ARCHITECTURAL REPERCUSSIONS OF ENVIRONMENTAL CLIMATE CONTROL IN THE GENERATION OF ADMINISTRATIVE BUILDING TYPES; DIFFERENCES BETWEEN MODEL AND TECHNOLOGY CHOSEN.

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ABSTRACT

This work will try to determine which models have truly been influential when considering the construction of a building for administrative use. This paper upholds four types created in the United States in less than a century of architecture and how one of the driving forces behind establishing the formal traits generated by these types and their corresponding sub-types is technological development linked to thermal installations in the office buildings.

The study is undertaken considering the climate control installations as volumetric elements to be implemented in the building and connecting them to it. Research allows us to establish the links between architectural type and thermal installations taking into account new trends, installation efficiency and possible integration of renewable energies into buildings with administrative use.

1. GENERATION OF MODELS

The generation of the models that would serve as reference points in Europe and Spain when considering the construction of a building for administrative use can be ascertained from an examination of a period of American architectural history running from the end of the 19th century to the mid-20th century. Here was where the need to implement new uses and advances in construction technology allowed the generation of new architectural types that led to the model par excellence: the glass skyscraper.

Four types with sufficient individuality have been identified which can be considered as models due to their capacity for systemization and later copying. Their general defining characteristics are detailed below and the environmental reasons behind their generation are highlighted.

1.1. Heavy block with open court

This type appeared in Chicago at the end of the 19th century primarily because of the birth of a new use: *The office* – with distinct requirements from known uses (mainly residential) and which needed to be located in the most densely populated areas in the city. The first signs of the work being organized were described thus by I. Ábalos and J. Herreros in their book: "*But we are dealing with an activity that is fixed in time and space, professional, depending on a physical medium – an activity that is associated with single-purpose buildings and is linked to an urban model based on the grouping together of the tertiary sector*"[1].

Contrary to the buildings of the age, these can be considered putative skyscrapers and they could not have happened without the development of lifts or the advances in steel structures. However, as they were the result of "extrusion" in terms of height from complete plots of land – adjoining streets on at least two sides of the land – the proportions of these buildings were more those of a block than a tower and this type was given the name "Chicago Quarter Block"[2].

Fig.1: Guaranty Building

Fig.2: Guaranty distribution. Offices area and services area.

With its 13 floors, the *Guaranty* building (constructed in 1894 in Buffalo by Louis H. Sullivan, and stylistically referencing Italian buildings) was one of the first administrative buildings that was built skywards. While from the main access roads to the building the volumetric configuration seems compact, the building's floor has a setback in the form of a patio in the rear wall, the aim being to achieve natural lighting and ventilation in the majority of the offices – even in the stairwells and the services.

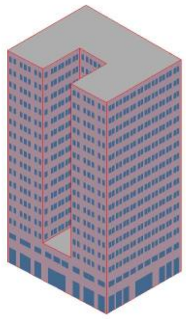

Fig.3: Heavy block with open court.

The 15-floor *heavy block with open court* designed by the Chicago School responded to the need for optimal use of each floor to obtain working areas. The useful area was conditioned by the depth of the intended shared office space which had to always be ventilated and lit naturally, thus obtaining optimal habitability in the large rooms. The result was floors in a "U", "E", etc. shape and a maximum surface area with gaps alternating between hollows and fillers, thanks to the light iron shell hidden within the façade.

The same volumetric configuration – though the upper floors were scaled in a recessed form – is found in the *Milam Building* in San Antonio, Texas, built in 1928. Additionally, this building (whose architect was George Willis and engineer M.L. Diver) signified a change in the approach to thermal conditioning of the work areas as it incorporated the installation of artificial climate control.

ºThe heavy building model was exported firstly to New York in the next few years, leading to the first "heavy" skyscrapers as a result of the cost of the land and the firmness of the surface where the buildings were constructed. Thus renowned recessed towers such as the *Chrysler Building* by William van Allen (finished in 1932) and the *Empire State Building* by Shreve, Lamb & Harmon (finished a year before the Chrysler) appeared. In both buildings, the depths of the floors, the setback on particular floors, the organization of the lift, services and storage core, and the configuration of the windows and offices are in response to the need for natural ventilation and light in all the work areas.

