function and utility can be best turned to advantage. Devices are meant to be useful in everyday life and have, in fact, become our aides in almost all the activities we undertake. In the modern era and especially over the past few decades, the appearance, shape, and even beauty of the various devices have become ever more relevant, bringing comfort and delight to the user. In fact, this merit rests with design, since it "forces" technology to envisage the performance of objects and machines bearing in mind their appearance as well, which has led to an artistic take on their work by engineers and designers or to collaborations between them and artists. We may rightfully say that *modern-day designers are "artists of objects", that "their works of art" are devices, machines and installations.* We believe that when expressed through practical everyday objects, beauty as artistic value is nothing short of art expressed in its more classical forms.

   In practical terms, our intention is to *apply our tenet that there is mutual support between technology and art* to lighting, which is our speciality and passion. We wish to demonstrate that light is a most refined artistic "substance" - which we have likened to music due to the evanescence and ubiquity that characterise them both – and that the way light is expressed depends on the technical devices we use to produce, model and project it. That is the reason why we believe it is important to bear in mind this particular aspect of the art of lighting – namely, that it is a process and not a "work of art" in the traditional sense. Light is a flux, light effects and lighting are complex technical procedures, which means that in a general sense, the art of lighting is a "happening", be it in private or public spaces. In order to get a clear idea about the importance of the art of lighting, let us just consider modern cinema for a moment, where expressiveness can sometimes be conveyed through the sheer interplay of lights, shadows, objects, shots and silhouettes (see the films by Tarkovsky, Sokurov, the Quay borthers, Peter Greenaway, Kubrik's famous *Barry Lyndon,* and so on).

2. **Method.** We think that in order to support the ideea underlying our project, we need to combine two different methods: 1) *the historiographical method,* which we used to pinpoint the moments, places and contexts in which certain utensils, devices or machines were discovered or invented – ranging from firearms to tools used in agriculture, construction, industry, and manufacturing shops, but also in art and design workshops. This method helped us underline the role all these tools have had in the development of various practical or artistic fields. 2) *applied analysis* helped us reveal the technical as well as the artistic features of various categories of objects, especially those that pertain to modern design. We consider that a prominent example of modern design is the *Bauhaus* school, whose principles are echoed in all modernist movements that tackle the relationship between technology and art.

3. **Structure.** Made up of eight chapters, this paper follows a common thread that brings coherence and shines a light on the connection between art and technology. It takes us through ancient civilisations, the Middle Ages, the era dominated by industrial revolutions and finally all the way through the modern-day forms of design and their applications in what we could call *the design of light.* This type of design has three main dimensions: 1) *aesthetic*; 2) *ergonomic* (functionality) and 3) *economically efficient* (low energy consumption), which we approach in the following way:

   Chapter 1. The emergence of art tackles the link between *utility* and *appearance,* between *technical* and *aesthetic* in terms of objects, artefacts, and structures. It dwells on the idea that *art is born when the aesthetic breaks free from the functional.* Aesthetic autonomy is thus a form of creative consciousness, which employs a different language and has other ends than the functionality and utility-seeking practical consciousness. *Artistic consciousness envisages art as a system of signs, symbols and forms of expression that produce and convey ideas, values, visions and general considerations* about being human, as well as about countless existential issues, whether serious, haphazard, or petty, but all expecting a reaction on the part of art. Unlike science or philosophy, art develops indirect, ambiguous, symbolic or parabolic answers, which are not irrelevant in the least; their structure is complex and revealing to the highest possible aesthetic level. We place great value on French archaeologist Henri Breuil's opinion that the origins of art are to be found in the natural capacity to make rhythmical movements with the hands, whose first form of expression is surface finishing. In the beginning, art had a decorative role and was associated with making objects; nowadays, we see *design as the ressurection of decorativism in all the fields of practical life, including lifestyle.* In our paper we draw on Maslow's famous hierarchy of needs – fundamental needs (survival and safety) and higher needs (self-esteem and self-actualization) – in order to highlight the value of art in people's lives. It goes without saying that art, which is not a basic need, is placed in the upper tier of the hierarchy, occurs quite sporadically and involves a certain level of sophistication, propensity and special skills.

