Air Conditioning and Installations in the Capitol Building in Madrid (1933)

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Introduction

> It is explained that in London, Paris, Berlin, Madrid, the number of construction workers and capable people multiplied extraordinarily […]. All this produced thousands of well-remunerated employees, people with greater personal exigencies, deciding to taste existence.
>
> A result of this desire is the birth, amazing multiplication of theaters, movie theaters, cafés, bars, dance and concert halls. The number of vehicles reaches prodigious amounts. Circulation problems become unsolvable.
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> A new kind of building is born at the time destined to satisfy all these necessities. It houses a theater, a dance-hall, movie-theaters, business offices, etc. This building is yet to find an adequate name. It is called "commercial building", although this really doesn't define its function.
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> One of such has been built in Madrid.[1]

These words start off a 1935 article about the Carrión Building[2] published in *Nuevas Formas* Magazine are describing a situation that no results foreign today. Over seventy years ago surged the need to resolve a complicated problem in a singular site while employing the moment's most modern technology in a country ridden with social, economic and political problems. All while reaching an outstanding architectural solution.

Even though air conditioning installation design is the main focus of this article, one finds it necessary to note that there were also some interesting technological advances: an architect that may adequately integrate the volumes for the production and ventilation is sure to transpose that preoccupation to the spaces dedicated for the rest of the installations. Furthermore, since the air conditioning system does in fact make up the bulk of the installations, the spaces and necessities hence impelled generate solutions and design criteria that will also by applied to accommodate the rest of the installations.

Therefore, before focusing in the air conditioning system design, without overlooking other fields like acoustics, fire protection or electrical systems, it is convenient to be

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[1] Nuevas Formas. Revista de Arquitectura y Decoración. Año II 1935 num 1. p 25

[2] In 1931 Enrique Carrión, Marquis of Melín, convened the " Carrión" competition destined to the development of ideas for the profitable use of a lot of his property. With time, the building came to be known under the name of the name "Capitol".

acquainted with the circumstances of the birth of the building, because as Luis Moya, the construction company's architect, remembers, all of this "is interesting to recognize the prehistory of contemporary technique"[3].

It is also necessary to note that this study is comprised within the collective investigate work on Twentieth Century Spanish Architecture taking place over the past few years in the School of Architecture of the University of Navarra, particularly, the investigation that I am currently conducting on the design, integration and mechanical systems in the most significant Spanish buildings of twentieth century[4].

The construction of the Capitol Building ended in 1933, over seventy years ago. Consequently, not all of the building's documentation is available, especially on such a specific subject. Hence one is obliged to mention the incommensurable help provided by Ignacio Feduchi, son of one of the building's authors.

Context, Building and the Architects

In order to understand the importance of this building, one must note that it portrays the cover of Angel Urrutia's "Arquitectura Española del Siglo XX" (*Twentieth Century Spanish Architecture*). The building constitutes a icon of an entire century of Spanish Architecture.

As Urrutia states, comparing the Capitol Building to the Flatiron Building in New York, the Capitol makes a magnificent example of *urbitecture*[5], of Architecture that makes urbanism, or of urbanism that makes Architecture (capitalized). This is because the origin of such a singular site dates back to the urban project of Gran Vía, an urban space sprinkled with heterogeneous architectures with the common denominators of strong visual impact and monumental yearnings[6] that may be synthesized in four symbols: the 'La Unión y El Fénix' Building, the Telefónica Building[7], the Capitol Building, and the Madrid Tower[8].

The building is sited on an original lot of over one thousand three hundred squared meters between Gran Vía and Jacometrezo Street, next to the Callao Plaza, in the heart of Madrid.

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[3] Revista Arquitectura. "Memorias del Arquitecto de la Contrata". Moya, Luis. Num 236 May- June 1982. p 60.

[4] At the same time, the Publication Services Department of the School of Architecture of the University of Navarra is preparing a publication about the history and construction of the Capitol Building as part of the Contemporary Architecture Collection (*AACC Arquitecturas Contemporáneas*).