1.2. Block with inner atrium

In Buffalo, prior to the development of the administrative building in Chicago, Frank Lloyd Wright built the first *sealed* and artificially air-conditioned office building – the *Larkin Administration Building* (completed in 1905). The importance of this building does not lie so much in how it served as a model for other similar buildings – though it had and has a repercussion in later buildings – but rather in how it saw the climate control installations as volumetric elements placed in the building and linked both internally and externally. As R. Banham says: *"History and critics have tended to focus exclusively on the happy achievement of inner spaces and their connection with the large exterior volumes, without noting that the climate control handling system has a crucial interface with the inner and outer shape"* [3]. The Larkin building is an invention in and of itself, a way of doing things.

Fig.4: Larkin Building.

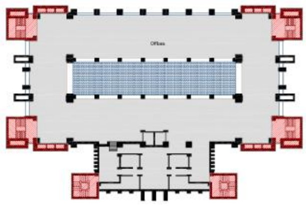

Fig.5: Larkin distribution. Cores stairs and offices area.

It is a compact block wherein the towers for the emplacing of the stairs and the gaps for the ventilation ducts and the rest of the installations have a bearing on the volumetric configuration of the block and are noticeable in the building's floors. It is possible to say that this is the first *articulated block* in existence. In addition to the external features of this building, the quality of the inner spaces needs to be highlighted: these respond to a model that was repeated in other major architectural works for administrative use – the *block with inner atrium*. This arrangement guaranteed light and the quality of the work spaces, with them being insulated from the adverse outdoors, though it did cause difficulties for the provision of climate control to the spaces at the highest levels. In the Larkin building, the ventilation grilles are found below the sills to ensure thermal comfort in work areas.

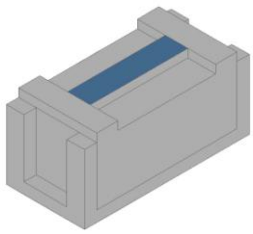

Fig.6: Block with atrium.

The references to Wright's building are unavoidable in many of the later administrative ideas given the obsession with sealing work buildings, the reduction in the number of windows accessible to users and the achievement of comfort through artificial systems as in the "windowless" building designed by Paul Witmer for the *Hershey Chocolate Company* (1934) or placing the core of installations on the outside of buildings in constructions such as the Richards Memorial Laboratories by Louis Kahn (1961).

1.3. The articulated tower

Fig.7: Articulated tower

By *articulated tower* we understand a building that consists of two differing volumes: a glass office tower and a rather more opaque core containing the services, mechanical systems and stairs. In this fashion, a maximum open-plan area was freed, thus providing the largest possible working area. The origin of this functional style of organization expressed in the external configuration of the building lies in the *Philadelphia Savings Fund Society (PSFS),* designed by Lowe and Lescaze in 1932. Of all the office buildings erected in America prior to World War II, this is without a doubt the one that had the greatest repercussion and its manner is such that when considering the construction of administrative buildings it is still referenced.

Fig.8: PSFS Building

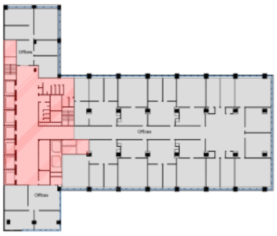

Fig. 9: PSFS distribution. Offices area and services, communications and facilities area.

The 32-story PSFS is considered the first skyscraper in the International Style[4], and it reveals the simplicity and stylistic features of this movement. Its T-shaped floor gives shape to the collection of rooms and elements used for installations, communications and services in the northern section. There are offices of differing sizes in the eastern, western and southern sections of the building. Externally, two polyhedrons are detectable: one is more glazed and the other more darkly opaque.

The origin of the articulated tower type is better understood if it is linked to the climate control systems of the time. The majority of buildings with air conditioning before the War were "All Air" systems with the consequent need for space required by having to emplace the vertical ducts. This was able to inspire aesthetics as expressive as that of the articulated tower: *"The era of the open-plan office had yet to arrive"*[5]. The development of enclosing the ducts in a false ceiling was a much more discrete way to resolve the issue, closing the chamber and hiding all the internal machinery in the building.

