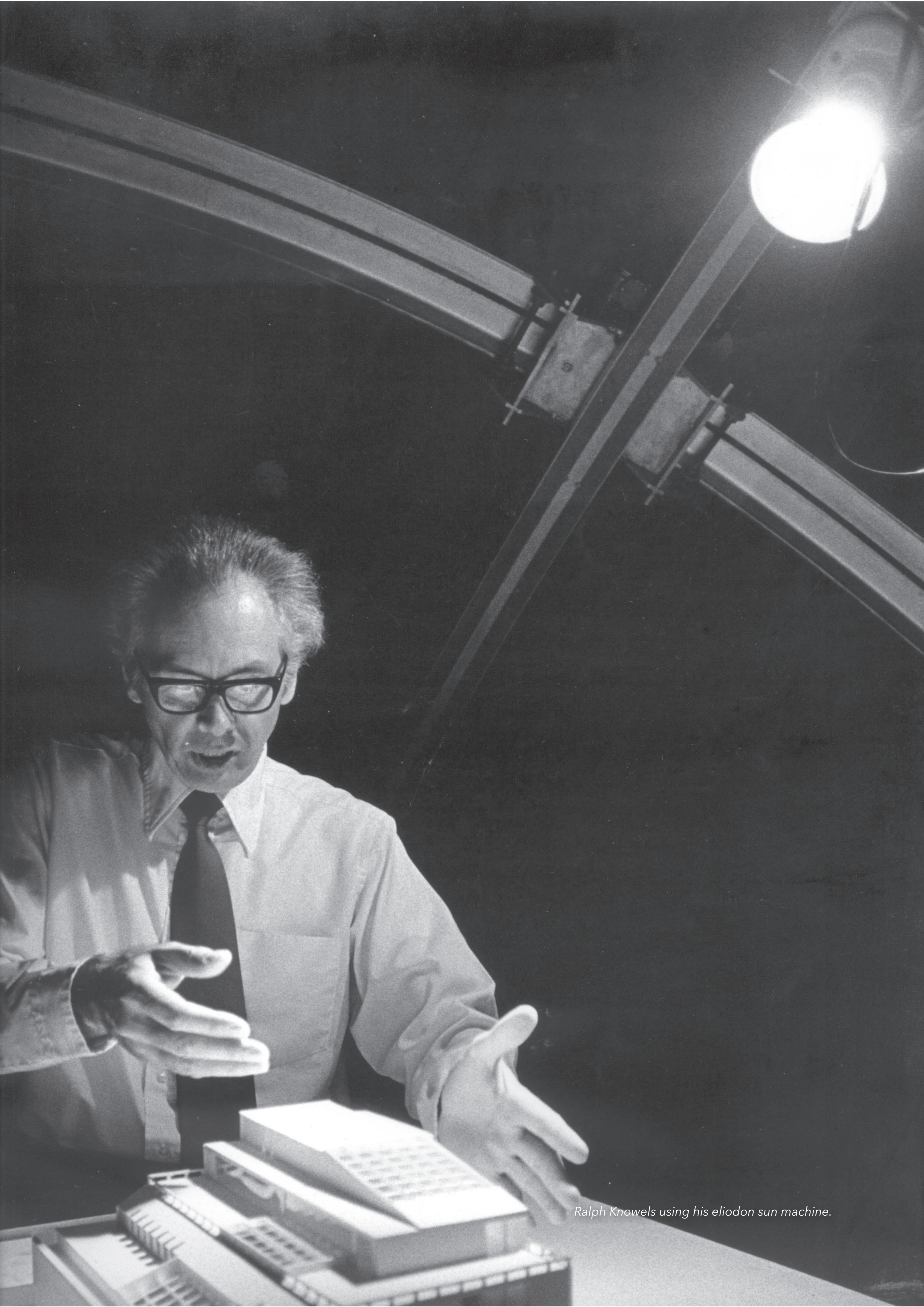

Ralph Knowels using his eliodon sun machine.

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The right to the sun in the urban design

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ABSTRACT

All the initiatives aimed at removing obstacles to the widespread use of renewable energy sources have costs for the Community. May they be economic, such as grants, reductions on taxation, discounts on concession or town planning charges, as prizes of cubic capacity building. But even in the case of mandatory standards the question of "solar rights" of existing buildings and open spaces during a given period of the year. Remains a crucial issuel in fact, among the various design strategies aimed at energy efficiency standards required, pursuit of those who use solar energy are determined. In the face of such costs created by the public authorities and the legal constraints, the current legislation does not guarantee the solar right in the urban planning. It is absurd to legislate and use collective resources to encourage or even force the adoption of strategies that are based on the solar energy and plan the city with rules that deny access to neighboring lots.

KEYWORDS

solar access, energy efficiency, urban morphology, solar envelope

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1. INTRODUCTION

The statement that the access to the sun is based on "rights" against the town planning, currently has gained credibility without a research on the implications on the design and the the city growth. Saying that to safeguard access to the sun could destroy the city, because it does not allow the erection of a tall building by allowing only low buildings, introduces a topic of obstacle to the achievement of a satisfactory degree of sustainability in the urban structure (Lepore, 2004). Access to the sun, when obtained using the solar envelope technique - introduced for the first time from Knowles (Knowles, 1981) - does not imply the waiving of the tall buildings and even affects the suburban density. The consideration of the "solar right" in the urban project is crucial to allow the passive heating of buildings in winter and improve comfort conditions of people in the streets and in open spaces. There is still a gray area where lines of urban design guidelines and building regulations overlap, especially at the city block level, where for the planning and building design, both regulations are ineffective. The morphology of the city block is shaped compared to traditional constraints as the terrain, distances, roads and economic aspects, all elements required, at this scale, greater account of energy efficiency. It is absurd, in summary, to legislate and use collective resources to encourage or even require the adoption of strategies that are based on the energy of the sun and plan the city with rules that deny access to the neighboring lots. Below we see how this problem was indicated as a priority from the very ancient times, and then amazingly was forgotten. If access to the sun is a fundamental right, then how can people at the same time enjoy the sun? In an equitable society, freedom of an individual ends where it impedes on the freedom of others. In the case of access to solar energy it involves bordering; the actions of which - the placement of the house, the outbuildings and the vegetation, their size and height - will determine the measure of its ability to take advantage of the sunlight. Similarly, these actions will determine the possibilities of its neighboring access. These two perspectives are not only different ethical foundations but also different legal conditions and design.

2. SOME HISTORY

The Hanging Gardens of Babylon were built on a series of elevated terraces and irrigated by the Euphrates with a pump system. These gardens can be considered as one of the first and spectacular examples of solar architecture.

Even the ancient Greeks believed in the importance of the role of the sun's heat to human health. Modern excavations in many Greek classical cities show that solar architecture flourished throughout that area. Individual houses were oriented toward the southern horizon, and all the cities were planned to enable their citizens equal access to the winter sun.Olinto, in Greece, had a reticular plant with north-south/east-west axes in which the houses were divided into insulae, a type of condominiums (Fig 1). Each house was designed to have a south facing facade and an inner courtyard.

In Macedonia, the sun city of Priene, one of the most important ports of the Ionian Federation, had already in the IV century A.C. a geometric urban plan, introduced by Hippodamus of Miletus (Fig. 2).

In Egypt, El-Lahun was built to house workers and slaves who worked on the construction of a nearby pyramid; and had a checkerboard layout consists of about 300 houses of four to five rooms, twenty houses for the supervisors and a dozen palaces for officials (Fig. 3).

Mohenjo-Daro, in the Indus Valley, is the oldest example (2500 B.C.). It was characterized by a grid plan with streets oriented exactly according to the north-south and east-west, and with waste collection systems already very advanced. The straight, wide streets, along the main axes of the city were therefore not intended for the current assets, which instead were held in narrow and winding lanes to better defend themselves from sun or wind (Butera, 2004).

