Of Life and Death: The Interior Atmosphere-Environments of the Greenhouse and the Gas Chamber

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This paper considers architecture as the creator of interior atmosphere-environments capable of cultivating spaces conducive to maintaining life through the mediation of variable external stimuli, but equally as possible is the articulation of this potential towards the construction of spaces intent on occasioning death. Architecture conceived with this awareness requires a rethinking of parameters, moving beyond the visual modalities of geometry, composition, icon or style, to instead utilize various qualitative materials like temperature, light intensity, relative humidity, air composition, air pressure, auditory and olfactory stimuli. This understanding is what Reyner Banham has called an "environmentalist" approach.

These two oppositional potentials of architecture's capacity as a creator of atmosphere-environments are considered in this paper first through examining a brief history of the development and design of the greenhouse – beginning as temporary wood structures assembled around planted specimens, to the development of permanent structures incorporating heating and ventilating technologies, to the iconic 19th century greenhouses with their greater use of glass and cast iron structure. In juxtaposition to the greenhouse is an examination of the development and design of the gas chamber – first adopted in the U.S. by the state of Nevada in 1921 pursuant of a more humane method of execution, but later advanced by the Nazis during WWII for the mass execution of Jews, minority groups and political prisoners.

The radical potential of these two opposing typologies of interior meteorological construction, although each originating from substantially different moments and circumstances of history, both technologically mediate the external environment towards the explicit creation of an interior atmosphere-environment intent on affecting inhabitants – how this potential is utilized as this paper describes is dependent upon those in a place of power capable of enacting such effects on life.

Both the greenhouse and the gas chamber are extreme examples of architecture as a form of technological mediation of the external environment through the creation of an internal atmosphere-environment with the principal intention of impacting the life of inhabitants. As argued by the British architectural historian Reyner Banham in 1962,[1] the productive future for architecture is one focused on creating "more fit environments" for human inhabitation and not handsome sculpture or a clever erector set. To further explore this potential, we will first examine the history and design criteria of the greenhouse, a building typology dedicated specifically towards the sustainment and amplification of life – in particular, plants.

GREENHOUSE

While there have been many techniques developed throughout history to "force" the development and production of fruit or vegetable crops, either earlier or later, from their natural growing season,[2] there is evidence that humans have been creating artificial climates for the sustainment of plants since as early as the fifth century B.C. in Greece.[13] The development of the greenhouse as an architectural typology however generally has its origins in the Renaissance, as garden design gradually increased in prominence, reflected in the many garden Villas built near, or north of Rome during this time, and as the first methodological botanical gardens begin to be established throughout Europe in the late 15th and early 16th centuries.[4] Many different varieties of citrus native to south-east Asia, like oranges, limes, and lemons were brought into ancient Europe over many centuries,[5] and in the more Northern parts of Italy and central Europe required some type of system to protect them from the colder winter months. In many cases the solution was to plant the fruit trees in large pots which could be moved indoors or into dry underground caves for wintering.[6] Some of the first dedicated structures aimed at the production of an artificial climate specifically for plants began as temporary wood constructions fitted around and between trees that had been planted outside directly in the ground and organized into rows.[7] [Fig. 1] These temporary structures would also have incorporated a heat source of some kind activated at times of great cold; an open fire or brazier was used in heating orangeries as early as the 16th or 17th century,[8] as well as other

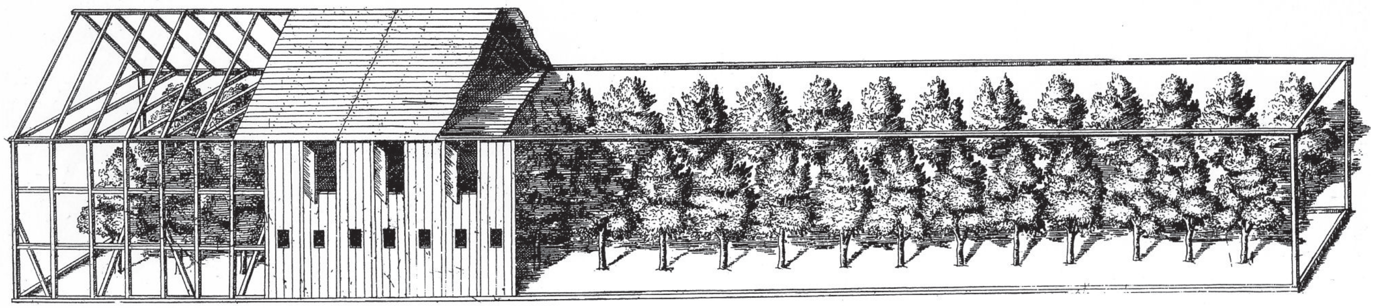

Figure 1. Portable wooden organery, constructed for the Elector Palantine in Heidelberg, engraving by Salomon de Caus, thought to be from 1619. Photo: British Museum.

portable combustion stoves. In an attempt to reduce the cost of assembly and disassembly these temporary structures began to be conceived as more permanent, with fewer removable parts. The plants were surrounded on three sides by permanent walls leaving the south side and the roof as removable elements during the warmer summer months[9] and more generally for ventilation. One significant advantage of a permanent structure was that they could be built more tightly, reducing draughts and increasing the efficiency of the heating system employed, which often required great effort to keep up during the coldest months of the year as it was. With increased interest in garden design, burgeoning global engagement, competitive aristocracies and university institutions, the "glasshouse" came into prominence around 1700 alongside the stone walled orangery.[10] It was in the United Kingdom during the height of empire and global colonialism in the 18th and 19th century that it was most radicalized architecturally, as well as atmospherically, into iconic houses of iron and glass. As the empire spread far and wide access to new and exotic botanicals, as well as many other animals and goods, proliferated, and as these exotic plants were taken back to England their continued survival in such a foreign climate demanded greater architectural and technological innovation.