[5] URRUTIA, Angel. "Arquitectura Española del Siglo XX", Ediciones Cátedra, Madrid, 1997. p329.

[6] PIZZA, Antonio. *Guía de la Arquitectura del Siglo XX*. España, Electa, Madrid. p 276.

[7] Luis Feduchi, "being a student works with Luis Gutiérrez Soto and Ignacio de Cárdenas in the Telefónica Building in Madrid"; this building, finalized in 1930, is partly designed from the United States by the North-American firm Clark Mac Cullen & Riley, and in which the structural conception of the building and the placing of the mechanical systems gain great importance. URRUTIA, Angel. *Arquitectura Española del Siglo XX*, Ediciones Cátedra, Madrid, 1997. p 327.

[8] URRUTIA, Angel. *Arquitectura Española del Siglo XX*. Ediciones Cátedra, Madrid, 1997. pp 150-151.

The building permit was warranted on April 21, 1931 and the Auditorium was inaugurated on October 15, 1933[9]. Over all, it took thirty months to construct a complex, multi-functional building (with cafeteria, reception rooms, offices, apartments…) under the direction of various young architects in the midst of political turmoil and an economically complicated Madrid. The situation was such that during some time the Capitol was one of the few buildings under construction in the city[10].

The building's promoter was D. Enrique Carrión y Vecín, Marqués de Melín. The architects, Vicente Eced y Luis Feduchi, were the winner of a restricted competition in which another five projects were presented.

Valencian Vicente Eced and Madrilenian Luis Feduchi "know each other since before being classmates [...]. After the Civil War, in which Vicente Eced serves as Army captain for the republican cause, [Eced] suffers 'temporal disability for public charges and permanent for the undertaking of directive and confidence positions', apart form his incarceration in several prisons in a never-ending pilgrimage until his indictment. He therefore embodies the figure of the non-exiled architect whose professional career gets affected by the military trauma"[11].

Luis Martínez-Feduchi, who will finally simplify his last name to be known as Luis Feduchi, was greatly influenced by his uncle, the architect Luis Cabello Lapiedra. The inclination towards popular architecture and the valorization of the monuments in all of Spain demonstrate such impact. Among many other activities, Feduchi will develop an important work of interior design, being tied to the firm Rolaco-MAC since 1933, which intervened in the fabrication of the furniture in the Capitol Building[12].

As a result of the Capitol project, Feduchi left Spain for the first time. With Vicente Eced he visited France and Germany to study the movie theaters that were being constructed at the time, not only for aesthetic reasons, but also from the standpoints of installations (air conditioning) and structure (Vierendeel structures were used for the first time in Spain in the Capitol Building). The trip to Germany was foresighted since both architects looked towards Germany in those years, especially Mendelssohn. Even though the Capitol is one of the most luminous and fascinating reflections of mendelsshonian thinking in Spain, it has been completely ignored by European historiography[13], as usually occurs with Spanish realities.

Luis Feduchi also traveled to London, Amsterdam and Hamburg with the engineer F. Benito Delgado to study questions related to illumination[14].

Referring to distribution, in brief, the building was constituted by a ballroom in the basement, a café on the ground floor, where the access to the hotel and the main hall are also located, a 'tea room' in the mezzanine level, and offices on the third, fourth and fifth floors, leaving the sixth and seventh stories for the hotel.

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[9] "Madrid. El Edificio Carrión", *Arquitectura*, Madrid, January-February 1935. p 4.
[10] Conversation with Ignacio Feduchi. Madrid, May 23, 2003.
[11] URRUTIA, Ángel. *Arquitectura española Siglo XX*, Ediciones Cátedra, Madrid, 1997, pp 326-327.
[12] URRUTIA, Ángel. *Arquitectura española Siglo XX*, Ediciones Cátedra, Madrid, 1997, pp 327-329.
[13] Nueva Forma. July/August 1971. FULLAONDO, Juan Daniel. "El Capitol, expresionismo y comunicación". p 5.
[14] BLASCO CASTIÑEIRA, Selina. "Luis Feduchi. 1901-1975". Colección de Arquitectos Españoles. Dirección General de Arquitectura – M.O.P.U. P. 5.

