

# **The Evolution of the Pompidou Centre's Air-Conditioning System.**

## **Toward a new figure of architecture.**

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### **Introduction**

The integration of technical services in architecture played a crucial role in the history of post-war construction. The Centre Pompidou, conceived and realized between 1971 and 1977 by the architecture studio Piano and Rogers and the engineering firm Ove Arup and Partners, is an excellent example in this regard.

Instead of reverting to traditional solutions such as service areas or suspended ceilings, Piano and Rogers chose to exhibit all the services of the building – from the air conditioning ducts to the movement system of people and goods – both in the interiors and exteriors. Exiled outside the envelope and placed within the “three dimensional walls” of the building, or rather clipped onto them, the Centre Beaubourg services were designed to serve the principle of “the maximum flexibility of use”. During the design process the refinement of these elements and the surrender to the pioneering audiovisual screens intended to animate the Centre's main facades, created an unprecedented aesthetic value. Initially conceived as simple functional tools, the Centre Beaubourg services became symbolic and didactic devices designed to make the building a man-scale machine, both joyful and understandable.

This paper focuses on one of the main services of the Centre Beaubourg, the air conditioning system, and aims to retrace the genesis and evolution of this element through all the phases of the design process, from the first ideas animating the preparation of the competition's proposal to the prefabrication of the built solution.

### **The genesis of the Pompidou Centre's air-conditioning system**

The configuration of the air-conditioning system of the Centre Beaubourg, today the Centre National d'Art et de Culture Georges Pompidou, must play a significant part in any reflection on the integration of plant into architecture since the Second World War. Its genesis, however, does not coincide with the solution presented to the international competition for the Centre Beaubourg by the Piano+Rogers and Ove Arup & Partners practices. It should be sought first of all in the reflections Richard Rogers and Renzo Piano devoted to such systems in the 1960s.

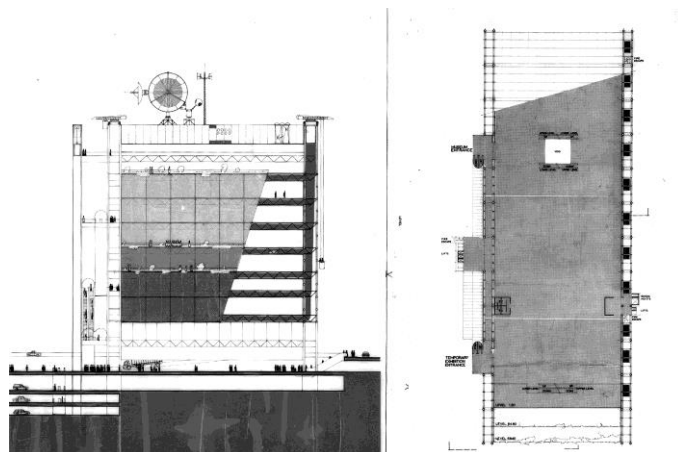
Crucial was the research Piano conducted into a total integration of plant within the envelope of the building, stemming from study of the solutions adopted by two of Piano's main influences, Marco Zanuso's designs of

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factories and Franco Albini's La Rinascente department store. This research culminated in a series of design solutions, which included a scheme for the integration of the conduits for modular prefabricated housing (1969) and the transformation of the bars and ball joints of the Burrell Collection Gallery's roof into a sophisticated system for air distribution (1971). The research carried out by Rogers, however, proved decisive. Interested in the conception of flexible and uninterrupted spaces, he treated the plant as systems integrated into the envelope or as "clipped-on" equipment. Examples of this include the underfloor systems of the Sweet Heart Enterprise offices at Gosport (1969) and the energy equipment clipped onto the shell of the prototype Zip-Up House (1968-71), as well as the structural plans for the plant of the hospital unit for the Association of Rural Aid in Medicine (ARAM, 1970-71) designed in collaboration with Piano.

In the original conception of the Centre Beaubourg, traceable back to a series of sketches made by Rogers in the spring of 1971,[1] the principles destined to characterize the whole evolution of the project were already spelled out: a series of continuous free-plan platforms suspended above a large public square and supported at the sides by two steel structures called "three-dimensional load-bearing walls". Clipped onto the outside of these or plugged into them on the inside were the ventilation, plumbing and power systems, as well as a cutting-edge telecommunications system consisting of large audiovisual screens able to turn the building into a broadcaster of information.

For the air-conditioning system developed along with Tom Barker, service engineer at Ove Arup & Partners, the architects opted for a solution able "to maintain the flexibility and adaptability in space planning and usage which is considered essential in the philosophy of this building".[2] The solution proposed was a "recirculated fresh air system" based on a modular unit with an area equal to one of the twelve bays into which each floor (12.80 x 48.00 meters) was subdivided. Although the type of plant and its characteristics fitted perfectly into the project, its location immediately proved problematic since the guidelines of the competition called for these elements to be placed underground. This would have implied the vertical passage of the ducts through the ground floor (left free thanks to the elevation of the building on "pilotis"), compromising its complete visual and spatial permeability, regarded by Rogers and Piano as an indispensable principle.[3] It was precisely to preserve the empty space under the building that the team rejected the competition instructions and opted for a solution with plant rooms on the roof and a cascade distribution on the perimeter.