The Greeks knew that in winter the sun, with its apparent path, trace a lower arc across the sky to the south, while in summer, passes above the head, built their homes so that sunlight in winter could easily get into the house through a portico facing south similar to a covered veranda. There was no glass between the portico under the open sky and the entrances to the rooms inside the house, as the Greeks had neither the

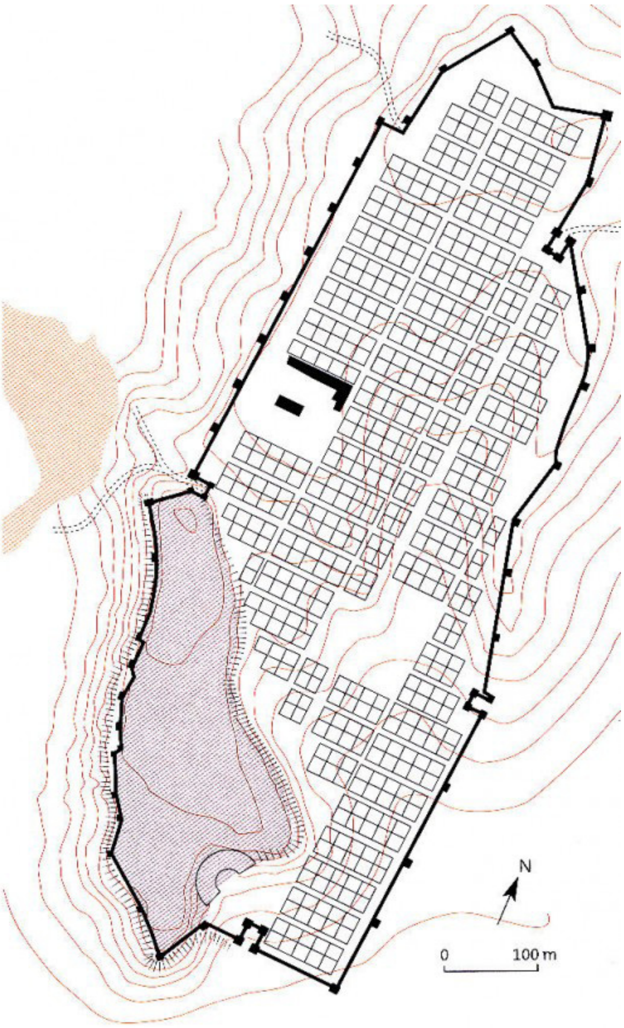

Figure 1.

A reticular plant of Olinto, Greece.

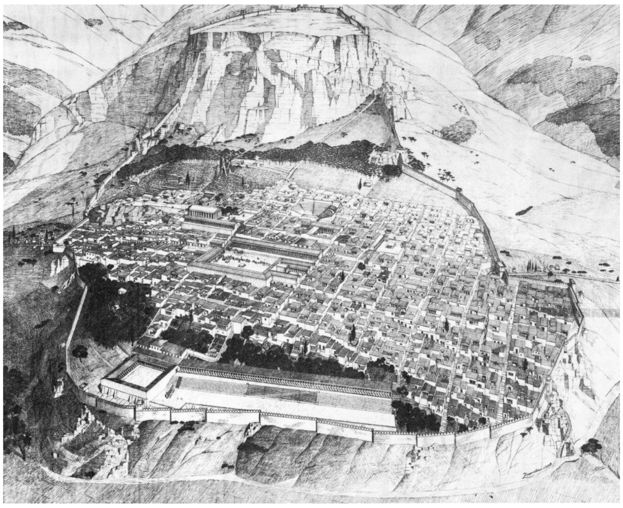

Figure 2.

Ancient solar city of Priene.

Figure 3.

El-Lahun in Egypt.

clear glass or other transparent materials for doors or windows. Not only that, the main rooms of the house, were warmed by the sun's rays penetrating through the porch, but they were sheltered from the north to keep out the cold winds, as Aristotle noted. During the summer, overhanging eaves or roofs shaded rooms of the house from the sun high during most of the day. These simple design principles have formed the solar architecture based on ancient Greece (Fig. 4).

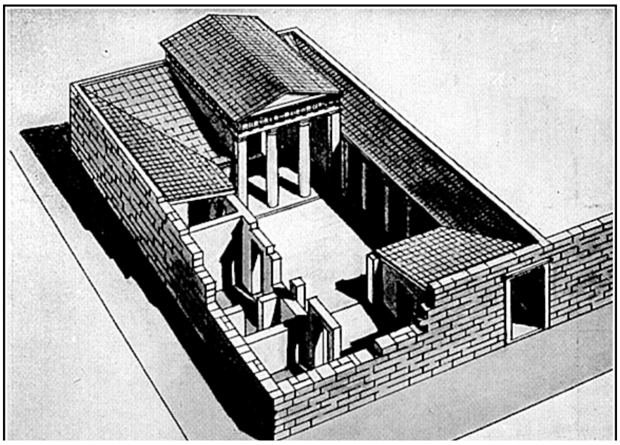

Figure 4.

Classical Greek home in Priene.

In Rome, in De Architecture, Vitruvius already in 27-23 B.C., described the need to ensure the sun and air to buildings:"...[Nunc explicabimus, quibus proprietatibus genera aedificiorum ad usum cacli regiones apte debeant spectare]... *(I will now explain what features should have individual environments with respect to their functionality and how it should be oriented).* In the first book, Chapter IV and VI, the urban scale and in the sixth book, Chap and IV, to the building scale (Fig. 5).

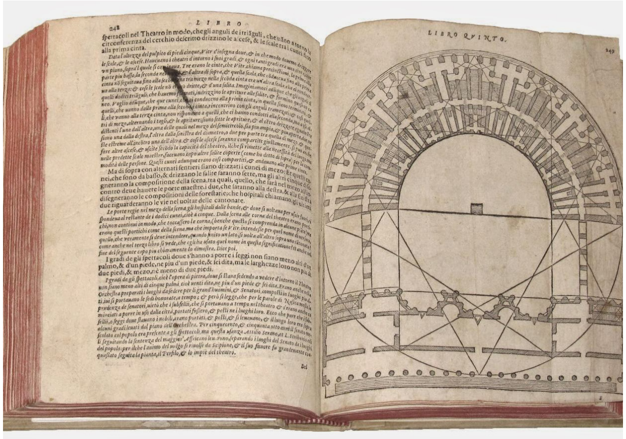

Figure 5.

Vitruvio, De Architectura.

Indeed, it should be noted, in imperial Rome, the attention given to the location and orientation of the buildings: a rule completely ignored since the mid-twentieth century, with the obvious consequences from the energy point of view. Vitruvius gives guidance on how to build a Roman patrician: *"Now we will discuss the qualities that should have all sorts of sites buildings for use both again because they are facing to the right aspect of the sky. Triclinia, therefore, in winter and bathrooms relate to the west. This is because you have to light the night, and beyond that the sun goes down, right opposite sends its rays, and with its heat makes it warm appearance on the evening ... ".*

Where possible, the Roman military settlement (*castrum*) - that most of the times it was the initial nucleus of the new city - was designed according to the principles of Vitruvius (Fig. 6). The typical layout of a new city was based on roads going from north to south crossed in a regular manner from the other perpendicular (*decumani*). This type of latticework, with axes oriented so as to allow the houses to have a facade facing south, was common throughout the Hellenistic age; not only presented the advantage of being able to more easily control the drainage of rainwater and to realize the waste collection systems with special ducts which in many cases were covered, but also to obtain

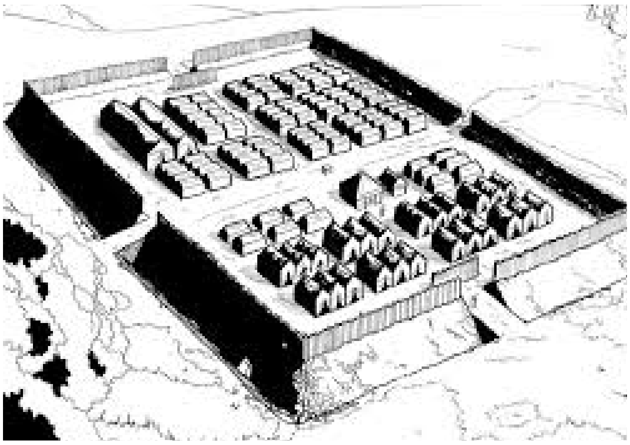

Figure 6.

Roman military settlement, Castrum.

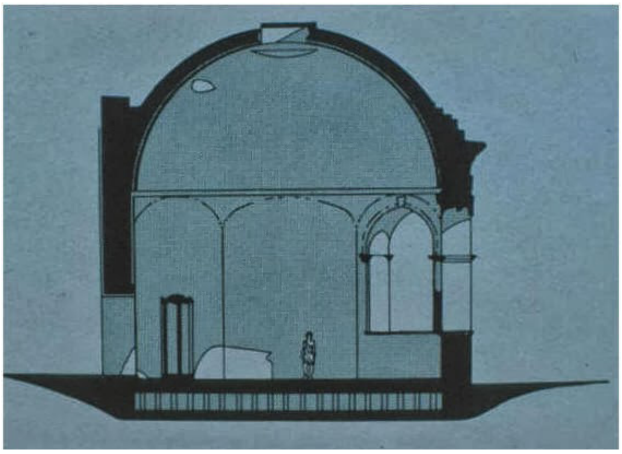

Figure 8.

Cross-section of Roman heliocaminus in the public baths at Ostia. In winter, the large, windows admitted plentiful sunlight.

Figure 7.