From Wright in the *Larkin* to Khan in the *Laboratories*, the installations in the buildings served to generate singular volumes in their architecture externally and to show the horizontal distribution of pipes and ducts – incorporating the aesthetics of the technique into the buildings. R. Serra referred to it when talking about the interconnectedness of technique and architecture: *"As in reality there is no real comparison between technique and art, a technical standpoint may favour the creation of a more attractive aesthetic or, on the other hand, an aesthetic approach to a technical or scientific problem may lead to a more rigid solution"*[6].

The purest examples of articulated towers where the offices and the services core were most clearly differentiated were to arrive a few years later, and included the *Inland Steel Building*, in Chicago, by Skidmore, Owings and Merrill (1958). The juxtaposition of the office block and the services, installations and communications core is the defining concept in the shape of the floor and the volumetric configuration of the tower.

However, the influence of the PSFS on the generation of models does not merely refer to the articulation of the two polyhedrons of which it consists but also that its design includes some of the most characteristic traits of later office towers: the intermediate mechanical floor, the framed element in the upper part of the tower and the base constructed on a plinth that has a commercial use or special rooms for the office building.

1.4. The polyhedral crystal tower

The aesthetic criteria promoted by the International Style in the America of the 20s or the later Modern Movement from Europe – with architects such as Le Corbusier and Mies van der Rohe – required the office tower, a paradigm of economic development in the post World War II period, to have a more compact, polyhedral and lighter external appearance. This type achieved its peak in cities like Chicago and New York in the 50s and 60s.

Thus, Mies van der Rohe's much desired glass skyscraper saw its pinnacle in his work in collaboration with Philip Johnson on the *Seagram* building in New York (1958)[7]. With its "H-shaped mullions" and 38 floors of offices, it is a step away from the predominant approach of the time as it incorporates into the whole a forecourt plaza which is fully integrated into the street-level transparent entrance. The framed element in the upper part of the tower contains the technical floor for the building and the three communication, service and installation cores (located within the completely open-plan office floors) which run along the building vertically and anchor the tower to the ground are the formal features constituting a characteristic type for the later administrative uses projects that Mies and others would undertake.

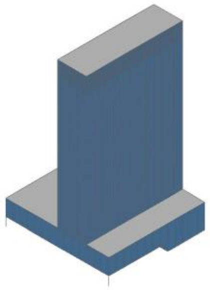
Fig.10: Crystal tower.

This new concept of the large *polyhedral crystal tower* could not have come about without the appearance of the curtain wall and the complete implementation of air conditioning systems. The rectangular office tower floor, central services and communications core freeing up a maximum amount of space for the offices and the glass-enclosed surface are the features that define the administrative building par excellence. Inside, the use of air conditioning systems using a water (instead of air) distribution system plus the consequent reduction in vertical ducts crossing the buildings made an open-plan office floor possible – fitting in with the minimalist aesthetic of the time.

The first block to be fully sealed and artificially climate controlled was the *Equitable Building,* in Oregon, (finished in 1948; designed by P. Belluschi). It was one of the first buildings to use double glazing tinted green to reduce solar transmission – the only element used to control solar radiation – from direct sunlight or glare. It was the first building to be heated, cooled and ventilated thanks to the air conditioning installation designed by engineer J. Donald Kroeker[8].


Fig.11: Lever House Building.

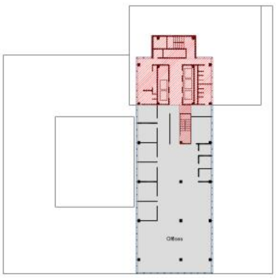
Fig. 12: Lever House distribution. Offices and service spaces.

However, the polyhedral tower of reference because of its four curtain walls has to be *Lever House* (construction finished in 1952; designed by Skidmore, Owings and Merrill) in New York. Its 21 stories allowed it not to have an intermediate mechanical floor. Its most characteristic features are: the plinth on which the office tower "floated" and the differentiation in the external appearance of the mechanical floor located at the top of the tower. These aspects would be repeated in other buildings with similar characteristics in the coming years in the western United States[9].