*Figure 1. Piano+Rogers and Ove Arup & Partners, Centre National d'Art et de Culture Georges Pompidou, 1971-77. Section and plan of the competition proposal, June 1971 (RSHP Archives, London).*

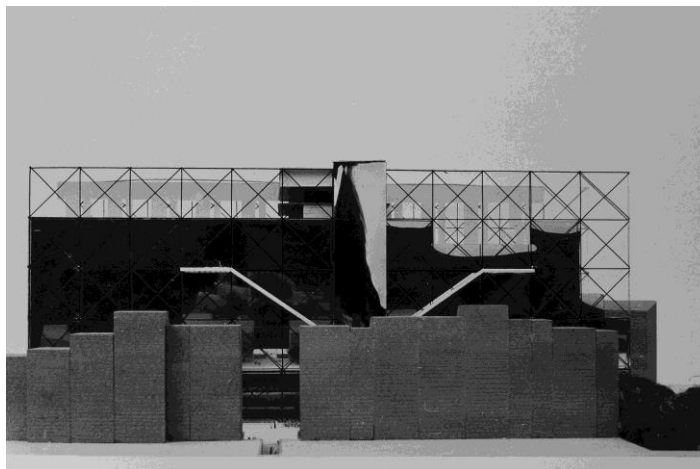


Figure 2. Piano+Rogers and Ove Arup & Partners, Centre National d'Art et de Culture Georges Pompidou, 1971-77. Competition model, June 1971 (Archives Nationales, Paris).

The final solution they submitted[4] consisted of a box-shaped plant room containing twelve independent “central station air-handling units” set on the building’s roof. (Figs 1-2) The plant room was connected to a large horizontal duct inserted in the “three-dimensional wall” on Rue du Renard from which ran eleven pairs of vertical rectangular ducts (two per bay, one taking air in and the other discharging it). At the height of each floor slab the vertical systems intersected with two networks of horizontal ducts concealed behind the false ceiling and used for the distribution of conditioned air through “reheat boxes” and its recovery through vents.

At this stage the air-conditioning system already revealed specific architectural genealogies and intentions. For its overall configuration the model was the air-conditioning system of La Rinascente, a project on which Piano had worked in the two years he had been an intern in Albini’s office, between 1960 and 1962.

Looking instead at the configuration of the plant room on the roof or of the ducts which could be glimpsed behind the audiovisual wall, the air-conditioning system reveals a more precise lineage, related to the projects and reflections of figures like Archigram, Cedric Price and Reyner Banham. It was due to their influence that the choice was made to locate the various components of the technical plant inside an isolated volume in a central position, as if to underline the unprecedented architectural nature assumed by a traditionally secondary and hidden element. In the plant room’s configuration, the influence of Archigram is most apparent. It is a temporary “clipped-on” piece of equipment conceived as an expandable capsule on which, not coincidentally, Rogers bestowed the appearance of the Zip-Up House,[5] which had its roots in Archigram’s research. The ducts’ expressive shape belonged to the same world. Although it lacked the zoomorphic dynamism of Archigram’s flexible pipes, the plant’s insertion into the semitransparent structure of the “three-dimensional wall” probably derived from a similar solution adopted by Archigram in the Control and Choice Dwelling, a design exhibited with the housing prototypes of the Richard+Su Rogers office at the Fifth Paris Biennale (1967).[6]

Although these compositional stratagems already denoted an architectural sensitivity in the approach to the design of the air-conditioning system, this element was still treated with uncertainty and subject to a logic in which structure and shell prevailed. This was true not just for the interiors, where the systems were completely concealed behind false ceilings,[7] but also in the more ambiguous one of the front onto Rue du Renard.

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Despite considerable inconsistencies between the competition plans,[8] there can be no doubt that the external structure of the “three-dimensional wall” and the audiovisual panels partially covered the plant, making it an element that could be glimpsed behind the façade. That the systems were not yet conceived as a predominant architectural element on Rue du Renard is further confirmed by the two models made by the architects between June and July 1971. (Fig. 3) In the first case this is shown by the decision to rework the model with a reflective film that hid the ducts inserted in the “three-dimensional wall” from view. In the second, produced following the announcement of the competition results, it is demonstrated by the total omission of the plant and the reduction of the “three-dimensional wall” to nothing but a translucent façade.[9]



*Figure 3. Piano+Rogers and Ove Arup & Partners, Centre National d'Art et de Culture Georges Pompidou, 1971-77. Competition model (left) and the model realized after the winners' announcement (right), June-July 1971 (Archives Nationales, Paris)*

### **The development of a decentralized air-conditioning system and the renunciation of the screens on Rue du Renard**

During the first meetings between the team and the Délégation pour la Réalisation du Centre Beaubourg, the interdepartmental commission charged with overseeing the execution of the project, the air-conditioning system was mentioned only in passing. The disappearance of the plant in the second model and the reduction of the “three-dimensional wall” to a translucent surface distracted the Délégation’s attention from the plant’s configuration. The observations were limited to the acoustic problems caused by the plant’s passage through the “three-dimensional wall” and the need to give the front onto Rue du Renard a “more intimate and enclosed” design, thereby revealing the desire to distinguish it from the one onto the square—a principle of asymmetry that would prove fundamental to the evolution of the design.[10] Crucial for the plant was the Délégation’s proposal to reconfigure the top floor of the building with a series of museum galleries using natural light from above—a proposal that conflicted with the position of the plant room adopted in the competition.[11]

The uncertainties relating to the air-conditioning system were confirmed in the summer by the radical revision of the structure, which moved toward an alternation of continuous main floors with the same number of “structural decks” built out of immense Vierendeel trusses in which to insert “ancillary activities”, including the services. This solution derived from Louis Kahn drew on a model Rogers and Piano had just applied in the ARAM project

with its alternation of “activity zones” and “service zones”.[12] Unlike this project, however, the proportions assumed by the “structural decks” of the Centre were so massive they would not be used solely to house the technical systems—“a series of services packages” conceived to ensure “maximum flexibility in the organisation of the building”—but also activities for the public and the staff.[13] (Fig. 4)