Ruins of heliocaminus in Villa Adriana at Tivoli.

a better *salubritas* in homes, in winter and in summer, thanks to the exposure of the façade.

From the days of Augustus in the first century A.C. until the fall of Rome, the use of solar energy to heat the houses, baths and greenhouses was apparently quite widespread throughout the Empire. The heliocaminus or room "solar furnace" was quite common caused disputes over the rights to the sun. In fact, with the increase of the population, buildings and other elements began to create shadows on some heliocamini, inducing their owners to resort to the Roman courts (Fig. 7,8). Ulpian, a judge of the second century A.C. declared itself in favor of the owners, declaring that the right to the sun of a heliocaminus could not be violated. His judgment was incorporated into the great Justinian Code of Law four centuries later: "If any object is arranged so as to take away the sunlight from a heliocaminus, it must be stated that this object creates a shadow in a place where the sun is an absolute necessity. Then it is violation of the right to the sun of the heliocaminus". This opinion, inserted in the Code of Justinian in the VI century, indicates with certainty that the construction of solar buildings continued until that date (Butti, Perlin ,1980).

3. SOLAR ACCESS IN THE NINETEENTH CENTURY

When the solar access in the cities, has regained the attention throughout the western world during the urbanization of the XIX and the beginning of the twentieth century, health was the one and only reason. The industrial revolution had brought cheap energy, but also many diseases. Millions of people died in overcrowded buildings facing on narrow roads and badly illuminated. Most of the medical experts were convinced that these diseases were caused by the lack of fresh air and sun. However you need to get to the end of the XIX century before this theory is generally accepted. In order to ensure solar access and fresh air, many cities in Europe and in the United States issued a series of building regulations between 1850 and 1930 (Fig. 9). Most of the rules were related to the size in height and in width of the streets. A Boston architect William Atkinson, saw the limitations of these rules, and emphasized that the shape of the building was just as important. In 1912 he published "The orientation of buildings, or planning for sunlight", where he writes: *"The process of limiting the height of the* (Fig. 10) *buildings with a horizontal plane, at a fixed height, or a height proportional to the width of the road, is of simple application, but it is not scientific, because it assumes that the correct height for the front wall or facade is also the correct one for the rear part of the building... Whereas the fact that the rear parts could have a greater height in proportion to their different distance from the road. The building height should be determined by a sloping line drawn from opposite sides of the road with a certain angle."*

William Atkinson was the first architect who produced the ideas for the creation of spaces with sunlight. After his architecture studies on hospitals, he mentioned the solar orientation and the sunlight for hygienic reasons. Hygiene is a key concept in bioclimatic design, referring to the germicidal properties of daylight, that embodies the concept that tuberculosis can be alleviated by exposure to sunlight (Lima, 1998).

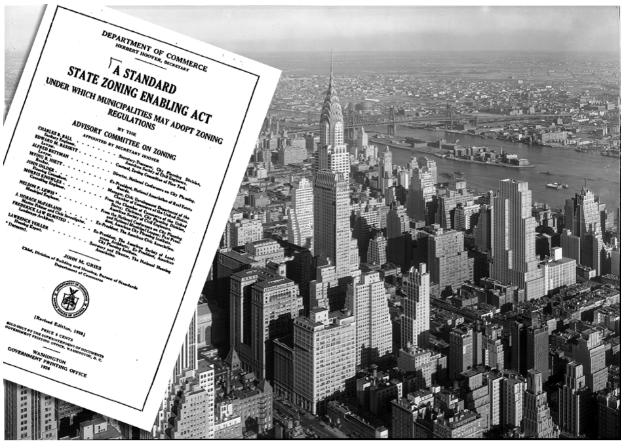
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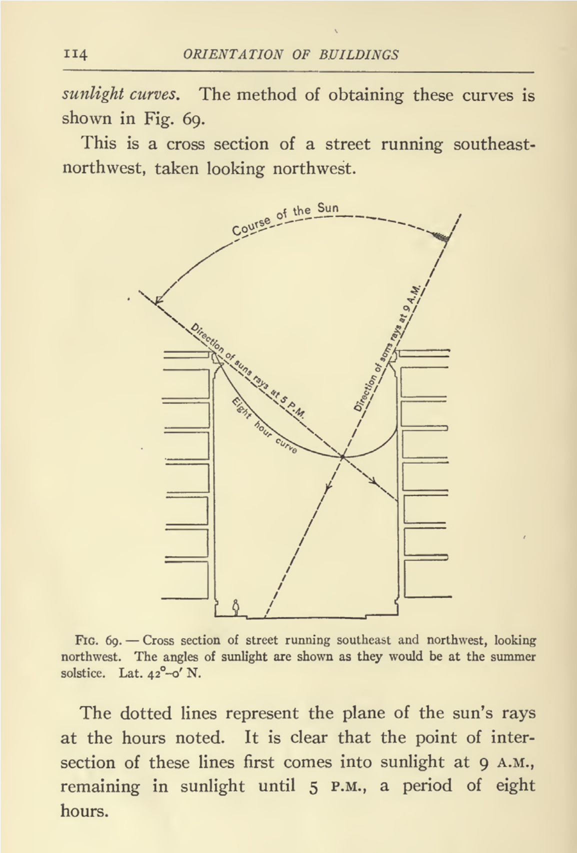
Figure 9.

1932, Manhattan shows the effect of the Standard Zoning Enabling Act of 1916

The efforts of Atkinson led, in 1904, for the first time the rules limiting the height of the buildings for the access to sunlight. He built an experimental facility of sun house in 1912 for Samuel Cabot - an aristocrat of Boston - to determine more precisely the sun warming potential (Butti, Perlin, 1980).

According to Watson in the same years F.L. Wright and his predecessor Richardson considered the climate, the breezes, the sun and the orientation as an integral part of their architecture, even if Wright does not explicitly stated in his first writings, as face much later, in 1930 when the principles of passive solar design spread further. Watson gives credit to Tony Garnier because of climate awareness of its projects and for the "rule of 45 degrees" (Simoes, 1998). As is typically seen in the early Modernist, their sensitivity to the role of climatic factors was more for the hygiene rather than for heating. The "rule of 45 degrees" places the southern facade of the building at a distance equal to the nearest building height on the south side and mentioned in Cite Industrielle but due to a poor adaptability to different heights not led to a great result (Watson, 1998).

Atkinson was inspired by building laws of Paris of 1902 (an adaptation of the original building code of Haussmann) which not only contained information



114 ORIENTATION OF BUILDINGS

sunlight curves. The method of obtaining these curves is shown in Fig. 69.

This is a cross section of a street running southeast-northwest, taken looking northwest.

FIG. 69. — Cross section of street running southeast and northwest, looking northwest. The angles of sunlight are shown as they would be at the summer solstice. Lat. 42°-0' N.

The dotted lines represent the plane of the sun's rays at the hours noted. It is clear that the point of intersection of these lines first comes into sunlight at 9 A.M., remaining in sunlight until 5 P.M., a period of eight hours.

Figure 10.

Original illustration from the book "The Orientation of Buildings or Planning for Sunlight" by William Atkinson 1912.

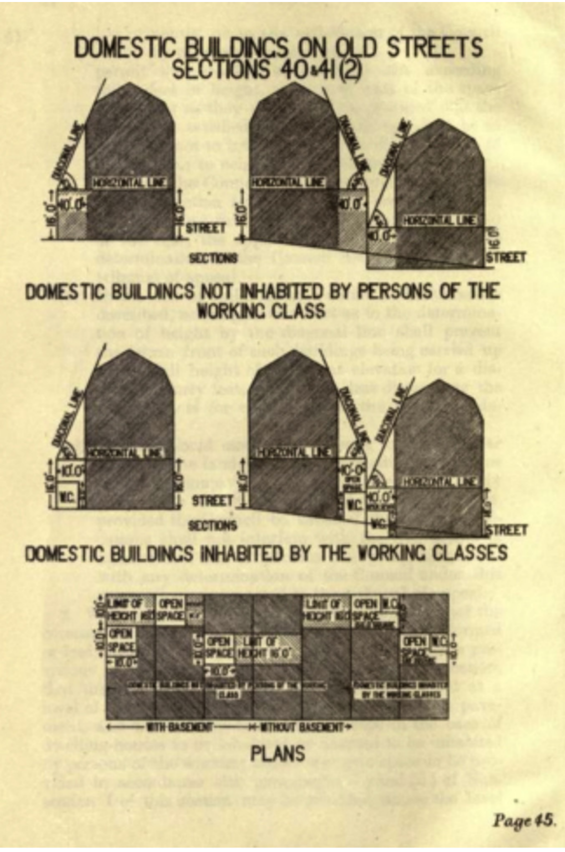


Figure 11.

London Building Act of 1984.