The lead up to this 19th century apex of the typology was a period of significant technological advancement, facilitated through two primary developments: more sophisticated systems of heating and the maximization of solar exposure through increased use and configuration of glass. These developments transformed what originated as simple protective structures into what we have come to understand today as the advanced interior atmospheric generator of the modern greenhouse – what the influential Scottish botanist and garden designer John Claudius Loudon coined as the creator of the "artificial climate."[11]

While the incorporation of a dedicated heating system was developed from other domestic heating technologies of the time period,[12] it was the greater recognition for the significance sunlight plays in the growth and sustainment of plants, precipitating a desire for maximizing solar exposure through the architectural construct itself – ie. the demand for more transparent surfaces. The greater availability of glass for architectural applications provided a means for increasing the transparency of building surfaces, resulting in larger operable glazed window panels within the vertical wall surfaces and the incorporation of glass into the roof surface itself.[13] What advanced from these strategies of glass incorporation was a kind of blending of the front wall and roof surface into a single south facing glass surface, sloped to maintain a perpendicular angle to the winter sun and leaning against a heavy masonry back wall – a concept J. C. Loudon also examined in *Remarks on the Construction of Hothouses* through an illustrative comparison of twelve greenhouses constructed over the previous almost one hundred years. [Fig. 2] With these observations in mind the section of the greenhouse, and in particular the slope of the primary south facing wall, could be calibrated based upon an understanding of fostering a perpendicular angle between the glazing and the sun's radiation dependent upon the latitudinal location of the structure, the type of crop one was aiming to cultivate, and the time of the year desired for ripening. In this way the articulation of the architecture is directly informed by the necessary requirements of the plant life it encloses, mediating the particular external environmental conditions to create the most desirable interior atmosphere-environment for the sustainment and production of the plant life in question.

Further on in *Remarks on the Construction of Hothouses* Loudon discusses a proposal for what he called a "forcing-house for general purposes," which included a "ridge and furrow disposition of glass" capable of being applied as vertical

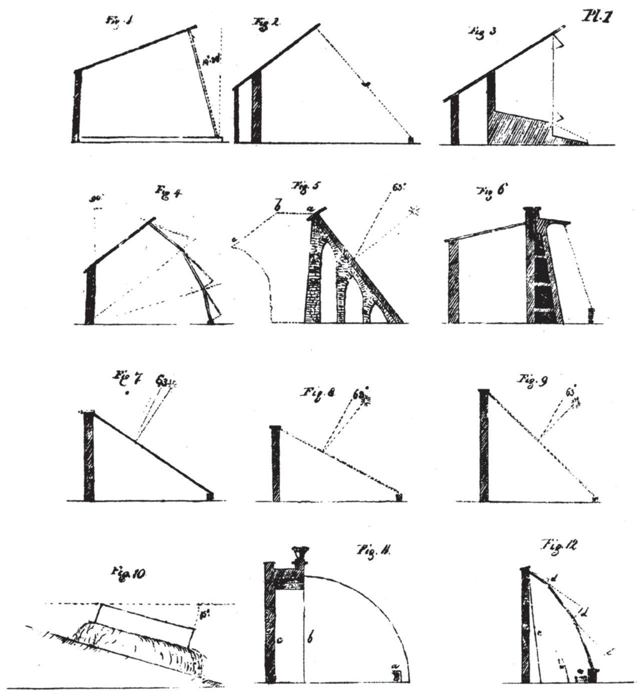

Figure 2. J. C. Loudon, greenhouse comparison in section. From: J. C. Loudon, *Remarks on the Construction of Hothouses,* London, 1817.

glazing or as roofing.[14] The benefits of such pleating, a simple, but ultimately radical configuration of the glass panels, was to maximize the perpendicular alignment of the glass with two daily solar meridians, one taking place earlier in the morning and another later in the afternoon, both moments when the sun's rays are less intense. During the middle of the day the sun's radiation would not be perpendicular with any glass surface, but its power will also be at its most intense, so Loudon argued "the loss sustained will be more than counterbalanced by the earlier and later meridians, which give a double chance of obtaining the sun's full influence in cloudy weather, and prolong his influence in clear weather."[15] The historian John Hix writes of Loudon that "[His] conceptions had the sophistication of an engineer creating environment control machines"[16] and that his proposal of the ridge-and-furrow glazing configuration greatly influenced the most recognized greenhouse designer of the 19th century, Joseph Paxton.