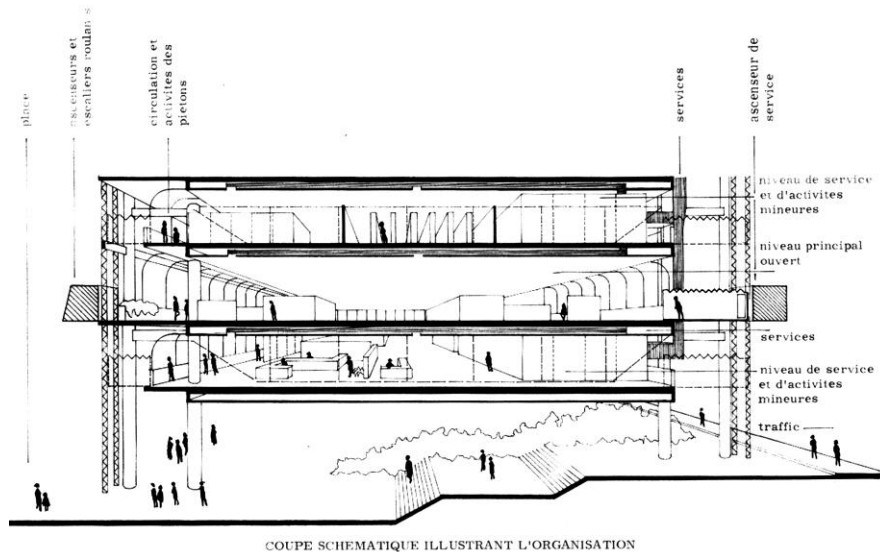
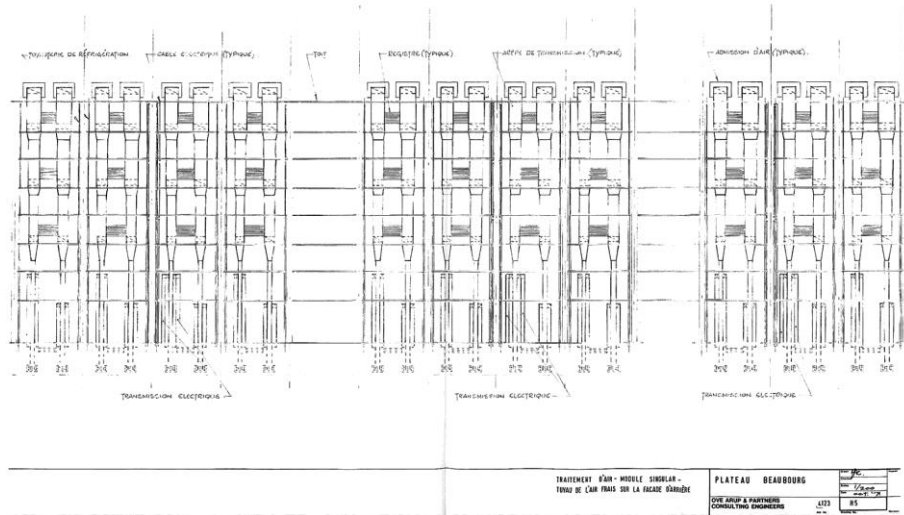


Figure 4. Piano+Rogers and Ove Arup & Partners, *Centre National d'Art et de Culture Georges Pompidou*, 1971-77. Schematic section, October 1971 (RSHP Archives, London)

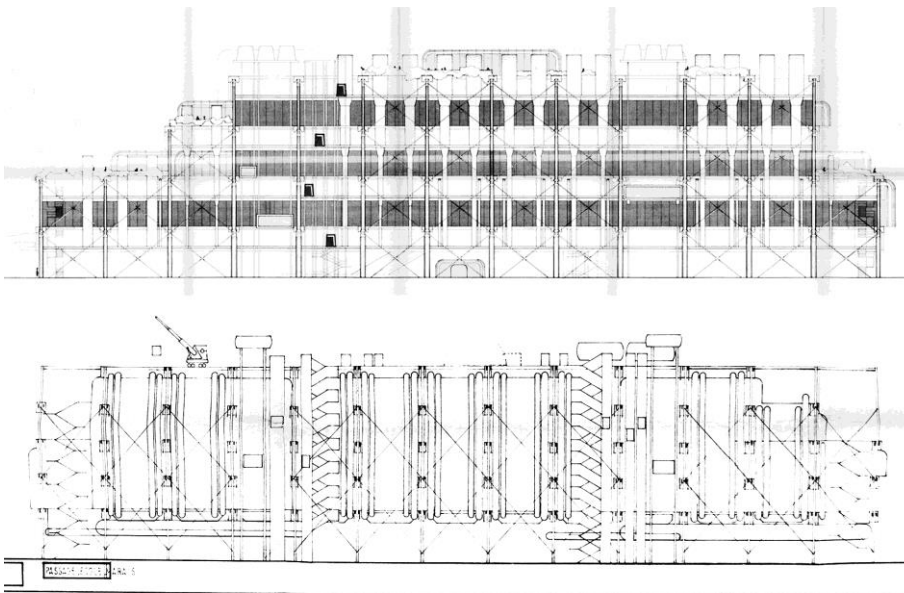
Barker and his colleagues did not immediately set about studying this new decentralized configuration, called the “local system solution”, in depth but continued to look at it alongside a variant known as the “centralised system solution”, assessing the potentialities and disadvantages of both.[14] This was probably a reflection of the doubts that the engineers harbored over the “local system solution”, an arrangement that on the one hand offered the advantage of complete integration into the Vierendeel structure and reduction in the time needed for its assembly and the number of ducts, but on the other would take up an enormous amount of space and require costly maintenance. Although the engineers’ reservations were still to be found in the technical report produced by Barker and his colleague John Hampson in October,[15] the team adopted the “local system solution”, including it in the *Avant-projet Sommaire*, the preliminary plan presented to the Délégation in November 1971.[16]