Macazaga was the construction company, which counted with the services of engineer Agustín Arnáiz[15] and architect Luis Moya. According to the latter,

> Another aspect of the construction of which there was little experience in Spain in those years was the installment of a 'total' air conditioning system. Its incidence in the interior composition of the building was important, for the large sections of low velocity air ducts needed to assure noise reduction. The problem is now simple, but it wasn't then. The installation was made by Constancio Ara, serving himself from English experience, and if memory does not serve me wrong, employing equipment of the same origin. I was astonished by the work cost, for I believe it was about a fifth of that of the total building; the necessary mechanical room's surface averaged that of the movie theater; also we count with the transformer substation, because of the large energy consumption required by this installation, and the illumination and plumbing system (for pumping).[16]

There is no surviving data as to who was responsible for the installment execution, even though one might observe a rubber seal with the text "Industrias Guillén Zaragoza – Madrid – Valladolid" on the plans.

Concerning the economic factor, the building had a final cost of 10.745.063 pesetas de 1933 (64.759 €), Installation costs being broken-down as follows[17]:

Heating, ventilation, refrigeration and drainage	1.126.144 ptas.	6.788 €
Electricity	1.300.000 ptas.	7.813 €
Elevators	339.781 ptas.	2.042 €
Sound Cinema and T.S.H.	148.959 ptas.	895 €

The installation ensemble supposed 27% of the total cost of the building, which would be in line with the current cost in buildings of similar characteristics.

Air Conditioning

Preliminary Facts

The first difficulty encountered when analyzing the study of this building's HVAC system was the practically non-existing specific documentation of the heating and cooling systems. Among the few available sources was an article published in 1935 in *Arquitectura* review. The latter was the actual memoir written by the architects on January 14, 1931 and the plans kept in Ignacio Feduchi's office. These plans are the following:

[15] "Memorias del arquitecto de la contrata". Moya, Luis. Nº 236 Mayo-Julio 1982.
[16] Revista Arquitectura. "Memorias del arquitecto de la contrata". Moya, Luis. Nº 236 May-July 1982. p 60.
[17] "Madrid. El edificio Carrión", *Arquitectura*, Madrid, January-February 1935. p 10.

Ventilation Ductwork sketches for the Ballroom in the basement, the Café on the ground floor, and the 'Tea Room' in the mezzanine level.
Plan and sections of HVAC[18] system, located in the basement, under the main hall.

Also, the documentation handed to the city government refers to the project description, plans, and work certificates of the electric, heating, cooling and ventilation installations (Manuel de Ortega, engineer, December 14, 26 and 29, 1933), as well as the project description, plans and work certificates of the elevator and lift installations (Luis M. Feduchi y Vicente Eced y Eced, architects, y Fernando Riaza, engineer, November 11, 1933)[19].

Given the available data, some information would be lacking in order to define for sure each and every one of the installation elements. Therefore, the differentiation made along the text between corroborated data, the recollections of the contributors and Feduchi's children, and the hypothesis of the system's functioning is important.

Calculations

In their memoir, the architects justify the applied solutions in relation to the current building code, referring concretely to article 98 of the Public Spectacle Code:

> The cubic capability of the area designated to spectators, when it is closed, will correspond to the special ventilation conditions in each premise and the kind of show to which it is destined, but **it will never be less than three cubic meters per person.**

One may observe that the code provided a minimum volume per person, even though it omitted the amount of air renovations per person and hour.

In this case, the architects suppose a total of two thousand spectators and an interior volume capacity of eight thousand five hundred cubic meters. Apart from the two thousand five hundred cubic meter capacity exceeding over the required volume, air is constantly renovated and purified, controlling the temperature and humidity exactly like the architects state in their 1931 project description: "through a ventilation system similar to that installed in the 'Paramount' and 'Olympia' cinemas in Paris, 'Kammerland', 'Universium' and 'Ufa' in Berlin, in many English and mostly all the North-American ones".