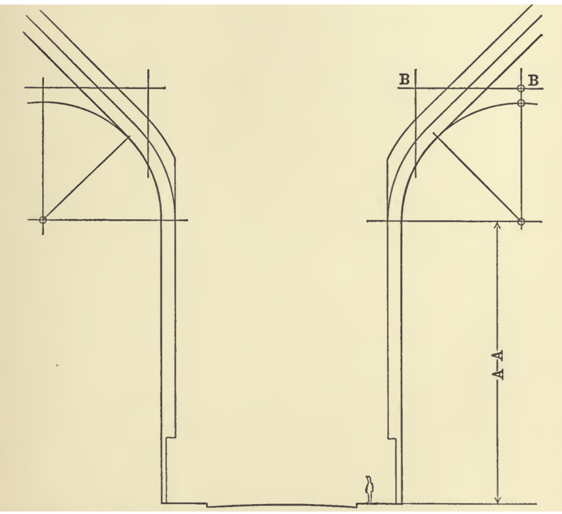
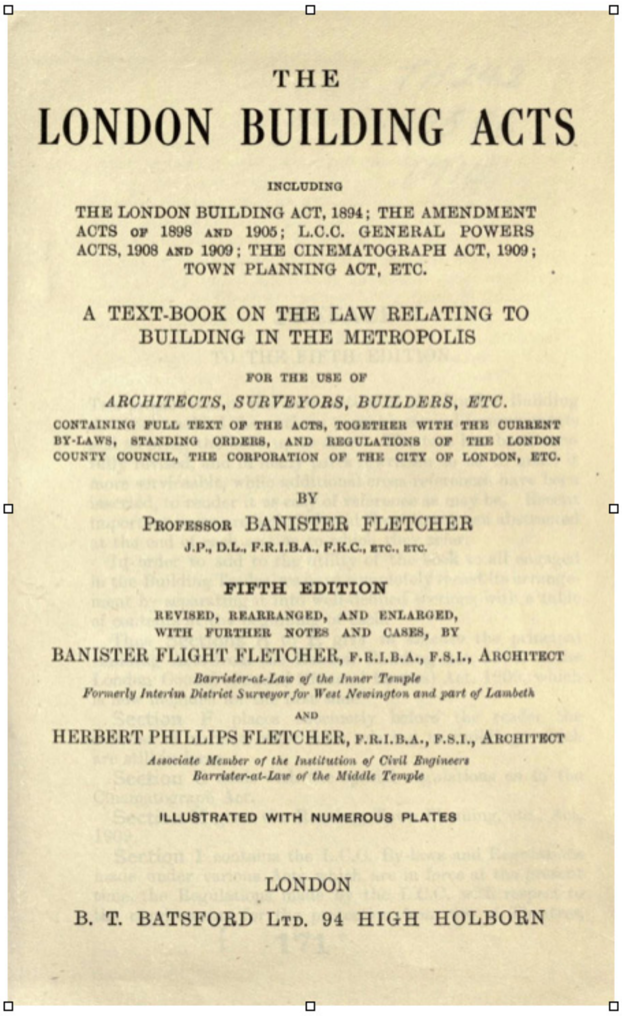


Figure 12.

Atkinson was inspired by building laws of Paris of 1902 (an adaptation of the original building code of Haussmann) which not only contained information and rules on the width of the streets and the height of the buildings, but which also introduced rules on the shape of the buildings themselves.



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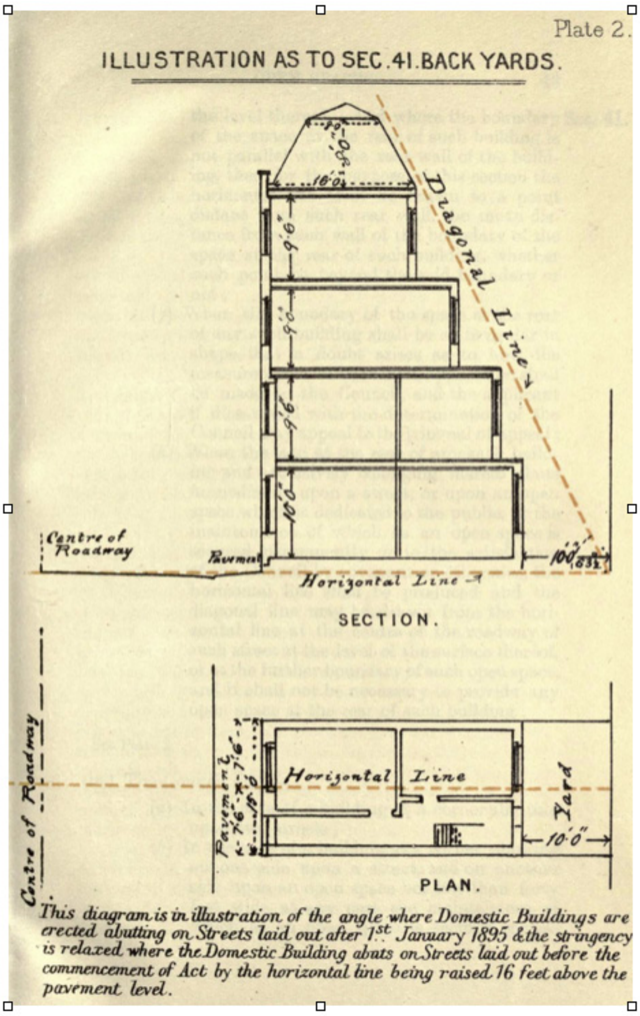

Plate 2.

ILLUSTRATION AS TO SEC.41.BACK YARDS.

This diagram is in illustration of the angle where Domestic Buildings are erected abutting on Streets laid out after 1st January 1895 & the stringency is relaxed where the Domestic Building abuts on Streets laid out before the commencement of Act by the horizontal line being raised 16 feet above the pavement level.

Figure 13.

London Building Act of 1984 prescribing sloping roofs instead of curved ones.

and rules on the width of the streets and the height of the buildings, but which also introduced rules on top of the shape of the building (Fig. 12). The illustration (fig.10, taken from the book by Atkinson) shows that the facade of a building in Paris (the vertical cross-section A-A) could not be greater than 20 meters, while the attic above (of which the height was also determined by the width of the road, could not exceed 10 meters) are made curved. This allows sunlight to penetrate the lower parts of the building across the street, while maximizing the building density. London had similar rules since the London Building Act of 1894 (Fletcher, 1914), while prescribing sloping roofs instead of curved ones (Fig. 11, 13). The skyscrapers in terraces which appeared in the United States, derived from the Zoning Standards Enabling Act of 1916, which regulated the shape of the building, while the height of the buildings were unfavorable to the access to the sun.

Optimistic about the potential of solar heating, Atkinson published his book. But history does not confirmed his optimism. Only a few American architects took advantage of his theories about the solar orientation role for winter heating. These Atkinson ideas were soon forgotten. For two decades after the publication of the book by Atkinson, in the United States, solar architecture laid dormant. But progress in Europe in the course of the years after the war, helped to inspire a new wave of interest. Some European Reports on the correct orientation of the buildings began to appear in the English language, see the study by the Royal Institute of British Architects in 1931-32. The Institute also develope a simple device called helidon which was used to determine the effects of the sun on a building while it was still at the design stage (Fig. 14).

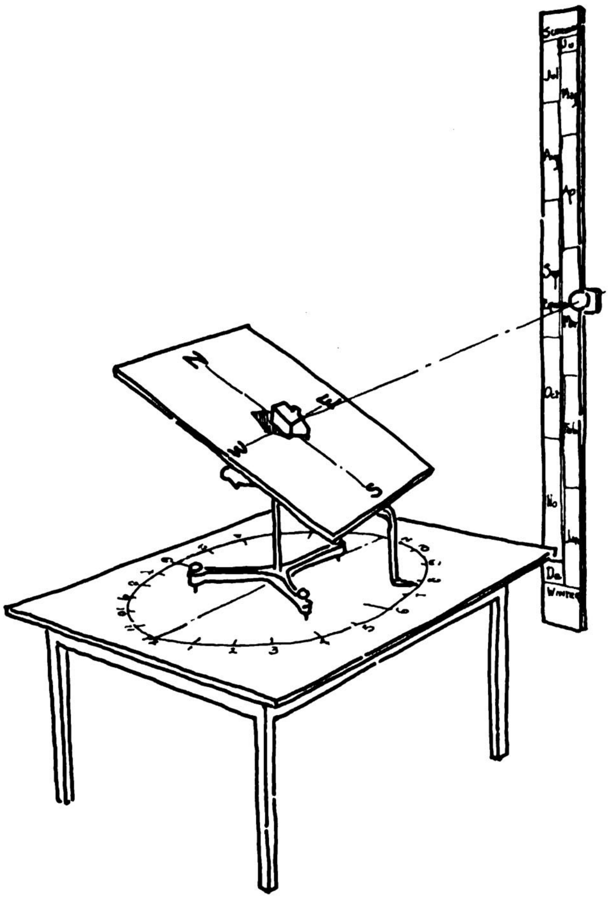

Figure 14.