The new “recirculated fresh air system” consisted of a series of individually controllable “air-treatment units” located on each of the four “structural decks” and arranged on a rectangular band facing onto Rue du Renard and taking up about a third of the floor area. Each unit conditioned the bay in which it was located and the one immediately underneath it through a system of horizontal ducts once again concealed in the false ceilings. What had changed was the configuration of the ducts inserted in the “three-dimensional wall”, now based on a module of two ducts used to take air in from openings set in the roof. The exhausted air was no longer channeled back to the upper floors but expelled directly from each “air-treatment unit” through rectangular grilles, called “registres typiques”, set in the front onto Rue du Renard. (Fig. 5)

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*Figure 5. Piano+Rogers and Ove Arup & Partners, Centre National d'Art et de Culture Georges Pompidou, 1971-77. Service organization for the Rue du Renard elevation (conceived by Tom Barker and colleagues), October 1971 (Archives Nationales, Paris).*



*Figure 6. Piano+Rogers and Ove Arup & Partners, Centre National d'Art et de Culture Georges Pompidou, 1971-77. Rue du Renard elevation in the Avant-projet Sommaire. October 1971 (above) and March 1972 (below) (Archives Nationales, Paris)*

It was precisely this technical detail that obliged the team to abandon the audiovisual screens on this front, although they were retained on the one facing onto the square. This choice resulted in an even greater asymmetry between the two main fronts of the Centre. With the elimination of the screens the front on Rue du Renard lost the last echo of a traditional façade, turning into a three-dimensional structure in which the plant acquired an unprecedented visual predominance that started reflecting compositional intentions.

A comparison of the engineers' technical dossier with the architects' slightly later one reveals many compositional variations with regard to the air-conditioning system. (Fig. 6 above) The pairs of vertical ducts were given a symmetrical reconfiguration and many of the technical elements designed by the engineers, such as the conduits for electric cables and "*registres typiques*", were dispensed with entirely. On top of this came both the reshaping along Kahn-esque lines of the air intakes on the roof. Its curved ends echoed the profile of certain towered elements used by Leonardo Savioli, and the plastic design of the "cooling towers", also on the roof.

Despite the abandonment of the audiovisual screens on Rue du Renard, the architects still displayed some uncertainty over the expressive value of the services set in the "three-dimensional wall". The concentration of the plant rooms on this side of the building, where their presence was marked by completely blank walls and the "*registres typiques*", turned the façade onto Rue du Renard into a sort of rear whose aesthetic potential was still not clear.

### **The adoption of a "centralised system solution" and the exposure of the "air-treatment units"**

After in-depth studies that included the development of an independent centralized air-conditioning system for the basement levels,[17] the Délégation rejected the Avant-projet Sommaire and the "local system solution" was dropped for good.[18] The air-conditioning system was criticized not just for its exorbitant cost but also for the excessive size of the plant rooms and the difficulty of deadening their noise for the activities to be located on the "structural decks".[19]

In an attempt to reduce project costs the architects opted for a single large plant room, a solution which Fred Dailey, a service engineer on Barker's team, helped to develop.[20] Given the impossibility of locating this element either on top of the building or in its basement, the architects chose to place the plant room on the lowest "structural deck" so that it would not interfere with the organization of activities at the Centre. To meet the same requirement of flexibility as the "local system solution" provided, the team used a "double duct system", a highly-efficient conditioning plant based on splitting the network of air distribution into two parallel ones carrying heated and chilled air to be mixed in the vicinity of individual rooms in order to create independent microclimates. The conditioning system's new configuration was characterized by the location of the intake and expulsion vents directly on the second floor, behind rectangular grilles, as well as by the splitting of the ducts in both the "three-dimensional wall" and the false ceilings.

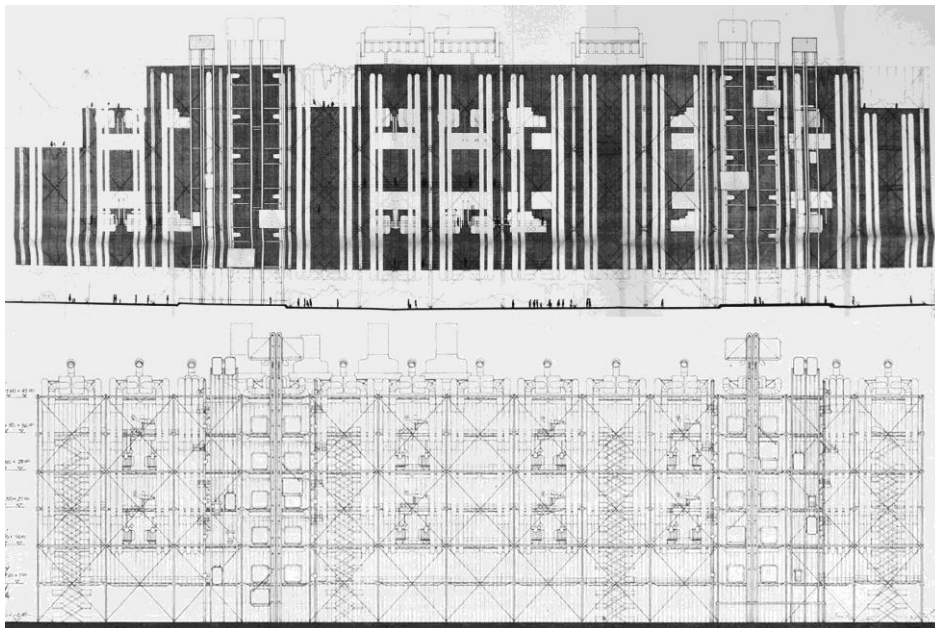
These modifications turned out to have a value beyond mere functional efficiency, heightening the role of the plant as an architectural feature not to be masked by screens. It is just this aesthetic sensibility that explains Rogers's choice to abandon the Vierendeel solution which required the plant to be fitted into a narrow space concealed by a false ceiling.[21] The desire to give the plant more room led Rogers to imagine a beam that could leave the technical members visible and to go for an "open-truss" structure, something he and Piano had already tried out in offices and industrial establishments like the studio-workshop in the Genoese district of Erzelli or the Universal Oil Products plant at Tadworth, UK. The architectural sensibility that was emerging in the

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configuration of the new air-conditioning system already anticipated the character the element would take on in the second *Avant-projet Sommaire*, no longer a technological apparatus to be located at the back of a building but a genuine theme of façade.