Chapter 2. The merger between art and technology as a premise of civilisation deals with the role of hand tools in the advancement of crafts and, implicitly, of the material evolution of civilisation. Hand tools include all tools used by craftsmen to carry out basic manual procedures and fall into three main categories: a) *gripping and handling tools*; *examples include: tongs, vices, and even workbenches.* b) *measuring and control instruments such as: the ruler, the compass, the set square, the plummet, etc.* c) *carving tools* make up the third, and probably most diverse category and include: *chisels, hammers, scissors, hand planes, files, etc.* Seemingly dispensable in an era powered by computer-controlled industries, these rudimentary tools in fact underlie all today's cutting-edge machinery.

Furthermore, this chapter covers the evolution of technology from the simple and basic processing of materials found in nature, to metalworking, which consists in smelting ore and casting metal in molds. The latter was only made possible after a long string of innovations had taken place in ceramic art. In this chapter we show that technological fields develop simultanously but unevenly, and that the progress made in certain fields fosters the emergence of new ones or allows for spectacular leaps, even revolutions, in other fields. Let us just think about the massive effect the chemical industry has had on the production of cars, domestic appliances and computers following the discovery of new materials.

Cap. 3. The Industrial Revolution of the Middle Ages described by J. Gimpel. Prerequisites of the industrial revolution seeks to demonstrate that the time period we sometimes inaccurately and unjustly refer to as the "dark ages", as opposed to the "Enlightenment", is not necessarily a time of ignorance and obscurantism in all fields, let alone in terms of technology. The image of a "dark age" that we are stuck with is, in fact, due to the absence of lighting, of the rudimentary capacity to operate with light, which means that the pace of active life is closely linked to natural light and the alternation of day and night. However, all throughout this period, remarkable technical discoveries are made, which J. Gimpel deems to be an "industrial revolution" *avant la lettre.*

One of the most significant achievements of the medieval period was harnessing the energy available in nature and proliferating the means to store and use this energy. Watermills were paramount to the economy of Western European countries. Relatively stable in terms of yield and easy to set up, they were widespread and constantly enhanced during the pre-industrial era. Watermills breathed new life into a vast array of industries ranging from the iron and steel industry to grain milling and woodworking. Certainly, the mills incorporated systems that ensured the transformation and transmission of movement through ever more complex shafts and gears whose operating principles date back to ancient times, but the advent of the *camshaft* in medieval industry played an essential part in the industrialisation of the Western world. The following crucial discoveries are also noteworthy: *the mechanical pendulum, cast iron, the forecarriage, and the crank mechanism-based suction and blowing pump,* all of which were invented in the 13th and 14th centuries. The progress made by medieval engineers who adapted hydraulic energy to metallurgy fuelled the 18th-century industrial revolution. Hydraulic force revolutionised the iron industry, considerably outperforming manual labour carried out using the anvil. During the European Middle Ages the use of machines in all fields spread more vigorously than in any other civilisation up to that point. This was one of the determining factors of the Western civilisation's dominance over the rest of the world.

Chapter 4. The industrial revolution – a turning point for humanity discusses the large-scale technical modernisation that percolated all fields of activity, led to an increase in production, population growth, and the massive development of large cities, with Great Britain at its core. In 1750 Great Britain was already a significant maritime and commercial power, and yet the majority of its population was still living off agriculture. A string of inventions and discoveries turned textile manufacturing and metal processing into world-renowned industries. Textile manufacturing, a small-scale, household activity up until that point, was confined to large factories, which radically changed the lifestyle of workers. Jethro Tull (1674 - 1741) of Berkshire was one of the great agriculturalists and innovators in agricultural technology. He invented the horse-drawn hoe and the horse-drawn seed drill, which was shortly adopted on a large scale throughout Europe. The progress made in agriculture supported an ever growing population. The efficiency of machines fostered by the abundance of various goods in the market led to an accelerated urban development. The Western society now relied more heavily on production and consumption. This was the cradle of the consumerism we now see dominate our world.