It was to be Paxton, the seventh son of a Bedfordshire farmer who at age fifteen became a garden boy at Battlesden, the seat of Sir Gregory Page-Turner[17] who would be responsible for some of the most iconic glass and iron structures of the 19th century.[18] It was however a relatively modest structure by comparison, his Victoria Regia House at Chatsworth, that could be regarded as his most substantial architectural achievement. It's precision in creating a specific, and intentioned, interior atmosphere-environment concerned with supporting life, but also its structural and technological precision that set it apart. Reyner Banham described the Crystal Palace as "little more than a by-product, an epiphenomenon, of [Paxton's] output of controlled environments for 'the vegetable tribe,'" and it was his Victoria Regia House that Banham proclaimed was "Paxton's masterpiece."[19] The structure preceded the Crystal Palace by one year and influenced greatly both the roof structure and cast-iron façade of the massive exhibition building.[20]

The Victoria Regia house, completed in 1850 at Chatsworth for the Duke of Devonshire, was designed specifically to support the most exhilarating aquatic plant of the mid 19th century, the South American giant water-lily then named Victoria Regia. Despite much attention the plant proved very difficult to cultivate outside its native tropical habitat; seeds were planted at Kew Gardens in 1849, but did not develop beyond seedlings and consequently the attainment of its bloom became the great prize for gardeners and botanical collectors of the day. In his 1962 essay "The Environmentalist" Banham describes his assessment of the plant as follows:

> *Victoria Regia* was a typical botanical white-hunter's prize specimen of the period – the largest, dreariest, showiest and most pointless aquatic plant ever negligently produced by the processes of natural selection. But also the most demanding environmentally and the most instructive structurally – and Paxton responded to its overblown challenge by creating the extreme micro-climate it demanded, packaged in a structure modelled on that of the plant itself.[21]
>
> —Reyner Banham, *"The Environmentalist"*

Despite Banham's lackluster enthusiasm for the lily itself, his assessment provides a sense of the plant's environmental need for an exceptionally well-conceived and well controlled interior atmospheric space, but also, the unique potential of its natural "structure" to inform Paxton's solution for a roof system design that was strong, but also light and materially efficient. In a lecture to the Royal Society of Arts in November of 1850, Paxton himself conceded the inspiration for the roof structure, an almost complete version of the modern space-frame, did indeed come from the plant itself.[22] In his comprehensive book *The Works of Sir Joseph Paxton*, George Chadwick describes

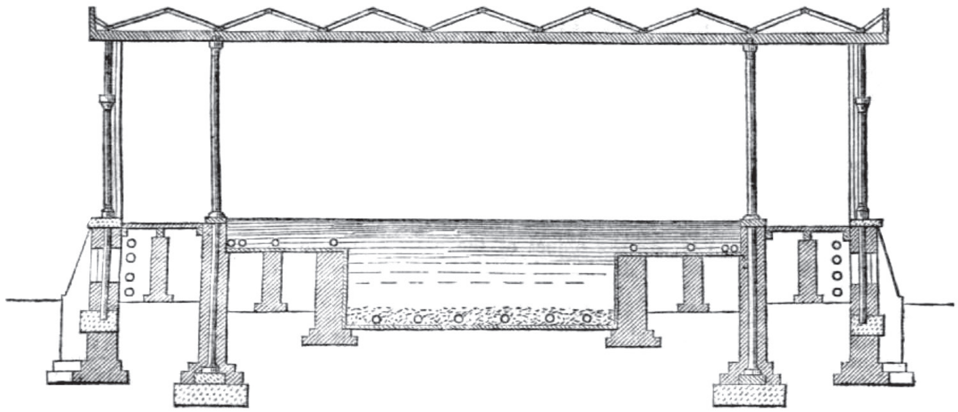

Figure 2.—TRANSVERSE SECTION.

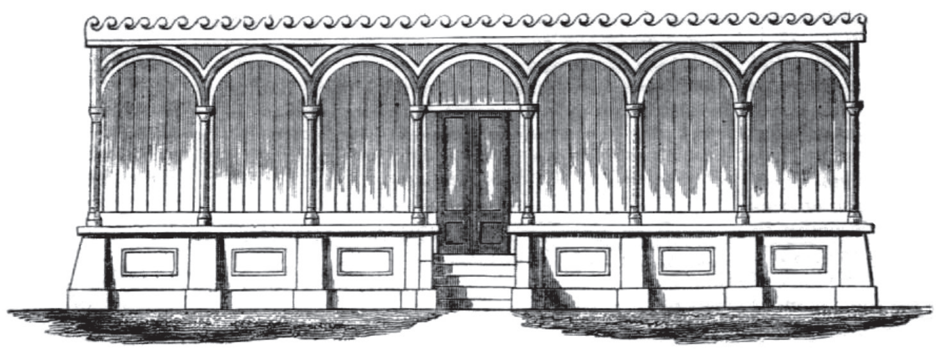

Figure 3.—END ELEVATION.

Figure 3. Section and elevation of Paxton's Victoria Regia House a Chatsworth. From: Joseph Paxton, "Description of the Victoria Regia House at Chatsworth," The Gardener's Chronicle 10, (August 31st, 1850): 548.

the structural significance of the lily's leaves in the following way: "The leaves of the great lily were formed of a flat upper surface supported by a series of webs like miniature cantilevers touching only intermittently; yet they would bear a considerable weight, as Paxton found when he put it to the very practical test of placing his own daughter Annie, then seven, on one."[23]

It was in the Victoria Regia House at Chatsworth that "Paxton's roofing system had reached its final perfection: the simplest, lightest, and most economical form of roofing then seen."[24] In a description of the building published on August 31st, 1850 in *The Gardener's Chronicle*, Paxton compared the house's roof design to his earlier conservatory on the Chatsworth estate in the following way: "…since that time the improvements in different branches of manufacturers enabled me to make the present Lily-house (though comparatively small) of a much more light and elegant appearance."[25] Paxton achieved this lightness and elegance through the efficiency of the overall design, creating a hierarchy between the different horizontal members arranged perpendicular to one another and on two different planes – one plane composed of his integrated and adjustable gutters, on the other running in the opposite direction, the primary supporting girders.