**From the conception of clipped-on “air-treatment units” to Laurie Abbott’s “typical bay” scheme**

The new air-conditioning system was employed for the first time in the revised *Avant-projet Sommaire* submitted to the *Délégation* in March 1972.[22] (Fig. 6 below) As a result of the renunciation of the “structural decks” in favor of a version with identical stories supported by Warren trusses, the team could no longer devote an entire floor to the air-treatment units. Out of this came the idea of reducing what had first been conceived as a large plant room on the building’s second floor to an appliance to be hung underneath its slab, directly exposed to view. Configured in this way, the volumes housing the plant assumed the form of suspended equipment, resembling the modular units that Rogers had “clipped on” to the base of his *Zip-Up House*. With the display of treatment units on the outside of the building’s envelope, the idea of making the ducts visible was now extended to all components of the air-conditioning system.



*Figure 7. Piano+Rogers and Ove Arup & Partners, Centre National d'Art et de Culture Georges Pompidou, 1971-77. Rue du Renard elevation in the revised Avant-projet Sommaire and the Avant-projet Détaillé, May-December 1972 (Archives Nationales, Paris; Fondazione Renzo Piano, Genoa).*

Although the architects could only count on still perfunctory technical information provided by the engineers, in the dossier of the revised *Avant-projet Sommaire* and in the one of the *Avant-projet Détaillé*[23] the idea emerged of making not just the ducts visible on Rue de Renard but also all the related technical devices, from the electrical substations to the transformers. (Fig. 7) The design of these elements gradually assumed such importance that



Rogers and Piano decided in the spring to set up the “Superstructure” team to oversee not just the structure but also the design of the “mechanical services”. It is no surprise that the man put in charge of the team was Laurie Abbott, a former collaborator of the Richard+Su Rogers office summoned to Paris for his exceptional talents as a draftsman and his experience in vehicle design—characteristics that would prove crucial to the design of the front onto Rue du Renard. In May 1972 it was precisely his skill in the analysis and representation of complex mechanisms that allowed Abbott to devise a two-dimensional typological scheme, called a “typical bay”, capable of integrating the still uncertain geometry of the ducts with all the new technical systems that were now housed in the “three-dimensional wall”, from elevators and hoists to transformers.[24] (Fig. 8)

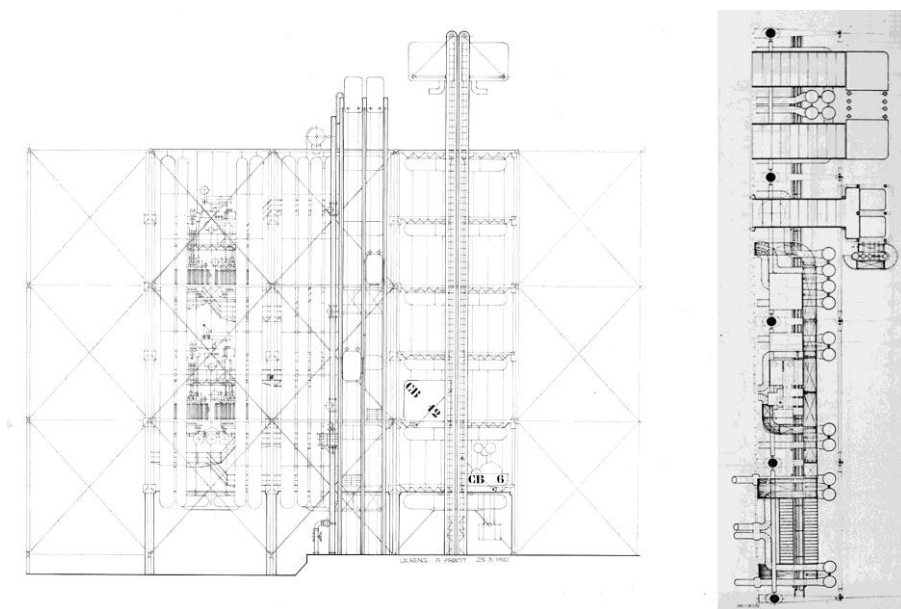


Figure 8. Piano+Rogers and Ove Arup & Partners, Centre National d’Art et de Culture Georges Pompidou, 1971-77. Elevation and plan of the “Typical Bay” scheme (designed by Laurie Abbott), summer 1972 (RSHP Archives, London; Fondazione Renzo Piano, Genoa)

The rate of progress in the summer of 1972 was so rapid that it caused difficulties for the engineers, who were slow to provide designs and detailed information on “overall plant sizes and positions” as well as on the individual components of the plant, from the “cooling towers” to “bulk items such as transformers and HV switchgears...”[25] Things slowed to such a point that Rogers was prompted to call a halt to work on the “mechanical services” owing to the lack of “detailed information”.[26] The deep crisis over the air-conditioning system reflected the value now assumed by this element, which was first mentioned in the reports written by the architects in the summer of 1972. The plant now on show in every part of the building was no longer guided solely by the principle of “flexibility” but had to respond to “the architectural principle...of visual appeal” and to that of “symmetry”[27] in order to make “the technical elements of distribution of energy, conditioning and vertical movement...the architecture of the building”.[28] It is no surprise that in a letter in which Rogers complained about the engineers’ slowness the plant was presented as a fundamental element of the project on which all the other elements of the Centre depended, from the structure to the envelope: a dependence that had nothing to do with statics but alluded rather to a symbolic and visual predominance.[29]