Heating and Cooling Production (HVAC)

Carrier[20] equipment was used for cool air production. The refrigeration compressors are located in the basement next to the conditioning unit and to the fans for ventilation[21].

[18] Acronym commonly used to refer to a building's Heating Ventilation and Air Conditioning system.
[19] This documentation could not be retrieved for the editing of this article.
[20] Conversation with Ignacio Feduchi, Madrid, May 23, 2003. Carrie Spain was consulted to confirm this fact but no records were available due to the antiquity of the installation.

Heat was produced through sixteen boilers (located in different rooms) with heavy-oil burners[22]: three of them serve the café, tea room and ballroom; five serve "home heating"; and four serve the Auditorium.

Most of the machinery was placed in the basement thus breathing through portholes positioned in the sidewalks.

Air Installation Design

> Lastly, we must consign that we plan to endow the cinema with a complete installation for the perfect constant ventilation and refrigeration of the Auditorium, through which we are allowed to maintain in the environment the so-called "artificial Spring climate", as exists in numerous cinemas abroad. The system consists of air renovation in the Auditorium, absorbing use air and injecting new or purified air with a special temperature and humidity, all achieved automatically. To that effect we have disposed of the necessary spaces for the installations and conductions and a four-squared-meter pure-air intake on one of the sides of the stage.[23]

The air-conditioned zones were the public areas in the basement, ground floor and mezzanine, as well as the main hall. The rest of the premises had radiators.

> The ventilation system is the most modern and complete installed in Madrid: there are two large fans that move a mass of ninety thousand cubic meters of air per hour, meaning that every five to seven minutes the Auditorium is completely purified and with the desired temperature and humidity. The controls are automatic and very modern [24].

The great air volume to be moved forces the creation of a technical room under the main hall that hosts part of the conditioning and electrical installations. The rest "will be taken in the most part through the space between the roof beams, whose roof space will be perfectly accessible and will even have windows for its proper ventilation"[25].

Thus, the auditorium space with covered with Vierendeel beams. The work's magnitude is evidenced if one thinks that until a few years later these were the biggest ones in the world. This type of beams was used not only for structural reasons, but also because solid or triangulated ones would not allow the exploitation of the technical space in the same way. The clearing for the installations would have been resented notably since it was necessary to dispose of large sections in the ductwork for low air velocity and noise prevention in the premises. Therefore, here lies an example of how a technical necessity generates a structural solution that will invariably influence the final form of the building.

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[21] "Madrid. El edificio Carrión", Arquitectura, Madrid, January-February 1935, p 6. In the plan that appears reduced in this magazine, the zone where the water pulverizers are located is defined as "conditioning (air cleaning)".
[22] "Madrid. El edificio Carrión", Arquitectura, Madrid, January-February 1935, p. 5.
[23] Memoria de los arquitectos. Madrid, January 14, 1931.
[24] "Madrid. El edificio Carrión", *Arquitectura*, Madrid, January-February 1935, p. 14.
[25] Memoria de los arquitectos. Madrid, January 14, 1931.

Cold air diffusion in the main hall is done through the ceiling while hot air is diffused under the seats[26]. The architects take advantage of the shape of the drop-ceiling to hide the diffusers and the grills necessary for air movement in this room as well as in the other premises. The drop ceiling was also designed for acoustic purposes, even though the forms were based on the experience[27]. This illustrates yet another example of how conditioning interacts with other traditional constructive building solutions.

Another premise in the basement hosting the fans corresponding to the ventilation of the café, the tea room and the ballroom compliment the installation.

Auditorium HVAC system

The Auditorium conditioner unit occupies a surface of three hundred squared meters of the building's basement in a location with a height of five meters. The air conditioner plan identifies various elements arranged in the following order (in the direction of air flow):
Fresh air intake at street level.
Louvered hatch regulating the entry volume of air from the street.
Bifurcation of the Auditorium's return-air ductwork by the louvered hatch: part of the air is re-circulated and thus restarting the cycle while part is expelled through an exhaust vent.
Mixer combining street air with that from the Auditorium's return duct.
Water pulverizers: Four batteries with 63 pulverizers each.
Drop separator.
Fan.
Water Batteries.
Auditorium supply.