> The four 54-foot master joists, which extended over the pool in 34-foot clear spans, were wrought iron beams 5 inches deep, reinforced by 1-inch-diameter round steel bars. They were supported on eight hollow cast-iron columns 3 ½ inches in diameter. The Paxton gutters, spanning 11 ½ feet, lay across these master joists and carried the ridge-and-furrow roof.[26]
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> —Georg Kohlmaier and Barna Von Sartory, *Houses of Glass*

It was however not the roof system's material efficiency or strength per se that was of greatest consequence to the lily, it was the resulting transparency achieved through such a light system that was most consequential. "Paxton's aim to make a building that would exploit to the full its load-bearing capacity, partly for the sake of economy but particularly to achieve maximum transparency of the roof."[27] These lighter, thinner and less frequent load bearing elements provided both a maximization of open glazing, which also had compartments on hinges that could open "by simple machinery, for the purposes of ventilation,"[28] but also greatly contributed to a literal and phenomenal atmospheric lightness within the interior. Combined with the fully glazed façade walls, made up of separate equally spaced cast-iron columns, 6 feet 6 inches center to center, and connected by cast-iron arches, the exterior vertical surfaces of enclosure became equally environmentally dematerialized. The façade columns were also intentionally set forward of the glazing surface creating a compressed depth to the façade, emphasizing the vertical elements and separating out the various layers of the enclosure.[29]

In the Victoria Regia House, it seems the utilization of this early "space-frame" roof, effectively allowed for a structural disconnection between the vertical and horizontal systems, a cantilevered system only really feasible with a two-way multi-layer structural system. While Paxton was likely perhaps unaware of the future potential for such a disconnection between roof and wall, it is clear from how the project was drawn and hatched in section, as published in the 1850 *Gardener's Chronicle* article, that he was clear of the separation and hierarchal logic between the vertical and horizontal systems. [Fig. 3]

Although many of the technical architectural components of the house had been developed, at least in principle, in Paxton's previous projects or proposals, the *Victoria Regia* plant species presented a set of requirements distinct from the other greenhouses he had designed. It was a species of "water-lily" requiring predominantly aquatic medium, typically residing in shallow waters with its shoots extending down to the soil below. At the time of the completion of Paxton's Victoria Regia House in 1850 there had been no other aquatic house built that was as finely tuned and calibrated to the construction of an atmosphere-environment conducive to this most difficult of water lily species.[30]

Paxton's sectional design of the aquatic tanks and the systems required to create the necessary thermal conditions of the pools, as well as the interior atmosphere-environment were equally as sophisticated as his structural design for the ridge-and-furrow "space-frame" roof. George Chadwick describes them succinctly in the following way:

> A consideration of the lily house would be incomplete without a further reference to its inhabitants and the ways in which their comfort and wellbeing were secured. Apart from the main tank there were eight smaller tanks in the angles of the house which held other aquatics: *Nymphaea*, *Nelumbium* and *Pontederia*. The main tank had a central deeper part, 16ft. in diameter, which contained the soil for *Victoria*; embedded in the soil were 4 in. diameter iron heating pipes, whilst 2 in. diameter lead pipes were placed in the shallow part of the tank. The house as a whole was heated by a system of 4 in. iron pipes running round inside the basement walls. Thirty openings between the piers of the basement wall allowed for low-level ventilation, and opening lights in the roof "made to open by simple machinery" gave additional ventilation when required. Four small water-wheels were provided in Victoria's tank to give gentle motion to the water and a cold water supply was placed above each so that the water temperature could be modified as required, (average tank temperature 83°- 85°F, house 80° - 90°F).[31]
>
> —George Chadwick, *The Works of Sir Joseph Paxton*

The conception, design and execution of the house reflected an architecture completely focused on the propagation and affirmation of life, in the case the very specific life of the South American giant water-lily, but it is not too much of a leap to extend Paxton's thinking towards other possible inhabitants, including human beings.[32] To extend Paxton's "environmentalist" approach would be to rethink many of the parameters of design to help better cultivate human experience, human physiology, human psychology and most importantly to cultivate a better relationship with the changing external environment within which all life finds itself living. For Banham what was so significant about Paxton was his ability to maintain a "broad, holistic vision of the landscape" and "sense of ecological wholeness in the human environment," while continuing to provide "an enquiring, experimental grasp of technology" towards advancing the quality and effectiveness of the artificial environments he created.[33] This is the approach that prompted Banham to describe Paxton as "the first great environmentalist," a necessary and fundamental alternative to what he referred to as the "School of Philadelphia" and its "phoney monumentalism" of the early 1960's.[34] What Paxton's "environmentalist" approach exemplifies is a radical reconsideration of how architecture understands both the internal atmosphere-environment it directly manifests, but also, and perhaps even more importantly, the external environment within which it participates. The "environmentalist" approach requires the *explication* of the environment itself as the possible locus of design.

GAS CHAMBER

The potential to construct an inter-active architecture through the explication of the environment is, in and of itself, a neutral endeavor, capable of being used towards the propagation of life as much as it could be implemented towards its extermination.