The growth of industrial production shaped new aesthetic values, even though at first the specific mechanisms of objects were out of sight. This was a time when engineers and technicians shaped the artistic identity of the "Machine Age" from iron. At the time, few theoreticians realised that engineers made splendid functional works of art from iron. Many of the outcomes of technological innovations have gone unnoticed by art historians. It was only in the last twenty years of the 19th century that researchers of the modern history of architecture realised how important the "age of the engineers" had been. Even today, an vast array of innovations ranging from machines to brand new objects that had a great impact on the emergence and development of design are still ignored in art history.

A good example of how engineers have contributed to the field of design is the sewing machine. The merit for its invention goes to the American Isaac Merrit Singer, who in 1850 stroke the right balance between the technical, economic, ergonomic, functional and formal aspects of the sewing machine and on 12 August 1851 patented his own model in New York. Another noteworthy invention is the chain-drive bicycle, designed in 1879 by Harry John Lawson from England. The model produced by Raleigh Cycle Company in Nottingham (1905), which was equipped with the pneumatic tyres invented by John Dunlop and the three-speed gear invented by H. Sturmey and J. Archer, had the same operating principle as today's bikes. Another very important example is that of Michael Thonet, a cabinet maker who in 1830 managed to implement a procedure that was going to bloom into a whole industry by the end of the century. The bentwood technique he developed in his workshop in Boppard am Rhein was going to streamline the production of Rococo and Biedermeier chairs, which were so widespread in Central Europe until the end of the 19th century. In Moravia, Thonet built a chair model that could be easily assembled and held together with just a few screws. Nowadays, this model is used for most chairs and pieces of furniture.

Chapter 5. *Art 1900.* Form and structure describes the schools and movements that laid the basis of modern rational design, such as *Arts&Crafts, Art Nouveau, and Bauhaus,* the last of which we explore more in depth as the first organisation that succeded in creating a systematic and coherent education model, valid to this day. The movement born around the 1900s in fact heralded all modern art and architecture. The most important thing about *Art 1900* is that it brought organising principles to the visual and decorative arts without drawing on previous artistic styles. It was an international style relying on decoration and strongly challenging Academic art in all fields; it rebuked the bad taste of the era, achieved the modern synthesis of arts and lent credibility to graphic art turning it into an art form.

Henri de Toulouse-Lautrec was the fist artist to elevate publicity to the degree of fine art. This shift has had extraordinary consequences in art history and has torn down the boundaries between established art - painting, drawing, sculpure – and the new art represented by posters, logos, and other forms of visual culture. In this chapter we also underscore the profound changes brought to architecture by Victor Horta, the Belgian architect who used metal structures with visible riveted connections and visible metal railings and columns in his work – *Hôtel Tassel (1892), La maison du Peuple (1896-1899), L'Innovation* department store (1901) in Brussels, the *Grand Bazaar* (1903) in Frankfurt -, Antoni Gaudí's works in Barcelona – *La Sagrada Familia, Park Güell, Batlló House, Milà House, the church-crypt in Santa Coloma de Cervelló,* and others-, French architect Hector Guimard's *Metro entrances in Paris, Humbert de Romans* Concert Hall (1902), and Frantz Jourdain's *La Samaritaine* department store, which he built in collaboration with Henri Sauvage in 1905.

Art 1900 has left an indelible mark on object design belonging to the following movements: *Jugendstil, Modern Style,* and *Secession;* all these styles were a novel approach to objects and their shapes. *Art 1900* was the first to adopt a stylistically-cohesive style in organising the surrounding environment in a new and original view in all artistic fields: fashion, graphic art, painting, theatre, ballet, cinema, architecture. The masters of *Art 1900* did not reject the idea of working alongside machines, even if most pieces were handcrafted or partly handcrafted; quite on the contrary, they even sought an efficient collaboration between art and machine, so they put forward standardised models and obtained noteworthy results with furniture, cutlery, ceramic tableware, metal dishes and clothes.

As for furniture design, Charles Rennie Mackintosh's work stands out, as part of another art movement that came before the Vienna Secession. The ratio between the parts that make up the famous high-backed chair combines the improvised air of the Gothic with the machine-generated straight lines. Certainly, Mackintosh is not solely known for his high-backed chair, but also for his interior design, where he used light in a trailblazing way, introducing light wells where windows would have been impossible to integrate (see the famous Hill House).