A similar concept had been used a couple of years previously in the *United Nations Building* in New York (finished in 1950). Although the original idea came from Le Corbusier, the undertaking was achieved by Wallace Harrison. A building with a greater surface area meant two intermediate mechanical floors had to be included, in addition to the basement and the roof, with the intention of optimizing the space needed by the vertical air conditioning ducts. The large glass tower was possible thanks to the use of the "air and water" air conditioning system, known as the "Carrier Weathermaster". This latter became established as the means of artificial climate control in fully glazed administrative buildings. R. Banham expressed it thus: *"Le Corbusier accomplished his dream of creating a large glass building in an urban location and here in New York he also found the talent of the one man who could make it work: Willis Carrier"*[10]. In this style of building climate control, the inductors located at the perimeter of the office floor would require spatial needs that defined the distribution of the façades with curtain walls while the space occupied by the high-speed air ducts that passed through the ceiling of the offices below was less than with previous systems – as it alone replaced the building's ventilation needs, though it did necessitate an acoustic false ceiling.

From the PSFS and thanks to advances in construction techniques both in cladding and in artificial climate control systems, other sub-types of glazed tower became possible: *the articulated tower, the tower on a podium, the tower with framed floor on the roof* and *the tower with intermediate floors*,mainly, whose formal traits in pure or combined forms would be repeated in towers. future

2. <u>INFLUENCES IN EUROPE IN THE 60s-80s</u>

Following a few decades of "*frustrated"*[11] attempts by the Modern Movement architects to construct tall buildings in Europe with natural ventilation, it was not until the consolidation of the polyhedral crystal tower in America that this type began to be exported for administrative use to cities like London or Berne, for example. The influence of American office building models with their consequent reliance on artificial climate control was more notable in Britain than in northern Europe where administrative buildings were more predominantly organic and linked to the outside world. When referring to exporting the concept, this is to mean not just the formal type but also the construction technology and the mechanical systems that made this development possible.

By way of an example, the following are two administrative use buildings which clearly reflect the formal defining features of the type as described in the preceding section and built in London at the end of the

60s: the tower for the *Commercial Union Assurances Co.*[12] (designed by architects Gollins, Melvin, Ward &Partners) – with its 24 floors of offices and its two technical floors, it was able to achieve a square open floor with a compact central core of stairs, lifts, services and installations; the neighbouring tower for the *Peninsular and Oriental Steam Navigation Co*., which was part of the same project (1969), comprises a glazed eleven-floor tower on a double-height plinth with a framed floor to house the installations for the building.

Another administrative building that was constructed thanks to artificial climate control via perimeter convection in the enclosure of the work area was the *Radio Schweiz*[13],AG, tower in Berne (1971) whose architect was F. Geiser. Once more there was a square floor with four glazed walls and a central core.

It was not until the 70s that the glass office tower began to make an appearance in Spain: *“This was a period in which the bank buildings quickly appropriated the precepts of the International Style – with its geometric volumes, straight lines, smooth flat surfaces and flexible floors – into modern construction use. This volume and verticality – as the maximum expression of the capitalist process of accumulation – was the most requested expressive form for this type of prestigious architecture”* [14].

Among the first towers in the 60s, the *Philips Building*[15] in Madrid (by García Benito) stands out with its thirteen floors and twin office towers articulated around a core of stairs that remained partly hidden. This whole was placed on a setback plinth that was adapted to the plot of land. Then, from the period of economic splendour there is the *BBVA Tower* by Sáez de Oiza (1978-1981), also in Madrid and clearly influenced by Wright[16].

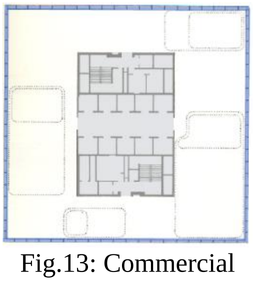

Fig.13: Commercial Union Assurances Co distribution.

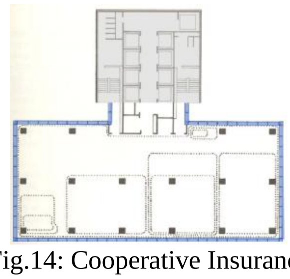

Fig.14: Cooperative Insurance Society distribution.

The articulated tower that was born with the PSFS saw its representation in Europe in the 60s: a pure example with a clear differentiation between the mechanical services core and the office space can be found in the *Cooperative Insurance Society (CIS)* [17] building, constructed in Manchester in 1962 (by architects Gordon Tait and G.S. Hay), with 25 floors, a five-story podium and a technical floor on the roof.
The articulation of the communications and installations core and, above all, the incorporation of the inner atrium above which the work spaces are located is present in the design of one of European architecture’s most recent representations of the administrative building: *Lloyd’s*[18] in London by R. Rogers (finished in 1986). The difference with the Larkin is that Rogers designs offices based around the central atrium in the building without losing light or views, which modern sealed and glazed architecture permits.