The contemporary German philosopher Peter Sloterdijk has pinpointed what he claims is the modern explication of the atmosphere-environment to a singular historical event that took place in the time between the establishment of the two architectural typologies under discussion, the greenhouse and the gas chamber. In his book *Terror From the Air* Sloterdijk describes the 20th Century's "discovery of the 'environment'" through the inaugurating use of toxic chlorine gas on April 22, 1915 by the Germans against unsuspecting French-Canadian troops in the northern Ypres Salient.[35] For Sloterdjik the creation of this "unlivable milieu" marks the fundamental moment where, through intentioned design and technical application, the atmosphere-environment became *explicit*, no longer subjugated as simply "background givens," but now itself the potential locus of design. As Sloterdijk states "…by means of gas terrorism, modern technics crossed over into the design of the non-objective – it came to include the explication of *latent* topics such as physical air quality, artificial atmosphere additives, and other factors of climate creation for places of human-dwelling. It is precisely this process of progressive explication that binds terrorism with humanism."[36] For Sloterdjik the event at Ypres Salient marks the confluence of the three defining aspects of the 20th century: terrorism, product design and environmental thinking; a triad of atmosphere-explication and reactionary action intent on surprise, destruction and death. [Fig. 4] This binding of terrorism and humanism now remains ever present, because to explicate the atmosphere-environment, a fundamental condition for human life, is to reveal that something once invisible, has now, through acts of terror /war, become the possible locus for design. Capable of either affirming or denying life itself. After the war ended in November of 1918 the "non-objective" design of the atmosphere-environment intent on death continued virtually undeterred, but towards alternative entrepreneurial applications. The use of these deadly gas technologies developed for war, were applied towards "productive" applications in industry, and even towards the implementation of a higher standard of health and cleanliness advertised for the benefit of humanity. The "peaceful use" of these gas technologies and their further development into new products was quickly leveraged for profit, being recast as innovative and totalizing solutions to pest control, including bed bugs, the common mosquito, flour moths, and lice.[37]

Despite the development and use of toxic gas as a weapon for the battlefields, these peacetime applications instigated thinking in both the scientific and legal establishments for its potential use as a "humane" form of capital punishment in the United States, an alternative to hanging, firing squad and electrocution. In fact, this thinking actually predated the war by some time; starting in the late 19th century American's were interested in more humane alternatives for administering the death penalty. The New York State commission whom issued a report in 1888 evaluating various potential methods of execution, briefly considered the basic idea of using lethal gas as a humane method, but ultimately recommended electrocution as the preferred method of death.[38] There was a second brief consideration of lethal gas during this time after some early electrocutions brought disturbing results. The Medical Society of Allegheny County, Pennsylvania, in the winter of 1896-97, concluded that poisonous gas would be more humane than electricity, and that hypothetically if a prisoner's cell could be made airtight, then the lethal gas could be released into his room at night when the prisoner was asleep.[39] "The benefits to the prisoner would be twofold: he would die without experiencing pain, and he would be spared the anxiety of attending a ceremony devoted to his own death."[40] However, as electrocutions ran more smoothly, interest in using lethal gas and the development of a space capable of creating such an "unlivable" atmospheric milieu, faded. This changed in early March, 1921 when the legislature of Nevada, a sparsely populated western state largely controlled by mining interests, quickly passed the Humane Execution Bill allowing for execution by lethal gas, which was then signed into law by Governor Emmet D. Boyle on March 28th, 1921.[41] While the bill did not provide specifics about how exactly to administer the lethal gas, or even what specific gas should be used, its signing required that a suitable cell be constructed and that "the warden, a competent physician, and six other citizens must witness the execution"[42] effectively leaving all other details for the prison officials to work out.[43] According to reports in the New York Times contemporaneous to the bill's signing, as well as from proponents of the law, the expectations were that condemned prisoners would be administered the lethal gas one night "while asleep in their cells, without ceremony, in the sight of a small number of spectators."[44]

Attention then turned towards the design of a space capable of effectively administering the lethal gas and creating the necessary atmosphere-environment, while still allowing spectators to view the execution, but also, importantly, protecting them from its detrimental effects. This last, very real, consideration was only necessary in the use of the gas chamber as a method of execution and reflects how the explication of the atmosphere-environment required a very different conceptual understanding of the potential for architecture to effect human inhabitants in ways previously unconsidered. [Fig. 5] While the idea of administering the gas during sleep sought to uphold the

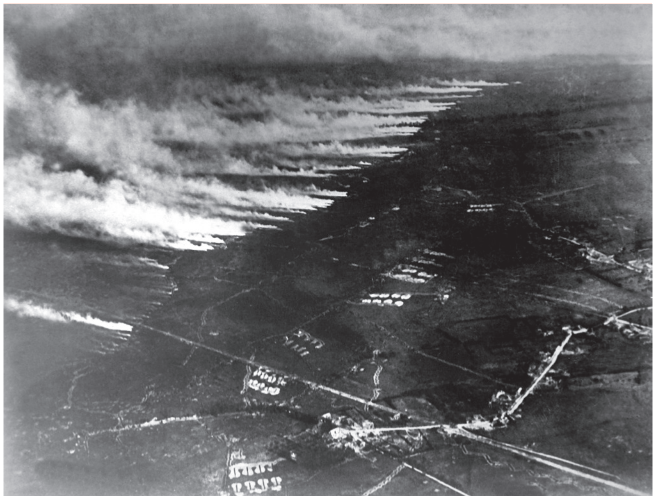

Figure 4. French soldiers making a gas and flame attack on German trenches in Flanders, Belgium, ca. 1918. From: Photographs of American Military Activities, made available in the holdings of the National Archives and Records Administration, catalogued under the National Archive Identifier (NAID) 530722. https://catalog.archives.gov/id/530722.

narrative, and possibly the action, of a more humane method of execution, it generally proved to be impractical.