The whole of the installation is regulated by a pneumatic group that also acts over different membrane valves through compressed air lines. Various control elements like thermostats and humidistats appear.

In conclusion, the plan also shows other installation elements like a convector, ductwork registers, coke filter, drains, floater valve, and water circulation pumps.

Fire Protection

Fire prevention measures take evident importance in buildings of public concurrence such as this one, as well as the evacuation, egress and fire control measures to be taken in case of emergency.

[26] Conversation with Ignacio Feduchi. Madrid. May 23, 2003.
[27] Conversation with Ignacio Feduchi. Madrid, May 23, 2003.

Conscious of this, the architects will define from the beginning the measures to be taken to increment fire protection and security:

> We projected the construction of the movie theater in reinforced concrete, a perfectly fireproof material. After a meticulous study and with an intense preoccupation for the maximum fire-protection guarantees possible, we have determined to also employ incombustible materials for decoration to complement the security that concrete offers against fire. The fabrics we will use for the wall veneers, curtains and seats, as well as the carpeting, with be fireproofed through special procedures already used with absolute efficiency in France and Germany. The seat armors, handrails, railings, and most of the decorative elements will be made out of metal. Marble and fire-resistant materials will be used in the vestibule. All possible parts of the gridirons will also be made out of metal, and, as stated before, a metal safety curtain and a mechanism to project another hydraulic curtain in case it is needed. We will also place pressurized water registers [sprinklers] in strategic places as well as electronic fire detectors of proved efficiency. [28]

The need to minimize the fire risk is transferred to "the electrical installation following all the measures prescribed in articles 141 to 154 of the Public Spectacles Code and adopting the latest advances in the field that, like the suppression of apparatuses and the employment of insulation procedures, overflow in benefit of lighting security and the diminishing of fire danger"[29].

Acoustics

Acoustics should not be considered and installation for it is not. It is the branch of physics that studies the behavior of sound in architectural spaces. Among other things, it is the testament to whether or not the architectural measures taken are adequate for an auditorium to accomplish its main function: to hear sound satisfactorily.

The measures taken to improve the acoustics of the different quarters of this building were based on experience, did not involve any previous study, and yet the acoustics in the auditorium were resolved in a simple yet effective manner for its uses as cinema as well as theater. The lateral and back walls were veneered with thick velvet-covered cork. The ceiling and the proscenium were left as reflecting surfaces.[30] Vaults and domes in the ceiling were avoided for their capacity to produce echoes that may decompose the sound. The ceiling is projected as multiple surfaces and moldings that favor with their form a perfect acoustic[31].

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[28] Memoria de los arquitectos. Madrid, January 14, 1931.
[29] Memoria de los arquitectos. Madrid, January 14, 1931.

[30] Revista Arquitectura. "Memorias del arquitecto de la contrata". Moya, Luis. Nº 236 May-July 1982. p 61.
[31] Nuevas Formas. Revista de Arquitectura y Decoración. Year II 1935. p 27

Electricity and Lighting

An expert in installations and luminotechnia and a constant client of Feduchi's during his entire life, Engineer Francisco Benito Delgado was responsible for the electricity and lighting installations[32].

To give you an idea of the importance of this installation let us just say that in the auditorium's ceiling alone were more than seventy kilometers of different sectioned wires[33]. This abundant wiring was paired to a great energy consumption that required a substation with Bordón transformers in the basement to distribute energy to all other installations and a specific premise to locate the electrical command center[34].

"The Auditorium's lighting installation is also interesting. Light regulation is done through a series of levers, a total of 120, which combine into infinite color mixtures" [35]. A regulation that allows a "luminous graduation studied from an ophthalmologic point of view before commencing the session (white-yellow-green-blue-purple-black)"[36].