In the period described in this section, the types that served as a model for the administrative building persisted, the enclosure construction systems evolving to become structural elements, dematerializing the central service cores and granting ever more importance to the floor-frame-ceiling as a whole as a horizontal distribution element for energy contributing to total flexibility of the office floor and using variable air volume (VAV) systems which are adapted to the heating needs of users.

Fig.15: BBVA Tower.

Fig.16: Space Tower.

3. <u>REINTERPRETATION OR GENERATION OF NEW MODELS</u>

The start of the oil crisis in 1970 saw all the buildings which had been completed with curtain walling came into question and conditioned all the inner heating fixtures to artificial climate control. It was time to examine some of the aspects that might have the most influence on the reinterpretation of the given models or on the creation of new administrative building types.

On the one hand, the single glass skin cladding the glazed towers would become multiple layers, complex and variable – constituting an active part of the climate control systems for the building and improving energy efficiency. The cladding would include shading elements and the regulation of natural light, double glazing with specific technology for solar protection, low emissivity, etc. and chambers through which air would flow to condition the rooms. Two examples of the use of a façade as an air renewal system: for the offices in the *New Parliament building*[19]in London by M. Hopkins & Partners (finished in 1999) and the active façade as an element to attenuate external climate conditions in the *Space Tower*[20] in Madrid (2007) by Pei Cobb Freed & Partners. The differentiated resolution of the various glazed façades in the office tower had begun to be an important design criterion.

The completely sealed skin was questioned while the ideas of boosting natural ventilation and night-time cooling gained greater credence as design criteria in modern office buildings. The use of an inner atrium not just as a meeting place or for its views but as a mechanism to extract stale air and as an indoor garden is a strategy in thermal conditioning that defines the formal traits of many current office buildings. For examples, see *The Boots Company PLC* in Beeton[21] (designed by DEGW; finished in 1998) or the reinterpretation of the atrium as a spiral in the *Swiss Re*[22] by N. Foster in London (2004).

The generation of heating and cooling through the inclusion of renewable energies should be a factor that means the building is unavoidably integrated into the landscape and the skyline and it must be incorporated into the architectural design; it will go on to define new formal traits for administrative types. For evidence of this, see the refurbishment of the *CIS* articulated tower in 2004 where the three sides of the stairs, services and installations core serve as a support for the emplacement of photovoltaic panels. This action included the positioning of wind turbines on the roof.

Henceforth, only installations including domotics or regulation and maximum energy efficiency will be considered adequate for the artificial climate control of buildings. The inclusion of energy efficiency elements such as heat exchangers or centralized control rooms means the reorganization of spaces intended for the active climate control installations in office buildings.

Additionally, the latest changes in the understanding of the work space including the presence of computers and information technology are of interest not so much for how they influence the design of "virtual space" but rather in the sharing of floor and ceiling space – horizontal distributors of heat energy – and in the increase in power this means for the building and the need the equipment has for cooling facilities.

4. CONCLUSIONS

One of the driving forces behind the establishment of the formal traits of the various architectural types for the building designed for administrative use that emerged in the America of the late 19th century to its culmination in the glazed office tower of the 1950s is the adequate heating of the work space.

In the first half of this period, the shape, cladding and volumetric configuration of the office blocks were defined starting from achieving optimal natural ventilation and light conditions in most of the offices considered for construction.

The majority of the climate controlled buildings dating from before World War II had "All Air" air conditioning systems. The result was administrative buildings whose height and shape was conditioned by the spatial and energy needs of the vertical climate control ducts.

Only the implementation of the "air and water" systems allowed complete dominion over the interior environment of the office buildings. The development of fully sealed, transparent cladding made possible glazed office towers which were open-plan and adaptable to the needs of the users.

The models created in cities like Chicago and New York were repeated in Europe in the succeeding years, thus confirming that the choice of type when designing an office building conditions the type of thermal installations needed therein.

Fig.17: Lloyd's in front, Commercial Union Assurances Co. and Swiss Re Tower behind.

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