> To satisfy the twin goals of humanity and visual display would have required an airtight cell large enough to live in for several days, with thick glass windows along one wall, and with two systems of valves, one for ventilation during the prisoner's last days and the other for releasing the gas. Prison officials settled for a small airtight chamber, just large enough to hold a wooden chair, with a window through which spectators could see the prisoner's head.[45]
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> —Stuart Banner, *The Death Penalty*

The small physical size of the chamber, the limited ability to accommodate spectators[46] and the necessary technical expertise required to carry out the gas executions, all demanded that the event take place within the existing confines of the prison itself, instead of outside within the public sphere which was historically the tradition with hangings. While electrocution also shifted the space of execution into the prison the possible adverse effects to spectators by threat of the gas chamber malfunctioning and its technical requirements of operation greatly reduced the number of potential spectators. This change in location and public participation effectively re-framed the literal and symbolic meaning of fulfilling the death sentence, shifting the onus of the action from one of community justice, to one of state authority and power.[47]

A decade after executions by lethal gas were being carried out in Nevada its accepted use began to spread and so did knowledge of how to most efficiently, and seemingly effectively, carry out the action. The sequence of steps the prisoner would enact during the execution were even so predictable that in the state of Missouri the prison physician had a printed form listing out each step with blank spaces to record the time it had occurred. "Prison officials knew for certain that the head would fall forward, then backward, and then forward again."[48] The fact that within a matter of seconds from inhaling the gas most prisoners appeared to just fall asleep, along with the procedure's predictability, both reinforced the idea of the gas chamber as a "matter of practical social reform."[49] In this sense, as Sloterdijk describes, the use of the gas chamber as first developed in Nevada reflected the realization of a "modern" explication of the human dependency on the atmosphere-environment. As he says: "In this field, 'modern' can be defined as that which promises to combine a high level of efficiency with a sense of humanity – in the case at hand, through the use of a quick-acting poison administered to delinquents."[50]

Despite having its practical origin in the terror gas attacks of World War I, the creation of an atmosphere-environment intent on death facilitated through the contained and technologically mediated construction of the gas chamber, made it possible to reframe this action, not as one of war, but one of humanity; both for the prisoner destine to be executed, but also in the fulfillment of justice for the victims afflicted. The historian Scott Christianson describes this transformation in the following way:

> Although the world had recently undergone the horrors of chemical warfare, advocates of gassing claimed that the poor soldiers on the battlefield had suffered more because of low concentrations and other conditions, whereas a lethal chamber would provide highly concentrated doses in an enclosed space, thereby ensuring a quick and painless death.[51]
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> —Scott Christianson, *The Last Gasp*

Despite its increased adoption and use exclusively in Western and Southern states[52] over the following two decades after 1921, its use had many challengers who questioned its effectiveness and ability to deliver a peaceful death.[53] In the United States by the early 1950's, as a greater understanding of the Nazi atrocities carried out during the second World War and their reliance on the gas chamber as a mechanism for mass human extermination had come more fully to light, it had "acquired an extremely bad reputation,"[54] the perception of its so-called humanity radically shattered.

The Nazis' implementation of the gas chamber as it regards the explication of the environment towards the destruction of life through specific atmospheric construction, was fundamentally in line with the earlier developments of lethal gas as a method of capital punishment in United States. Their use was in many ways less advanced, relying often on the retrofitting and conversion of existing structures to carry out the action,[55] carrying out executions without much knowledge or concern for those being killed. Most significantly their use of the method cared only for how to most expediently induce mass death, without any pretense of humanity. The Nazi gas chamber was a mechanical "answer" to the "question" of how to most efficiently and effectively conduct mass execution, genocide, of Jews, gypsies, political dissidents, prisoners of war and any other minority groups felt to be unworthy – there was no justice being served through the advancement of death, it was only death. The radical potential of these two opposing typologies of interior meteorological construction, although each originating from substantially different moments and circumstances of history, both technologically mediate the external environment and articulate an explicit reconsideration of creating an interior atmosphere-environment intent on affecting inhabitants – how this potential is utilized as this paper describes is dependent upon those in a place of power capable of enacting such effects on life