The Chicago School is a benchmark in the field due to the work of its founders as well as that of their disciples. One of the most famous representatives of this school was Frank Lloyd Wright, who is deemed to be the father of modern American architecture and an advocate of functionalist art. Metal frames for both inside and outside walls were first used around 1888, when the *Leiter II Building* department store was built, and helped generate large windowpanes later called *Chicago windows.* The Chicago School also influenced well-known European architects such as the Dutch architect H.P. Berlage and the Austrian architect Adolf Loos, who was a dyed-in-the-wool functionalist of the early 20th century. Other architects who shared functionalist views were Otto Wagner of the Academy of Fine Arts in Vienna, and Louis H. Sullivan, who famously coined the principle of the functionalist movement: *form follows function.*

The Weimar School, commonly known as *Bauhaus,* was set up in 1919 by architect Walter Gropius, who would become the theoritician of the movement. It played a crucial role in the development of design and architecture, particularly due to the pedagogical system it put in place, still referred to today, revolving around the phrase: *Art and technology, a new unity.* The contribution of the Bauhaus was paramount to the world history of culture and art from a twofold perspective. On the one hand, it contributed to the general process of interpreting all forms of visual expression – architecture, painting, typography, dance, and industrial design - in a new and modern art synthesis. On the other hand, its experimenting in pedagogy revolutionised art education, which was still in its mimetic and academic phase at the time. Its fundamental tenets, phrased by Walter Gropius, were aimed at creating a perfect unity, an organic symbiosis "*between Life, Industry, Architecture, Industrial Design and the Fine Arts*" or, more generally, between all visual arts. This school was the first to create a complete and cohesive system for teaching design, and its curriculum and students changed the way people perceived design in the 20th century.

This movement supported functionalism and wanted to educate a small "creative elite" whose tastes would be later imposed upon as many people as possible through industrialisation and mass production. The aim was to *attain aesthetic perfection through functionalist solutions.* The wish to come by a highly complex, ideal product, led to the development of a philosophy bringing together aesthetics and ergonomics within the mass production framework. In 1933, when the school closed, its members emigrated and exported the philosophy to the United States of America. Their influence reached Harvard and the *New Bauhaus* in Chicago.

Car aesthetics saw its heyday in the 1920s, when it benefited from the technologies that sprang up after World War I. *The car age* was a time when cars were considered "*the icons of a new religion*". Concerning car design and its trends, Henry Ford literally set America's wheels in motion by producing millions of the Ford "T" model over a period of 18 years. In 1927, when Ford was already struggling to avoid collapse, General Motors set up the first design section in a car factory. The section was called *Art and color,* and was led by Harley Earl, an already famous designer who heralded a new era in how cars were designed. General Motors would use the *line* as an important element of car design. Earl was the one to add features of luxury cars to line-assembled cars, drawing on the concept of aerodynamics. The 1930s thus saw emerge a new trend that would percolate all fields of design, namely *streamlining* – cars were now made to produce less air resistance. Paul Jaray, who implemented this style founded the *Jaray Streamline Corporation.* Streamlining went on influencing car manufacturing and even evinced an image of the society of the future. Its success was mainly due to a need for speed and efficiency.

Chapter 6. Design and the new materials points to the connections between the chemical industry that was producing new materials – polymers, plastics, rubber, polyethylene, plexiglass, polystyrene, PVC, nylon, acrylic glass, artificial leather, melamine, xantal, linonelum, ABS, etc. – and the development of new industrial and artistic design models. World War II provided considerable impetus to technological innovation, particularly concerning materials. Nowadays we call newly-produced materials *advanced materials* or *smart materials.* Since they first came out, they have changed the language we use when we talk about art. Besides, we cannot possibly ignore the impact photography, digital photography and digitisation have had on the fine arts. The decorative arts, themselves, have also embraced the use of new materials and have generated shapes, structures and elements that would have been impossible to obtain from traditional materials.