### **The criticism of the Délégation and the humanization of the air-conditioning plant through the reinstatement of the audiovisual screens**

The explicit formal value acquired by the plant prompted criticism from the Délégation and the other authorities involved in the Centre's construction, worried by the appearance the front onto Rue du Renard had now assumed. Evidence for this comes from the comments on the model presented to the interdepartmental council on May 30, 1972, relating to the industrial aesthetic of the front onto Rue du Renard ("large pipes that evoke an industrial building"[30]), and the anxieties of the Délégation, concerned about the hyper-technological appearance the Centre had taken on.[31] One of the observations made by the Délégation is crucial to the understanding of the air-conditioning system's evolution over the following months: the paradoxical visual predominance the air-conditioning systems assumed at the expense of the audiovisual screens, originally conceived as the principal element on Rue du Renard.[32]

The Délégation's comments were reflected in the proposal for reinstatement of the audiovisual screens contained in the *Avant-projet Détaillé* drawn up in the fall of 1972.[33] The restoration of this element did not imply, however, a return to the effect of partial visibility that had characterized the plant in the competition project. Notwithstanding the attempt to re-establish the lost balance between audiovisual surface and technical members, the air-conditioning system had by now acquired such significance that it could no longer be tucked away behind a semi-transparent façade. This was confirmed by the nature of the large vertical screens that Rogers and Piano were planning in collaboration with some of the leading exponents of the avant-garde Op Art movement—sem-transparent panels designed to create "optical effects" by interacting with the technical members behind them, from elevators to ducts.[34] The unprecedented dynamism conferred on the front onto Rue du Renard was a reflection of the team's reaction to mounting criticism from the Délégation and public opinion: not a negation of the industrial aesthetic that was now a feature of every part of the Centre but an attempt to make it human and comprehensible by turning it into a work of art.

### **The evolution of the configuration of the "air-treatment units" on the roof**

The aesthetic sensibility of the air-conditioning system found further confirmation in displacement of the "air-treatment units" on the building's roof, reconfigured, after a series of modifications, as a single opaque and level surface. There were several reasons for this change, including the functional problems connected with locating the air-treatment units just a few meters above the heads of passers-by,[35] but also the desire, still present, to retain the empty space under the building.

Appearing between July and October 1972 in a study model[36] and then in the dossier of the *Avant-projet Détaillé*, the new configuration of the "air-treatment units" was initially conceived as a simple box-shaped module set on each of the roof's thirteen bays. Over the course of 1973, Abbott abandoned the monolithic configuration of the "air-treatment units" and decided to free them of their casing, leaving all their components visible as formally recognizable elements. The compositional and figurative value imparted to the "air-treatment units" over their evolution is clearly discernable in the air intakes, which gradually took on the sculptural shape of industrial chimneys, turning, along with the "cooling towers", into truly monumental elements of the roof. Testimony to the aesthetic value of the "air-treatment units" is provided by the models made by Shunji Ishida, a member of the "Superstructure" team. (Fig. 9) These were produced not just to assess the three-dimensional configuration of the components of the air-conditioning system but also to study its spatial and figurative qualities.[37] This formal sensibility was finally confirmed in the *Projet Définitif* with the reconfiguration of the

“air-treatment units” into six large bipartite modules, each spanning two bays, recognizable precisely by the symmetrical arrangement of the monumental air intakes.[38]

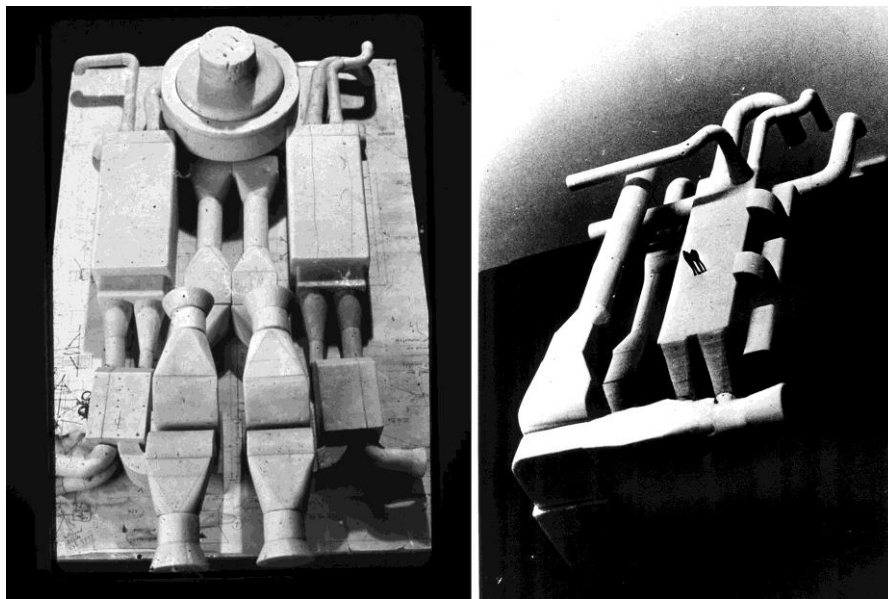


Figure 9. Piano+Rogers and Ove Arup & Partners, *Centre National d'Art et de Culture Georges Pompidou*, 1971-77. Study models of the air treatment units (realized by Shunji Ishida), 1973 (Fondazione Renzo Piano, Genoa; RSHP Archives, London)