ENDNOTES

1. "The more we see of architecture, the more we are forced to realise that the only progress in the field is in making more fit environments for human activities, and that no building that can't offer this is really worth a second look as architecture, even though it may be a handsome sculpture, *á la* Kahn, or the cleverest erector toy in the world, Wachsmann-fashion." (Reyner Banham, The Environmentalist *Program* Spring 1962, 59).
2. The main concept is to increase the temperature of the soil and the amount of solar exposure beyond what the external environment naturally fosters. "Using all the techniques at their disposal, Roman gardeners employed the principle of forcing growth by making hot-beds, either by digging pits in the ground, or by constructing raised beds surrounded by a low brick wall and filling them with manure. A third option was to make a bed on wheels, a giant wooden wheelbarrow that could be trundled in and out." From Mary Woods and Arete Swartz Warren's book *Glass Houses: A History of Greenhouses, Orangeries and Conservatories* (New York: Rizzoli International Publications, 1988) 3.
3. John Hix, *The Glass House* (Cambridge, MA: The MIT Press, 1974) 9.
4. Hix, *The Glass House,* 9.
5. Mary Woods and Arete Swartz Warren, *Glass houses: A history of greenhouses, orangeries and conservatories* (New York: Rizzoli International Publications, 1988) 3
6. Woods and Swartz, *Glass Houses*, 4-5.
7. "This principle was in widespread use, as ground-planted trees are taller and bushier with more flowers and fruit, and in many ways easier to grow for they do not need constant watering. The disadvantage was that erecting the winter house every year must have been a major performance…" Quited from Woods and Swartz, *Glass Houses*, 5.
8. Hix, *The Glass House,* 30.
9. Georg Kohlmaier and Barna Von Sartory, *Houses of Glass: A nineteenth-century building type* (Cambridge, MA: MIT Press, 1986) 43
10. Kohlmaier and Sartory, *Houses of Glass*, 43
11. Hix, *The Glass House,* 29
12. These early heating systems were developed from other domestic heating technologies of the time period, originating from simple in room iron stoves, to more elaborate extended flue systems, to the use of boilers for steam and hot water pipes
13. Hix, *The Glass House,* 16.
14. John Claudius Loudon, *Remarks on the construction of hothouses, pointing out the most advantageous forms, materials, and contrivances to be used in their construction; Also a review of the various methods of building them in foreign countries as well as in England* (London: Printed for J. Taylor by R. and A. Taylor, 1817) 23.
15. Loudon, R*emarks on the construction of hothouses*, 24.
16. Hix, *The Glass House*, 20.
17. George F. Chadwick, *The Works of Sir Joseph Paxton, 1803-1865* (London: The Architectural Press, 1961) 15.
18. Still today his grand works like the Great Conservatory at Chatsworth (1836-40), and his two versions of the Crystal Palace, first constructed at Hyde Park (1851) and then reconstructed on Sydenham Hill (1856), are generally considered among the most important buildings of the second half of the 19th century. This is a point Reyner Banham explicitly discusses in his essay "The Environmentalist" challenging the acceptance of the Crystal Palace specifically as "the first great monument of modern architecture," instead arguing that despite its advanced use of materials and methods, its "architectural conception had vastly more to do with the period before 1851 than the period after it." This argument however specifically concerning the Crystal Palace's proper place in history did not take away from Banham's regard for Paxton's 18th century holistic view of the natural environment as a designer capable of constructing highly effective interior climates of botanical habitation. See Reyner Banham, "The Environmentalist" *Program* 2 (Spring 1962): 57-64.
19. Banham, "The Environmentalist," 62.
20. Kohlmaier and von Sartory, *Houses of Glass*, 225. In an article published on August 31st 1850 in *The Gardener's Chronicle* Paxton himself describes how the Victoria Regia House proved specifically inspirational towards the design of the Crystal Palace. "It occurred to me that it only required a number of such structures as the Lily-house repeated in length, width, and height, to form, with some modifications, a suitable building for the exhibition of 1851." See Joseph Paxton, "Description of the Victoria Regia house at Chatsworth" *The Gardener's Chronicle*, Vol. 10, 1850, pg. 549.
21. Banham, "The Environmentalist," 62-63.
22. See Paxton's lecture to the Royal Society of Arts, Nov. 1850. *Transactions*, vol. LVII, 1850-51, pg. 1.
23. Chadwick, *The works of Sir Joseph Paxton*, 101.

24. Chadwick, *The Works of Sir Joseph Paxton*, 101.
25. Joseph Paxton, "Description of the Victoria Regia House at Chatsworth," *The Gardener's Chronicle* 10, (August 31st 1850): 549.
26. Kohlmaier and von Sartory, *Houses of Glass*, 226.
27. Kohlmaier and von Sartory, *Houses of Glass*, 226.
28. Paxton, "Description of the Victoria Regia House at Chatsworth," 548.
29. Again, from Paxton's description in *The Gardener's Chronicle* of 1850; "By this section it will be seen that the upright sashes are placed behind the cast iron columns, so that the shafts of the pillars are isolated." Paxton, "Description of the Victoria Regia house at Chatsworth" pg. 548.
30. In the end Paxton, even before the dedicated house had been built at Chatsworth, who was the first to be able to effectively grow and eventually bloom the species, presenting the first English grown bloom and leaf to the Queen and Prince Albert at Windsor castle on November 8th 1849. Hix, *The Glass House*, 50.
31. Chadwick, *The Works of Sir Joseph Paxton*, 102.
32. While the recent idea of the "smart home" might to some reflect just such a strategy, it in fact cultivates an interior environment completely foreign to the actual needs of humans, instead promoting new forms of capitalization, marginalization and subjugation.
33. Banham, "The Environmentalist," 60-61.
34. Banham, "The Environmentalist," 64
35. Peter Sloterdijk, *Terror from the air*, trans Amy Patton and Steve Corcoran (Los Angeles: Semiotext(e), 2009) 10.
36. Sloterdijk, *Terror from the air*, 24-25. Italics added here for emphasis.
37. Sloterdijk, *Terror from the air,* 30.
38. Stuart Banner, *The Death Penalty: An American History* (Cambridge, MA: Harvard University Press, 2002) 196.
39. Banner, *The Death Penalty*, 196.
40. Banner, *The Death Penalty*, 196.
41. Scott Christianson, *The Last Gasp: The Rise and Fall of the American Gas Chamber* (Berkeley, CA: University of California Press, 2010) 63.
42. Christianson, *The Last Gasp*, 63.
43. Banner, *The Death Penalty*, 197
44. Banner, *The Death Penalty*, 197.
45. Banner, *The Death Penalty*, 197.
46. Stuart Banner makes the argument in his book *The Death Penalty: An American History*, that the limitations of the physical space required for economic efficiency and the safety of spectators, as well as what seemed to be the desire by States limit viewings primarily to state officials, contributed to the insular nature of the lethal gas method of execution. He also makes the point that like the electric chair, the gas chamber reinforced the small world of capital punishment as an exclusively male domain. See Stuart Banner, *The Death Penalty: An American History* (Cambridge, MA: Harvard University Press, 2002) 204.
47. Banner, *The Death Penalty*, 206.
48. Banner, *The Death Penalty*, 202.
49. Christianson, *The Last Gasp*, 1.
50. Sloterdijk, *Terror from the air,* 39.
51. Christianson, *The Last Gasp*, 63.
52. Banner, *The Death Penalty*, 199.
53. Scott Christianson recounts that "By December 1937 national discussion about the pros and cons of lethal gas had become so widespread that *Reader's Digest* published a comparison of the arguments." One side arguing that it was "practically foolproof" and the other arguing that the method was "neither painless nor easy to watch." See Scott Christianson, *The Last Gasp: The Rise and Fall of the American Gas Chamber* (Berkeley, CA: The University of California Press, 2010) 121.
54. Christianson, *The Last Gasp*, 171.
55. The first use of lethal gas in a chamber at Auschwitz took place in late 1941, when Zykon B, originally utilized for delousing and pest fumigation, was used on 250 "incurable" inmates and 600 Soviet prisoners of war. The gas was administered in the existing basement of block 11, which proved problematic for the Nazis as it lacked ventilation and was at too great a distance from the existing crematorium. See Jean-Claude Pressac and Robert-Jan Pelt, "The Machinery of Mass Murder at Auschwitz" in *Anatomy of the Auschwitz death camp,* ed. Yisrael Gutman and Michael Berenbaum (Bloomington: Indiana University Press 1994) 209, and Christianson, *The Last Gasp*, 152.