Chapter 7. From the first industrial revolution to the last deals with the innovations brought about by the four so-called "industrial revolutions" – the first in Great Britain, at the turn of the 19th century, which gave us the *steam engine.* The second revolution started at the end of the 19th century with the discovery of electric power and all the ensuing innovations, such as the electric engine, the electric railway, the telephone, the telegraph, and electric lighting. The third revolution was sparked in 1968, when Schneider Electric Modicon in the US invented the first intelligent machine, *the programmable logic controller;* it meant massive progress for the operating autonomy of machines, especially in industrial production – due to its capacity to self-regulate. The more recent fourth industrial revolution revolves around the advent of internet, of cyber-physical systems connected to the internet and used in production, of anisotropic devices for the home capable of: operating and being operated in the Cloud, of interconnecting and of acting as a whole, something we now call IoT – *the internet of things*.

Chapter 8. Design and the new LED technologies approaches the activity of a designer from a personal perspective and dwells on working with light fittings and lighting installations (dealt with at length in the Appendix). Light fittings are standalone objects, so they need to be highly effective as far as structure and shape are concerned. We have pointed to the fact that the changes brought about by technology have made light fittings ever more amorphous, while light itself has become pure artistic expression. Light fittings oscillate between impression and expression, they are like yin and yang and "move" inwardly; during the day they are ornamental, whereas at night, when lit up, they become expressive. The various types of light – their shape, intensity, and colour temperature – can join together interiors and the objects they host. One might even say they form types of existential syntaxes where *objects, light and people* coexist in a complex reality dominated by the "authority" of light. It is obvious that the design of light has become an essential part of our modern lifestyle in private as well as in public spaces.

4. Conclusions:

We have posited in our paper that the relationship between *function* and *form* - something modern design tackles systematically – can be found all throughout the material civilisation, from the most rudimentary prehistoric tools to the cutting-edge devices and machines we use today. We have also postulated the idea that the first form of *practical rationality,* which is specific to what anthropology calls *homo faber,* lies in mankind's relationship with tools. It is paramount that we comprehend and admit that technicism and the engineer's pragmatism that took off in the modern period are rooted in primitive, *practical rationality.*

Modern art is deeply influenced in its subject-matter, language, and style by scientific and technological discoveries, just as it is shaped by the ideological convulsions of the times. However, its core purpose stays the same: to depict the condition of humankind and the uniqueness of the human being as a creator of value. Seen as a ubiquitous kind of art in contemporary society, design deals with artistic values. Therefore, besides the practical aspect of the objects/fields it applies to – appliances, machines, devices, home interiors -, it also supports their everyday aesthetic function. This is the reason why we believe that *the great merit of design rests with its role as aesthetic mediator in a utilitarian and pragmatic world.*

Midway between pure technology and pure art, *design is equally involved in both fields; it helps art be present in technology via aesthetic features, but it also helps technology be present in the evolution of art via more refined and honed means of artistic expression.* Without design, technology would probably still remain efficient, but inexpressive and unaesthetic at the same time, which would negatively impact comfort in practical, everyday life. However, once added to the technical capabilities of devices we use on a daily basis, *design contributes to the higher attainment of aesthetic requirements in daily practice.* We do like to use good and efficient tools, but we also like these tools to be beautiful.

In the conclusion of this paper we mention that the greater today's technological resourcefulness, the greater the need for design, and that is because *any new technology needs to have the appropriate aesthetic shapes in order for it to be warmly received.* Besides utility, this is the other important aspect that may determine the *commercial success* of a product. We cannot ignore the fact that te world we are living in has become an immense marketplace and that the *production-consumption* tandem defines the way we behave. The utopia of endless industrial production must be supported by an endless consumption mindset. Art and beauty have been commodified in their turn, due to an endless capacity of industrial reproduction, whereas industrial design allows for the possibility to reproduce "beautiful objects". What has been lost is the uniqueness of a beautiful piece, which is something typical of the traditional art and artisanal handicraft that came before the "age of mechanical reproduction", in Walter Benjamin's words.

The starkest differences between “unique” and “serial” can be easily illustrated using the parallel between painting and photography: each painting is unique, while photographs can be reproduced infinitely in identical form and with identical characteristics. This difference is paradigmatic for our world, as it reveals the major differences between art and design.

Design has now become a tool to teach aesthetics at a social level, as it has percolated most aspects of practical life – appliances, devices, installations, or generally useful objects –, and due to the principles it promotes and applies. Thus, it fashions models and models fashion, and one way or another, has a say in shaping people’s tastes.