1931, Royal Institute of British Architects, the Dufton-Beckett Heliodon, the first machine build for architectural analysis.

4. THE BARCELONA EXAMPLE

The most interesting example of planning a solar city of XIX century is the Barcelona "Eixample" (in Catalan or "enlargement" in Castilian), designed by Ildefons Cerdà Sunyer (Fig. 14). Barcelona Eixample can be considered the largest existing solar district, occupies the central part of the city in a wide area of 7.45 km^2, the most populated district of the city and in the entire Spain. Moreover his story exemplifies the tension between solar access and development needs. Unlike the Baron George-Eugene Haussmann in Paris, Cerdà had no way to demolish Barcelona to adapt the city to the massive flow of immigration of the period. Medieval Barcelona was surrounded by a large plain open with just a couple of small villages in the periphery. In 1850, Cerdà planned an urban plan as a great "chessboard" that surrounded the center of the old town and annexed the peripheral cities. The neighborhood consisted of streets of 20 meters intersected by a few boulevards of 50 meters and large urban blocks 113 x 113 meters (De Decker, 2012). Cerdà saw the need that cities are made for people and thought especially of health problems, both physical and mental and social level of the citizens. The separation between the buildings and the need that they do not exceed

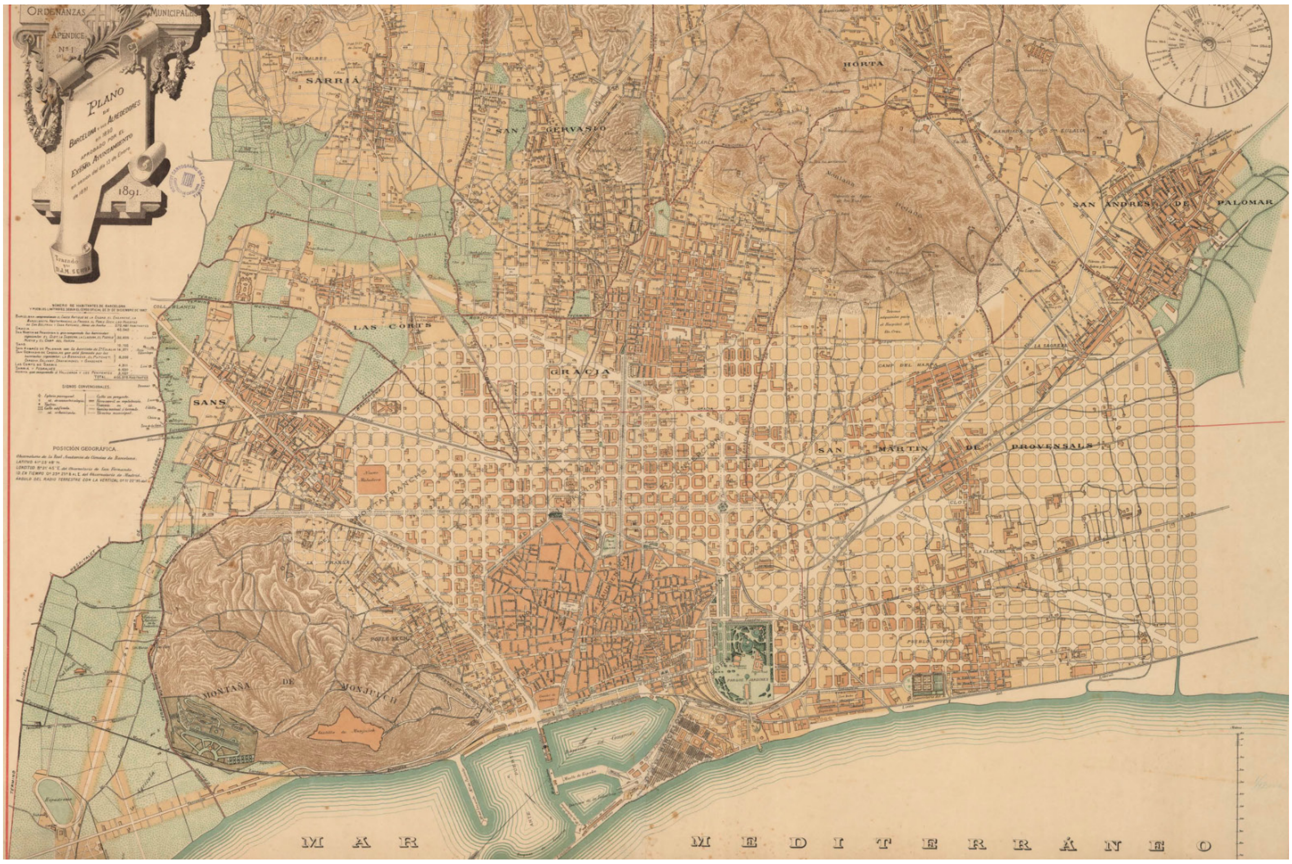

Figure 15.

Barcelona, plan of 1891 designed by Ildefons Cerdà i Sunyer.

the height of the width of the streets on which faced, justifying this with the need to get the sun in all streets without obstruction from buildings. He came to the conclusion that the roads should be 20 meters wide and that the buildings should not exceed 16 meters in height. The width of the buildings should not exceed 14 meters and the houses werehave a front and a back, this combined to the width of the roads would allow a good ventilation and the sun penetration in all homes, two issues considered vital for the health of the people. To amplify this effect he established that the city block had to be built on only two of the four sides, or parallel to each other or contiguous, allowing the creation of large interior spaces and the penetration of sunlight and fresh air at both sides of each building (Fig. 17).

All city blocks are 1.24 hectares and have the truncated corners (Fig. 19, 21). with a chamfer 15 m., by further improving solar access. Finally, he put the street grid diagonally at 45° with respect to the cardinal points. (Fig. 16)This gave all the apartments access to sunlight during the day, while shading all roads during the day. After one hundred and fifty years have survived only the truncated corners and the orientation of the streets. The plane Cerdà received a lot of criticism at the time, the main one was that he had lost too much building potential and and therefore money. Years later, they were built all four sides of each octagonal city block (Fig. 18). Even most of the interior spaces were occupied, albeit with low buildings in order to allow the sun to access the rear of the facades. It seemed that the speculative process would end with these changes to the project, but it was not so. If the roads were 20 meters wide, there would have been no problem if the buildings had been 20 meters high instead of 16, as being the sun at 45° would still illuminated all buildings, this argument joined to the construction of more low roofs made earning two stories high. Taking into

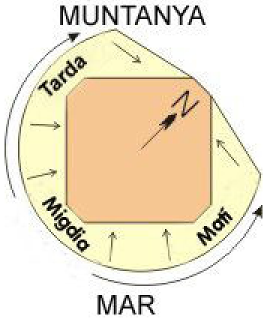

Figure 16.

Barcelona, a city block with the truncated corners.

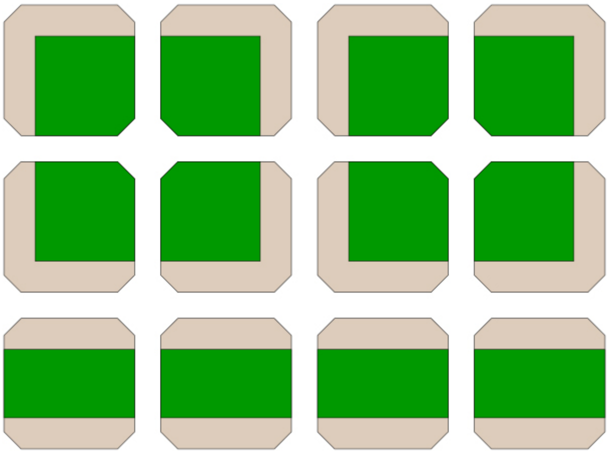

Figure 17.

Barcelona, the city blocks had to be built on only two of the four sides, or parallel to each other or contiguous.

Figure 18.

Barcelona, aerial view of urban grid.

account the same theory, if you built over the building an additional floor, but moved from the front as much as the higher the level, you would be able to increase the constructed space without the shadow cast on the other buildings. In this manner people began to also build a super-penthouse over attics (Fig. 20) . In this way, business owners seeking financial profits saw increased housing density without adversely affecting the solar access. The upper terraced buildings and the trunk of the corners of Barcelona, as well as the curved roofs in Paris and the sloping roofs in London can all be considered embryonic stages toward the "solar envelope" of Knowles.