### From the fascination with Pop tones to the color code of the Beaubourg's plant

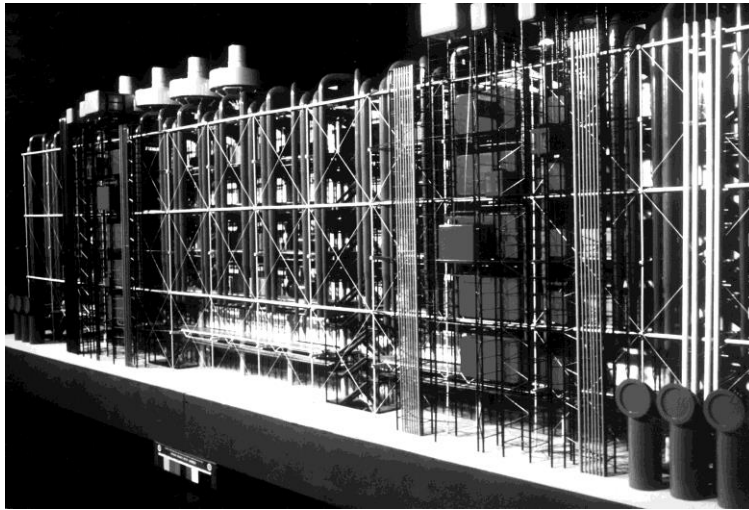
In the final solution presented in the *Projet Definitif* of fall 1973[39] the definitive elimination of the audiovisual screens on Rue du Renard led the architects to opt for another element capable of implementing that idea of comprehensibility and humanization of the technical members: color.

The question of color had already been tackled in the first *Avant-projet Sommaire* with tests based on the use of two Pop colors, yellow and red, amply utilized by Archigram but also by Rogers and Piano, from the structure of Wimbledon House (1966-68) to the roof of the prototype housing in Garonne (1970-71). Employed initially without a clear functional coding, these two shades remained predominant in the color tests carried out between 1972 and 1973. It was only in 1973 that Rogers and Piano, with the assistance of Alan Stanton, turned the Pop palette into a genuine educative and functional code capable of distinguishing the parts of the building and their functions, a solution whose models ranged from Le Corbusier's *Unité d'habitation* (1947-52) to Craig Elwood's Scientific Data Center at El Segundo (1966). In the new color code yellow and dark gray were used for the primary and secondary structure, green for the plumbing, red and blue for the ventilation ducts, orange for the electricity cables and sky blue for the compressed air supply.[40]

Until the end of 1973 all these experiments remained at the level of study tests reserved for the architects. In fact the *Délégation* had set up a committee to make the official choice of colors in December 1971. On it sat not just Victor Vasarely, Carlos Cruz Diez and Yaacov Agam, whose advice had already been sought on the façade's

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audiovisual system, but also Jean-Philippe Lenclos, a French colorist close to Pop Art, and Georges Patrix, a consulting engineer of industrial aesthetics known for the advice on color he had provided to major French industries. The committee opted at first for dichromatic palettes based on the use of color to distinguish elements on a large and small scale, with the exception of the plant, which was to be painted white. These tests would be followed by other variations favored by the committee, this time monochrome and based on, among others, the tones blue de France and khaki Tour Eiffel, in which the team's loss of control over the choice of color was now evident. Conscious of the material and perceptual dullness that these solutions would have imparted to the structure and other elements of the building, the architects succeeded in persuading the D el egation to go back to the functional coding that, apart from a few minor modifications, would be faithfully adhered to in the final version of the building. (Fig. 10)



*Figure 10. Piano+Rogers and Ove Arup & Partners, Centre National d'Art et de Culture Georges Pompidou, 1971-77. Presentation model, 1974 (RSHP Archive, London)*

### **The process of prefabrication and assembly of the plant**

Once the call for tenders for the lots relating to the Centre's different services had been issued, Abbott and Barker set in motion a synergic operational process among the architects, engineers and suppliers based on the possibilities of making technical improvements and aesthetic and formal modifications to the suppliers' shop drawings.

This method was also used for the air-conditioning ducts, consisting of a galvanized-steel core, an intermediate insulating layer and an outer aluminum casing. For the elements' coloring—a complex question that involved technical components made of different materials and by different suppliers, the team resorted to a process of coloring in the factory based on coating with a pigment by electrostatic deposition and subsequent baking.[41] Once prefabrication had commenced, Abbott and Barker set about coordinating the complex procedure of installation. To organize all the people involved in the supply and assembly of the plant the "Superstructure" team produced thousands of coordination drawings, schematic sketches in felt-tip pen used to indicate the positioning, anchorages and connections of each element.[42]

## Conclusions

With the completion of the building in January 1977 the evolution of the Centre Beaubourg's air-conditioning system came to an end. Viewed from Rue du Renard the construction presented the appearance of an unbroken wall of ducts and technical equipment. With the loss of the audiovisual screens, last trace of the traditional façade, the plant gained the upper hand, putting an end to the original balance between structure, envelope and technical members that Piano and Rogers had still sought in the competition project. The plant took predominance over the structure itself, reduced figuratively to slender milky white lines in support of a forest of piping that seemed to stand up by itself and at the same time hold the whole of the building together.

Before the Centre Beaubourg, all the leading architects of the first half of the century, from Le Corbusier to Kahn, had tackled the question of plant, seeking to contain and dominate it through the structure. No longer prepared to be overwhelmed by the structure, the plant erupted to the surface in Paris, turning the architectural object into a mechanical device. With its technical elements animated by an almost zoomorphic dynamism, the Centre Beaubourg took on the appearance of an enigmatic machine, looking almost as if it might get up and join the "walking cities", other mechanical creatures from the same universe.