Other Installations

Within this building's engineer-like description one may find opportune to talk about the building's vertical communications: "an elevator system that at best we may call a chain pump, made up of diversely colored cases according to the department to which they are destined"[37].

In the initial memoir the architects point out the usage of "a group of two fast 'Otis' elevators, with a surface of two squared meters each, and a freight elevator, also with a surface of two squared meters, completing the vertical circulation. One of the elevators had direct access to the upper floors of the tower"[38].

Finally they placed ten elevators, two of which moved at a speed of two meters per second, as well a platform for thirty-six musicians in the Auditorium[39].

[32] BLASCO CASTIÑEIRA, Selina. "Luis Feduchi. 1901-1975". Colección de Arquitectos Españoles. Dirección General de Arquitectura – M.O.P.U. P. 5.
[33] Arquitectura. Nº1, January-February 1935.
[34] FEDUCHI, Javier, Ignacio y Luz. "Plan Especial Capitol", p 1.
[35] Arquitectura. Nº1, January-February 1935.
[36] URRUTIA, Ángel. "Arquitectura española Siglo XX", p 331.
[37] "Madrid. El edificio Carrión", *Arquitectura*, Madrid, January-February 1935, p. 24.
[38] Memoria de los arquitectos. Madrid, January 14, 1931.
[39] Arquitectura. Nº1. January-February 1935. p 5.

Structure

Given its singularity, it is precise to mention the structural particularities employed in the Capitol, even if it departs from this article's pretensions.

The structural engineer was Agustín Arnáiz, military engineer, and according to Luis Moya, collaborated with Flórez and Muguruza in the works done in the *Teatro Real* between 1925 and 1930.

The building was done with a metallic structure, except in the two basements and the cinema where reinforced concrete was used (thus anticipating the fire protection norms necessary in this kind of premises)[40].

The Capitol was the first building in Spain to utilize Vierendeel beams[41]. They were also the largest in Europe, having a thirty-one meter span, a height of 3,10 meters and weighting approximately seventy tons each. There is also an iron beam with a fourteen-meter span and weighting close to fifteen tons over the cinema entrance[42].

"The rest of the building was totally constructed with a metal weave, calculating a load between 300 and 400 Kg per squared meter according to the place and use"[43].

Final Comments

The original machinery was replaced in 1973, when they were substituted for new ones[44].

The integration of the spaces required for the installations and architecture usually generates difficulties in the design process, and only in order and spatial generosity may they be considered long-lasting values [45]. This building has been able to confront a complex and variable program, over more than seventy years because these principles were considered throughout its design.

However, questions arise that may be applicable to other buildings. What are the criteria for the conservation of aged installations after they reach their useful lifespan? Can they be eliminated completely? In time, what will remain or that engineering (if not architectural) memory if they are completely eradicated? All machinery has a useful lifespan that inevitably will not coincide with that of the building. The acting criteria will not be the same in the Parisian Pompidou Center as it will be in an affordable housing

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40 Revista Arquitectura. "Memorias del arquitecto de la contrata". Moya, Luis. Nº 236 May - July 1982. p 59.
41 Luis Moya, "Memorias del arquitecto de la contrata", *Arquitectura*, Madrid, nº 236, May - July 1982, p 61.
42 Arquitectura. Nº1. January - February 1935. p 4.
43 Memoria de los arquitectos. Madrid, January 14, 1931.
44 Conversación con Ignacio Feduchi. Madrid, May 23, 2003.
45 Ignacio Paricio, El tendido de las instalaciones, Bisagra, Zaragoza, 1999, p 25.

block. One must also remember that the Capitol's technical solutions go hand in hand with its construction method: the supply diffusers and return grilles are integrated to the ceiling decorations.

Evidently, there is an open debate that should allow the formulation of intervention criteria for the moment in which the building will (or should?) retire their aged installations.

The question that we should be asking is how to define at which point architectural constructions can be separated from the installation and the spaces these occupy and contribute to define the ultimate form of the building.