Figure 19.

City blocks in Barcelona.

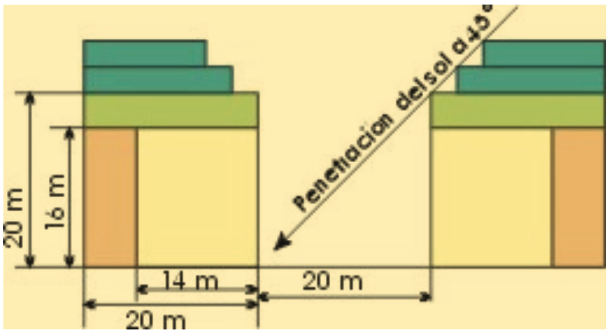

Figure 20.

Barcelona, the rule of 45°.

Figure 21.

Barcelona, truncated corners by improving solar access.

5. THE SOLAR ENVELOPE AND STREET ORIENTATION

The size and shape of a solar envelope are determined by the orientation of the streets (Fig. 23). In the United States the city layout is usually based on the orderly subdivision and the geometric shape of the territory. Typically, throughout the midwest and the west, the streets run in line with the cardinal points in such a way that the rectangular blocks extend in the direction north- south and east-west with the orientation of Jefferson grid (or US Land Ordinance, 1785)(Fig. 22). In the southern United States as well as in large parts of Latin America, we find a similar grid, with the difference that this is placed diagonally to the cardinal points, with streets oriented northeast-southwest and northwest-south-east. These grids were established according to the law of the Indies, a manual for the construction and management of colonial community, drawn up by the King of Spain in 1573.

In Europe, the existence of ancient buildings, resulting from centuries of growth without rules during the Middle Ages and the Renaissance, induced various urban planning experiments. Many European cities were modernised in the early twentieth century, from the construction of wide streets and avenues that cut the oldest parts of the city. Paris is one famous example. The solar envelope can be applied to all possible road

Figure 22.

Jefferson grid, 1875 US Land Ordinance.

layouts, even if chaotic, with different results.

In his book "The orientation of buildings, or Planning for Sunlight", William Atkinson devotes a chapter to the importance of the roads orientation for the solar planning. He argues that to provide an optimum degree of solar access in the city, the Jeffersonian Grid should be avoided. Instead, he shares Cerdà and the Spanish grid: "When the streets are arranged at right angles to each other according to the checkerboard plane, better distribution of sunlight is achieved when a series of streets is placed on the axis northeast- southwest and other northwest-south-east. It is regrettable that in many cases when the plan was adopted to "checkerboard", the streets were oriented north-south and east-west, which is the worst possible solution".

Atkinson agrees that *"if we were to base our judgment entirely on the amount of sunlight received through the windows, it should be concluded that the best location for a building both with its main axis situated to the east- west"*. However, he noted that there is a great disadvantage with this approach: it is a complete space in the "shadow" on the north side of the building during a half of the year (from autumn to spring), while in the case building diagonally oriented, all sides receive sunlight throughout the year. The same applies to the streets: *"With the streets oriented east-west the road surface does not receive sunlight during the six months of the year, and the buildings on the south side of the road are perpetual in shadow. Instead, when the streets are orientated diagonally on the cardinal points, the buildings shade the soil surface a lot less"*.

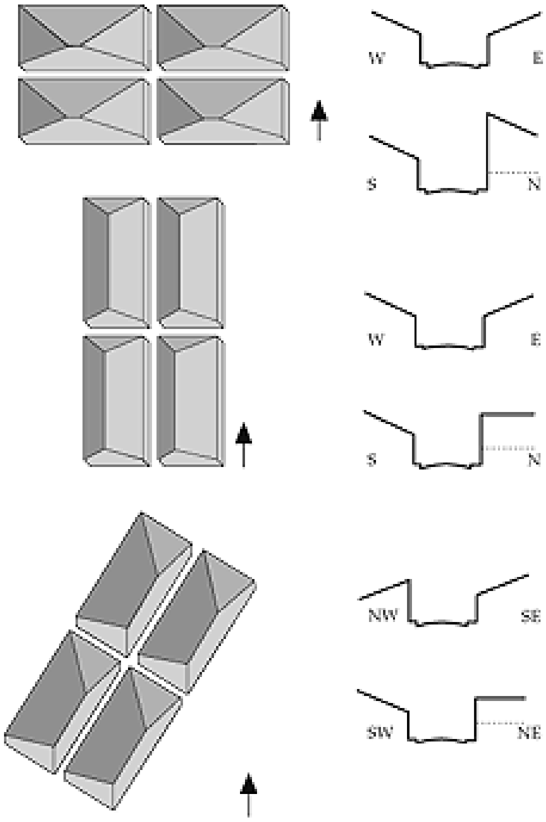

Figure 23.

Street orientation: effect on size and shape of solar envelope; solar envelopes over E-W blocks have the most volume and the highest ridge, generally located near the south boundary (top); N-S blocks produce less volume and a lower ridge running length-wise (middle); diagonal blocks produce the least volume and a ridge along the south-east boundary (bottom).

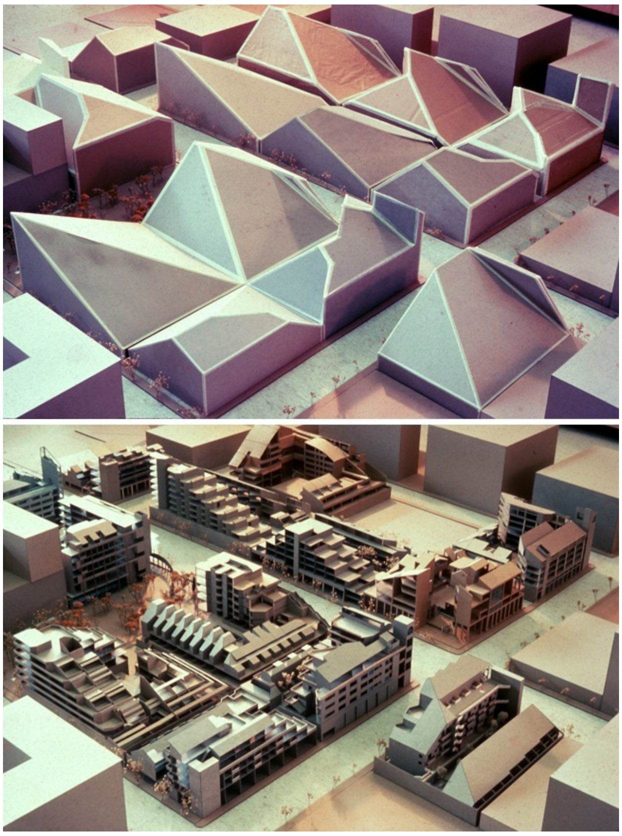

Figure 24.

Solar envelopes and housing. Ralph Knowels

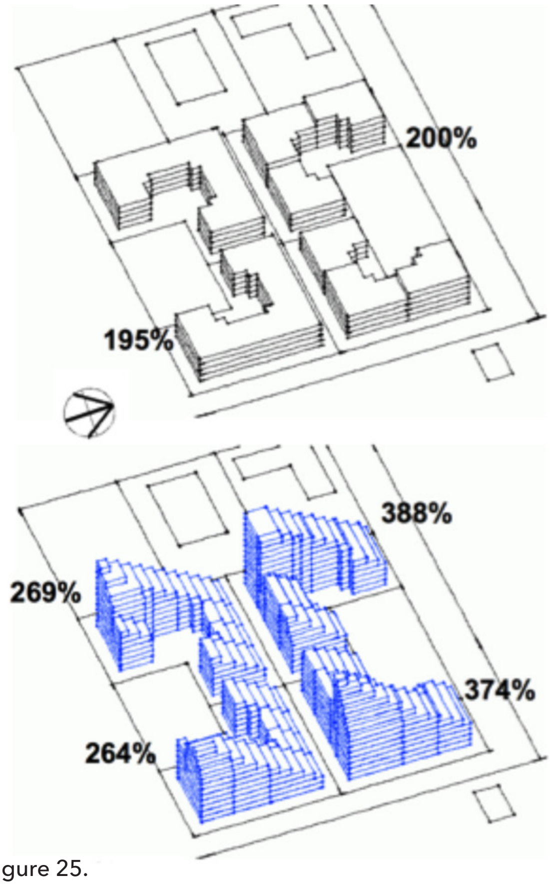

Figure 25.