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- [2] Archives Nationales, 20100307, Art. 19, Piano+Rogers and Ove Arup & Partners Engineers, 'Plateau Beaubourg Centre, Paris', Jun. 1971, p.10.
- [3] Ibid., p.4.
- [4] Ibid., pp.10-2, 14, 16, 19.
- [5] J. Young, Interview by Boris Hamzeian, 25 Jul. 2017.
- [6] *Cinquième Biennale de Paris: Manifestation Biennale et Internationale des Jeunes Artistes, September 30 to November 5, 1967*, Paris: Musée d'Art Moderne de la Ville de Paris, 1967, p.75.
- [7] Piano+Rogers and Ove Arup & Partners Engineers, 'Beaubourg', (Note 2) p.10.
- [8] Ibid., pp.14-9.
- [9] Archives Nationales, 20100307, Art. 19, 'Photographies maquettes'.
- [10] RSHP Archives, CO1/ J0099, ARC84135, 'Notes on a meeting held at the Grand Palais on Monday 19 July 1971'.
- [11] RSHP Archives, CO1/J0099, ARC73729, 'Centre Beaubourg-Programmation. 4 aout 1971'.
- [12] RSHP Archives, CO1/J0002, ARC77586, Piano+Rogers, 'ARAM Module 1971'.
- [13] RSHP Archives, CO1/J0099, ARC84135, M. Goldschmied, 'Notes on meeting on 18 August 1971'.
- [14] RSHP Archives, CO1/J0099, ARC84135, Ove Arup & Partners, 'Notes on meeting held at 21 Ayebrook [sic] Street, London W.1, on 6th October, 1971'.
- [15] RSHP Archives, CO1/J0099, ARC84160, Ove Arup & Partners, 'Centre Beaubourg Avant-projet Sommaire. Environmental Engineering', Oct. 1971.
- [16] RSHP Archives, CO1/J0099, ARC31, Piano+Rogers, 'Centre Beaubourg, November 1971'.
- [17] RSHP Archives, CO1/ J0099, ARC84135, J. Young, 'Service meeting on December 13, 1971'.
- [18] Archives Nationales, 20100307, Art. 97, 'Déroulement des études du Centre Beaubourg, 16 Février 1971', pp.1-2.
- [19] Ibid., pp.11-2.

*The Evolution of the Pompidou Centre's Air-Conditioning System.  
Toward a new figure of architecture.*

- [20] RSHP Archives, CO1/J0099, ARC84135, J. Young, 'Meeting with Fred Dailey on December 23, 1971'.
- [21] RSHP Archives, CO1/J0099, ARC84132, R. Rogers, 'Letter to Ted Happold' 24 Dec. 1971.
- [22] Archives Nationales, 20100307, Art. 217, Piano+Rogers and Ove Arup & Partners, 'Centre Beaubourg', Mar. 1972.
- [23] Archives Nationales, 20100307, Art. 266, Piano+Rogers and Ove Arup & Partners, 'Dessins pour la Consultation de la Commission Régionale des Opérations Immobilières et de l'Architecture (CROIA)', May 1972.
- [24] RSHP Archives, CO1/J0099, ARC71599, L. Abbott, 'Rue du Renard Typical Bay 29 05 1972'.
- [25] Archives Nationales, 20100307, Art. 220, L. Abbott, 'Design coordination meeting Tuesday 20/06/1972'.
- [26] RSHP Archives, CO1/J0099, ARC8132, R. Rogers, 'Letter to Povl Ahm', Jun. 1972.
- [27] Archives Nationales, 20100307, Art. 216, Ove Arup & Partners, 'Construction du Centre Beaubourg, Rapport de Base, Plomberie Sanitaire', 19 May 1972.
- [28] Archives Nationales, 20100307, Art. 266, Piano+Rogers, 'Construction du Centre Beaubourg. Note descriptive', 28 Jun. 1972, p.4.
- [29] Rogers, 'Ahm', (Note 29) p.2.
- [30] Archives Nationales, Paris, 574 AP10, H. Domerg, 'Note pour Monsieur Le Président de la République', 08 July 1972.
- [31] Archives Nationales, 20100307, Art. 214, Paris, R. Bordaz, 'Instructions données aux architectes du Centre Beaubourg par le Président de L'Etablissement Public', 4 Jul. 1972, p.6.
- [32] Ibid., p.6.
- [33] Archives Nationales, 20100307, Art. 219, Piano+Rogers, 'Documents provisoires pour la constitution du Rapport d'Avant-projet Détaillé, 27 10 1972', pp.18-20.
- [34] Ibid., p.19.
- [35] S. Ishida, Interview by Boris Hamzeian, 17 Jul. 2017.
- [36] 'Photographies maquettes', (Note 9).
- [37] Fondazione Renzo Piano, BE1-MOD 5538, 5539, S. Ishida, Photograph of the study model of the air-conditioning system on roof, 1973.
- [38] Archives Nationales, 20100307, Art. 269, Piano+Rogers and Ove Arup & Partners, 'Dessins du Projet Définitif', fall 1973.
- [39] Ibid.
- [40] Fondazione Renzo Piano, BE1-MOD 5412, Piano+Rogers, Photograph of the structure schematic model, Oct. 1973.
- [41] Archives Nationales, 20100307, Art. 129, R. Rogers, 'Letter to Robert Bordaz', 24 Jul. 1975.
- [42] "*Apart from Laurie we were only five at that time, all Japanese. After the tender's results for the air conditioning lot, we had to produce the coordination drawings for the suppliers. We had to help them understand not only how to do the pieces but, most importantly, how to assemble them. This meant thousands and thousands of drawings... It was impossible to prepare proper technical drawings. Laurie started to make them using a black felt-tip pen. No preparatory drawing in pencil, no rules. He was an amazing draftsman, after all. We had to learn from him and soon we all began working like this*". Ishida, Interview (Note 40).