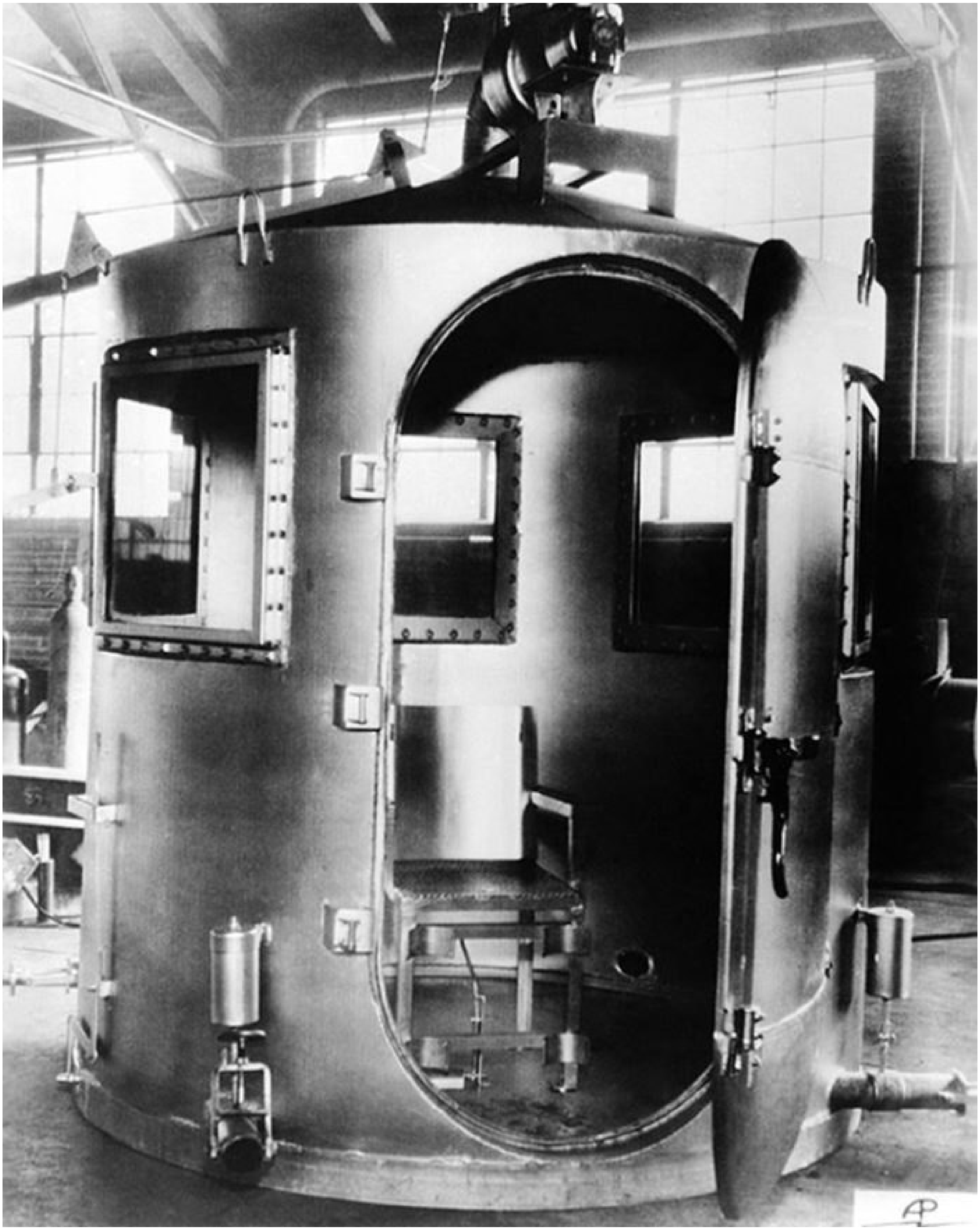

Figure 5. Wyoming's gas chamber on Nov. 17, 1936. From: AP Photo.