Rates compared between keeping solar rights planning (down) and regular planning (up)

6. THE SOLAR ENVELOPE, TECHNIQUES OF URBAN DESIGN TO ENSURE ACCESS TO THE SUN

The solar envelope, conceived in the University of Southern California, is a kind of maximum volume whose shape is determined by the relative motion of the sun. The buildings designed within this volume, in the critical hours of the day, they will not shade on adjacent lots (Knowels, 2006). This "shell" is therefore defined both by the temporal dimension of the motion of the sun, both by the geometrical constraints arising from the shape of the lots and roads. With the solar envelope, Knowles improves the concepts applied until then, substantially in two ways. First, he applies the idea of the sloping line throughout the whole building, not just the roof or upper floors. Secondly, its sloping lines actually coincide with the sun's rays, which is not in previous studies (Fig. 26). Add to this that the previous building code produced monotonous architectural forms and road prospects, while the buildings designed with the solar envelope technique may be different depending on their specific location and boundary conditions (Fig. 24).

Knowles began his studies, which led him to formulate

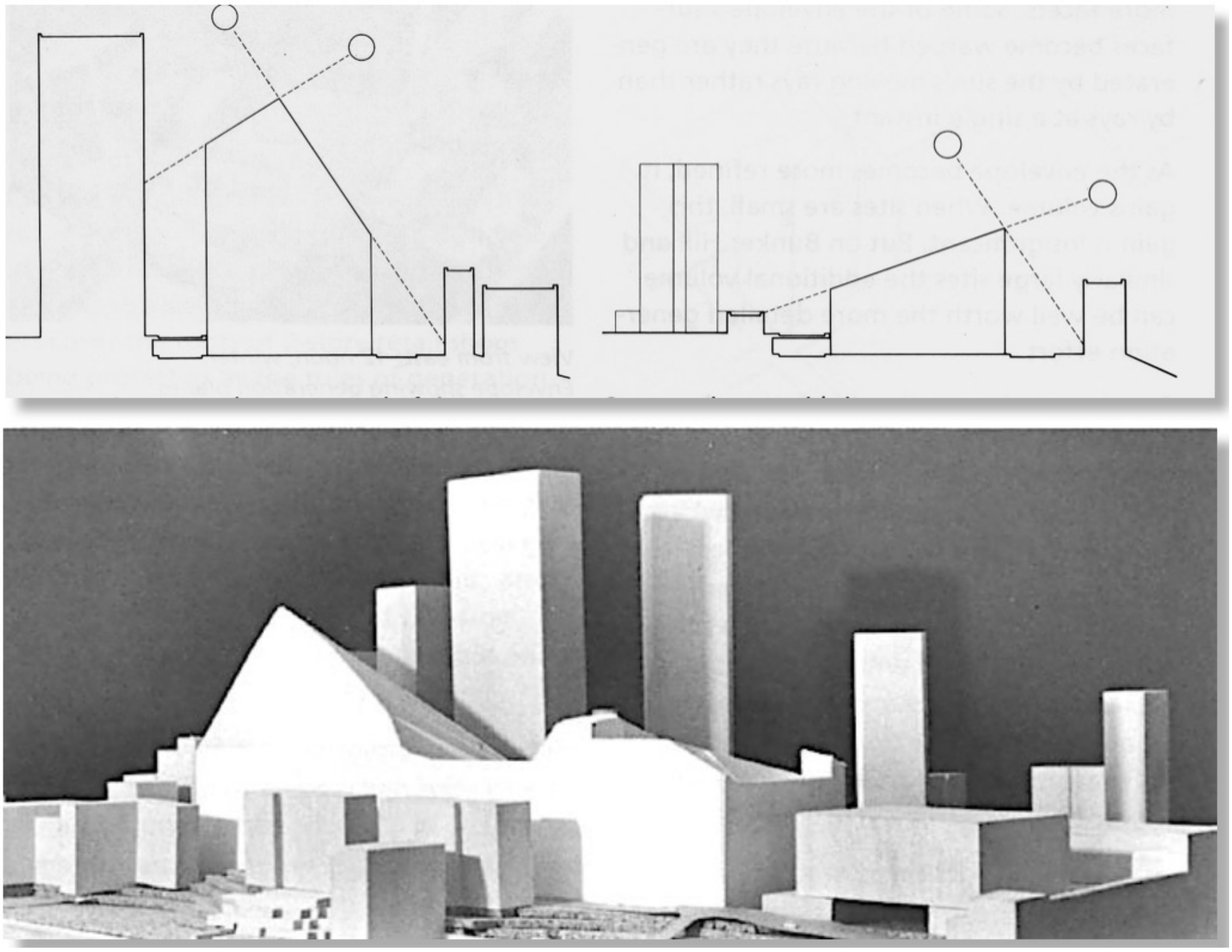

Figure 26.

The bunker Hill project: solar envelope generation the solar envelope by studying the natural forces that strike on buildings. The theme of the book entitled "Energy and Form: an ecological approach to urban growth", studied the conservation of energy through design. In this study he developed pyramidal shapes for particles that are parts of a site. The concept of the construction of these pyramidal shapes is based on the fact that the buildings made with this rule, should not overshadow on adjacent sites. That is, a maximum allowable volume without shadows extend beyond the batch during the critical hours of daily irradiation (Knowles, 1974). In his book "Sun, Rhythm, Form", he declared his vision of the solar design on the basis of the environmental impact on buildings. He conceives the action of construction as an adaptation to environmental conditions. For him this adaptation has three phases: choice of location, the definition of the form and the metabolic analysis (Knowles, 1981). The site selection indicates the environmental impacts which consist of several cyclical elements such as sun, wind and topography. The final configuration consists in a form having the signs of the surrounding environment (Fig. 27). According to the shape of the final phase of adaptation is conditioned by metabolism, which consists of the sum of all the chemical and mechanical processes that provide energy for the environmental control inside buildings (Knowles, 1981).

The solar envelope, then, is based on a strategy of design based on natural rhythms. The sunlight is guaranteed within the shape; then, designers can use and exploit of the directions and properties of light without fear that a taller building laying a day will penalize their solutions.

It is possible to conceive of architecture in terms other than static. The sunlight is able to integrate the dimension of time to form and conception of space. The physical limits of the properties of the neighborhood and the assured period for solar access, the way in which these measures are laid down defines the size and the final shape of the envelope.

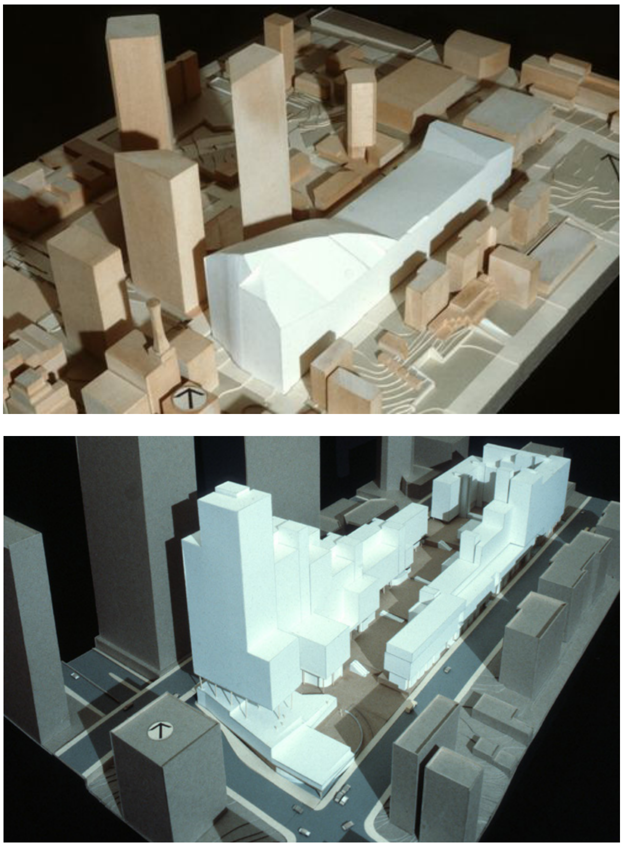

Figure 27.

The bunker Hill project: a building design that fits the solar envelope .

The solar envelope avoids unacceptable shadows above the limits designated for the properties and boundary lines; these limits are called shadow fences. The height of the shadow fences can be defined as a function of any surrounding element, such as private fences, windows or partition walls between properties. It is proposed as a device for zoning to gain access of the sun and adjusting the development within the limits resulting from the relative movement of the sun. The application of a fair distribution of rights requires a three-dimensional approach for zoning (Fig. 25). For each property it could be ensured equal access under the law. The result would be a maximum overall volume that may derive its shape and size from the size, shape, slope and exposure of the ground. For example: on site A is constructed a building that casts shadows to the north. Sometime after Lot B a north building

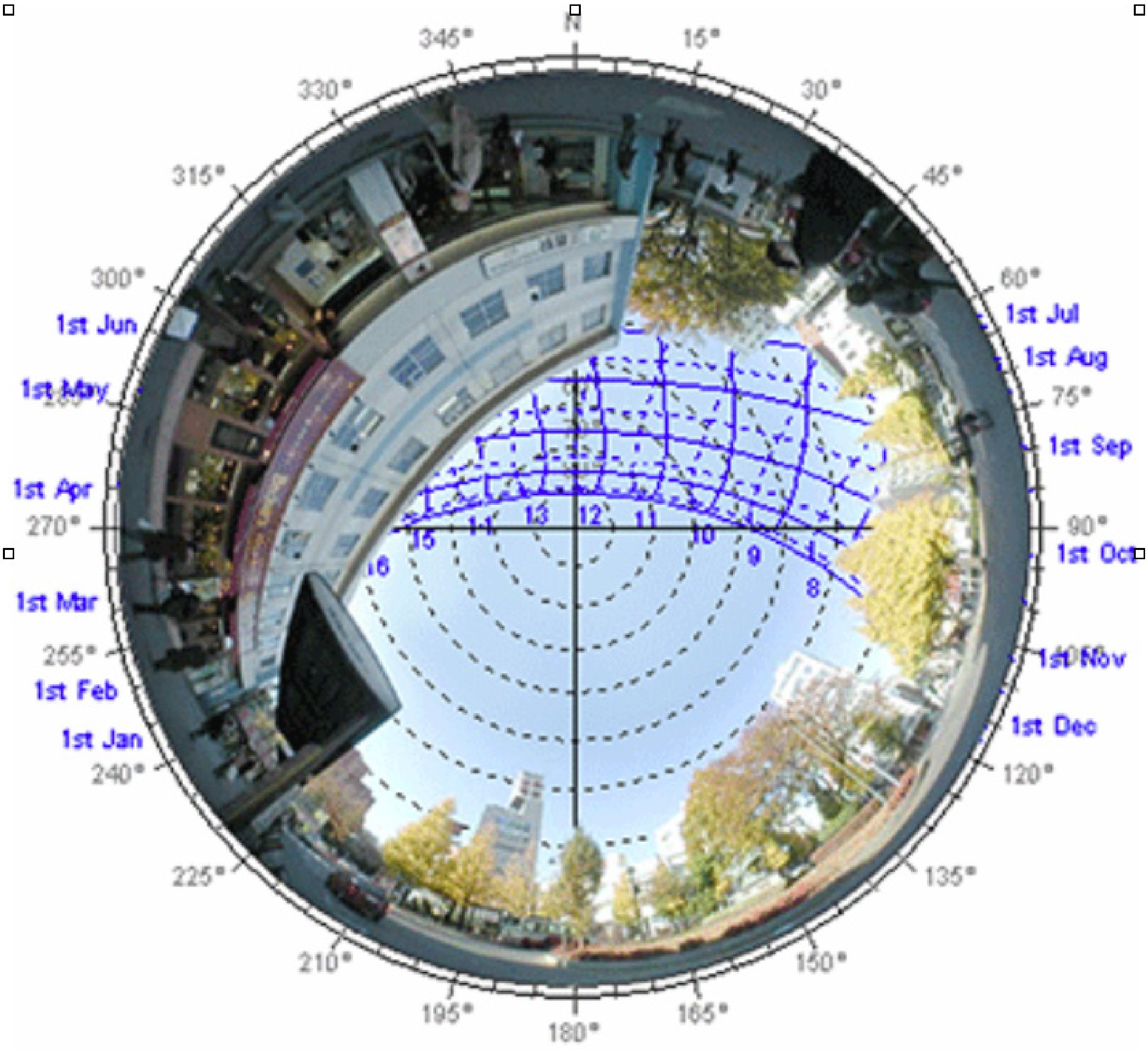

Figure 28.

Solar Pathfinder, for solar site analysis.

was built on lot B (downstream). The manufacturer B must be measured in some way with an appropriation from the outset of the resource "sun". Under this law, B would have no right to freely receive solar energy through some airspace. Its sole right would be the guarantee of the sunlight which falls perpendicularly on his lot. If instead the right to sun was guaranteed by law, the manufacturer C, which comes later, would have to accept the limitations of a building envelope with a base and no top. Unfortunately it can not be offered to C the same possibility to fill the missing part of the volume, because in any case this would have denied access to the sun to A (Knowles, 1981). There are also methods that allow the generation and the evaluation of different configurations of the buildings, ensuring both the right to the sun of each adjacent building, both of the open spaces between these, using the solar envelope concept, but without the need to use any specialized software (Fig. 29). The aim is to provide the architect nomograms easy to use to help during the early stages of design to determine the correct proportions and the geometry of the open spaces and roads, based on the desired level of building density, project location and orientation (Capeluto, 2006).

7. CONCLUSIONS

In this paper, we analyzed as the issue of the right to the sun has been addressed over time, to get to contemporary studies that have produced a morphological generator of urban rules of solar control: the solar envelope. The system allows you to renew the current urban regulations ensuring at the same time, the sustainability of urban growth. A precise analysis of the constraints of this element allows to generate urban rules consistent with the climate context and needs of shading and sunlight for a given region, providing the designer greater freedom to reach the goal while preserving the right to the sun. We conclude going to trouble even Vitruvius to remind us how certain issues were taken in substantial consideration for over 2000 years and to this day, despite being available, modern scientific instruments, these do not yet provide an adequate response: "Igitur, uti costitutio mundi ad terrae spatium in clinatione signiferi circuli et solis cursu disparibus qualitatibus naturaliter est conlocata, ad eundem modum etiam ad regionum rationes caelique varietates aedificiorum videntur debere dirigi conlocationes" (*and since the tilt of the zodiac and the course of the sun affect with different effects on the Earth's surface, in the same way it should be provided the buildings according to the particularities of the region and to the variety of climate.*) Marco Vitruvio Pollione, De Architectura (23A.C.).

REFERENCES

Atkinson W., The Orientation of Buildings or Planning for Sunlight, J. Wiley & Sons, New York, 1912

Butera F., Dalla caverna alla casa ecologica, Edizioni Ambiente, Milano 2004

Butti K., Perlin J., A Golden Thread: 2500 years of solar architecture and technology, Van Nostrand Reinhold, New York, 1980

Capeluto I.G., Yezioro A., Bleiberg T., Shaviv, E., Solar rights in the design of urban spaces. In: PLEA The 23rd Conference on Passive and Low Energy Architecture, Geneva, Switzerland, 2006

De Decker K. The solar envelope: how to heat and cool cities without fossil fuels, Low-Tech Magazine
http://www.lowtechmagazine.com/2012/03/solar-oriented-cities-1-the-solar-envelope.html
15/01/2017

Fletcher B., The London building act, Batsford Ltd., London, 1914

Knowles R.L., Energy and Form: An Ecological Approach to Urban Growth, The MIT Press, Massachusetts, 1974

Knowles R.L., Sun, Rhythm and Form, The MIT Press, Massachusetts, 1981

Knowles R.L., Ritual House - Drawing on Nature's Rhythms for Architecture and Urban Design, Island Press, Washington DC. 2006

Lepore M., Progettazione bioclimatica in ambito urbano, Aracne, Roma, 2004

Lima M.A., The establishment of bioclimatic design as a discipline. In: EXPO 98 by PLEA, 1998

Simoes F., Solar Access: A contribution to a comprehensive building code. In: EXPO 98 by PLEA, 1998

Vitruvii, De Architectura, Libri decime, Lipsiae in aedibus b. g. teubneri, 1899

Vitruvius, The ten books on architecture, Harvard University press, Cambridge, 1914

Marco Vitruvio Pollione, De Architectura, edizioni studio tesi, Roma, 2008

Watson, D., Kenneth L., Climatic Building Design, McGraw-Hill Book Company, New York, 1983

INSIGHTS

Capeluto G., Yezioro A., Shaviv E., Climatic aspects in urban design—a case study, Building and Environment, 2003

Capeluto G., From computer models to simple design tools: Solar rights in the design urban streets. In: Ninth International IBPSA Conference, Montreal, Canada, 2005

Givoni B., Man, Climate and Architecture, Applied Science Publishers, London, 1976

Goulding J.R., Lewis J. O., Steemers, T. C., Energy Conscious Design a Primer for Architects, B.T. Batsford Ltd., London, 1992

Knowles R.L., Kensek K.M, The interstitium: a zoning strategy for seasonally adaptive architecture, in Proceedings of PLEA 2000, Cambridge, UK, 2000.

Olgyay V., Design With Climate, Van Nostrand Reinhold, New York, 1992

Pereira F.O.R., Silva C.A.N., Turkienikz B., A Methodology for Sunlight Urban Planning: A Computer Based Solar and Sky Vault Obstruction Analysis. In: Solar Energy, 2001