



Figure 1. Image combining, Iglesia de Cristo Obrero (Church), Silo CADYL, and Deposito Julio Herrera y Obes (Warehouse). Images from FADU medio audiovisuales archive and Jesse Elliott.

A Church, a Silo, and a Warehouse

Eladio Dieste's Gaussian Vaults and the Workers of the Encofrados

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Traditional architectural history and theory discourse is built from the narratives of prevailing styles, renowned figures, and seminal buildings. This paper follows contemporary calls to center architectural discourse around the historical politics of labor and the legacy of construction workers. In this paper, labor is the collective organization of human force that enables the time-based, material production of built structures.

The pedagogical focus of this paper is grounded in the construction labor used to build Bóvedas Gausas (Gaussian Vaults), one of the structural innovations developed by the Uruguayan engineering and construction practice, Dieste and Montañez S.A. Intrahistorias, Miguel de Unamuno's epistemological mechanism for uncovering anonymous histories, and Ariella Azoulay's notion of "potential histories" are the lenses used to study the relationship between workers and the design of encofrados (formwork/scaffolding) used to construct the vaults of three structures: Iglesia de Cristo Obrero (Church), Silo CADYL (Silo), and Deposito Julio Herrera y Obes (Warehouse).

Without preserving anachronistic forms of labor, the student work presented in this paper injects construction history with a diverse set of intrahistorias and potential histories. Studying the Dieste and Montañez S.A. Archive, students made virtual computer models of the encofrados used to build the Church, Silo, and Warehouse. These models extend the edges of historical documents and construction images collected in the archive. Crafting a new set of images that connect this engineering and construction practice to the legacy of immigrant workers in South America is central to this ongoing labor-based project.

INTRODUCTION

During the second half of the twentieth century, the Uruguayan engineering and construction practice, Dieste and Montañez S.A., constructed over one million square meters of Cerámica Armada (Structural Ceramics) in Uruguay, Argentina and Brazil. Eladio Dieste, an engineer, and one of the founders of Dieste and Montañez, was primarily responsible for the repertoire of steel-reinforced masonry innovations that were used to build a range of structures. These innovations were categorized into four types: Gaussian Vaults, Ruled Surfaces, Self-supporting Vaults, and Folded Plates. Each thin-shell structural system was designed to resist gravity through form without resorting to what Dieste called, "the awkward accumulation of matter."¹ This paper focuses on two variations of gaussian vaults used to build three different structures: Iglesia de Cristo Obrero, Silo CADYL, and Deposito Julio Herrera y Obes (Figure 1).

Though a recent surge of interest in Dieste's work has supported calls to expand the architectural canon in the Americas, much of this attention seems disinterested in addressing why Dieste's work continues to resist simple classification. The work has been called modern, proto-digital, regionalist, and other kinds of stylistic categorizations. Structural audacity, sensorial effects, and technocratic materiality continue to be the primary frames used to categorize, study, and admire the work of Dieste and Montañez. There is no denying that the structures are photogenic, lending themselves to a bevy of online pinterest boards and instagram accounts. Underlying this admiration—and minor social media stardom—are the bodies and minds of workers, primarily Italian and Spanish immigrants who labored over the construction of these structures. It is this labor that is reflected in Dieste's notion of Economía Cósmica (Cosmic Economy).

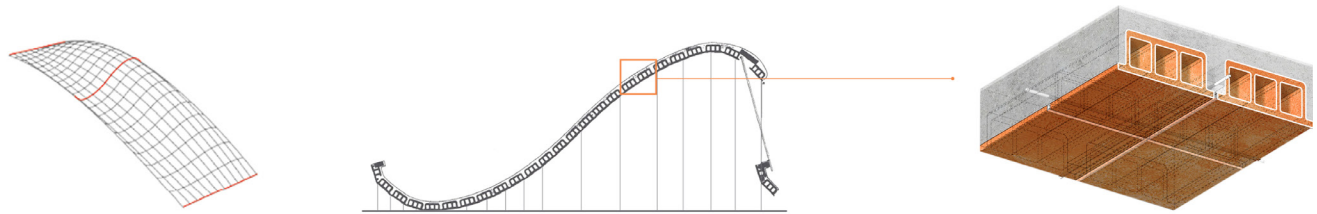


Figure 2. Double-curvature geometry and material assembly detail for long-span, shallow gaussian vault. Images by author.

Within the flow of capital, cosmic economy is a material philosophy at the intersection of material resources, workers, and structural invention—or according to Dieste, the “deep profound order of the world”.² While this material philosophy, which grew out of ideas tied to the School of the South, is not explicitly folded into the argument of this paper, it underlies the poetic pragmatism of Dieste’s work without exerting many of the philosophical or metaphysical anxieties that are associated with phenomenological thinking.

Much of the documentation found in the Dieste and Montañez archive attempts to sort this cosmically ordered world. Organized throughout the office, but largely consolidated in a small room, the archive is filled with images of workers in action. The archive, an accumulation of practice-based documents, not a curated collection of archival materials, highlights the intrinsic links between the practice and the bodies of people involved in the construction of its most daring structures. Links that can also be seen in Dieste’s writings, drawings, and interviews with workers.

The first section of this paper summarizes the geometry and materiality of gaussian vaults, while explaining the role of encofrados or formwork/scaffolding used in the construction of the vaults. Intrahistorias and Potential Histories, the second section of the paper, describes worker-based perspectives in the teaching of architecture through the production of images. The student work featured in this section, uses virtual computer models to extend the edges of archive images, making new historical images grounded in the temporality of the building site.

GAUSSIAN VAULTS AND ENCOFRADOS

The structural principles of gaussian vaults are based on using double-curvature geometries to resist gravity through a particular set of formal manipulations. Simply put, surfaces that are curved in two intersecting directions are more difficult to bend than single planar surfaces. Out of the four innovations in structural ceramics, gaussian vaults present the most nuanced variations of scale, typology, and materiality. Those variations are evident in two primary types of gaussian vaults: long-span shallow vaults and a high-rise continuous vaults.³ The Silo CADYL is an example of a high-rise continuous vault, while the Iglesia de Cristo Obrero (Church) and Deposito Julio Herrera y Obes (Warehouse) are examples of long-span shallow vaults. Adjustments in the combination between structural walls and vaults, as well as the geometry of the vaults themselves, reveal the differences between the Church and Warehouse.

For Dieste and Montañez, rational structural and material expression—the design of a cosmically ordered world—was indifferent to hierarchical ideas of program. Building typologies were not categorized according to their perceived cultural significance. A warehouse carried the same type of dignity as a church, silo, gymnasium or factory. This programmatic and typological flattening is central to how La Iglesia de Cristo Obrero, Silo CADYL, and Deposito Julio Herrera y Obes, form a trio that articulates the complexity of the structural ceramic system and the agency of workers within that system. Dismissing ideas of typological flattening, most scholarship about Dieste has gone through great effort to include the Church at the edges of the architectural history canon at the expense of highlighting the role of labor.

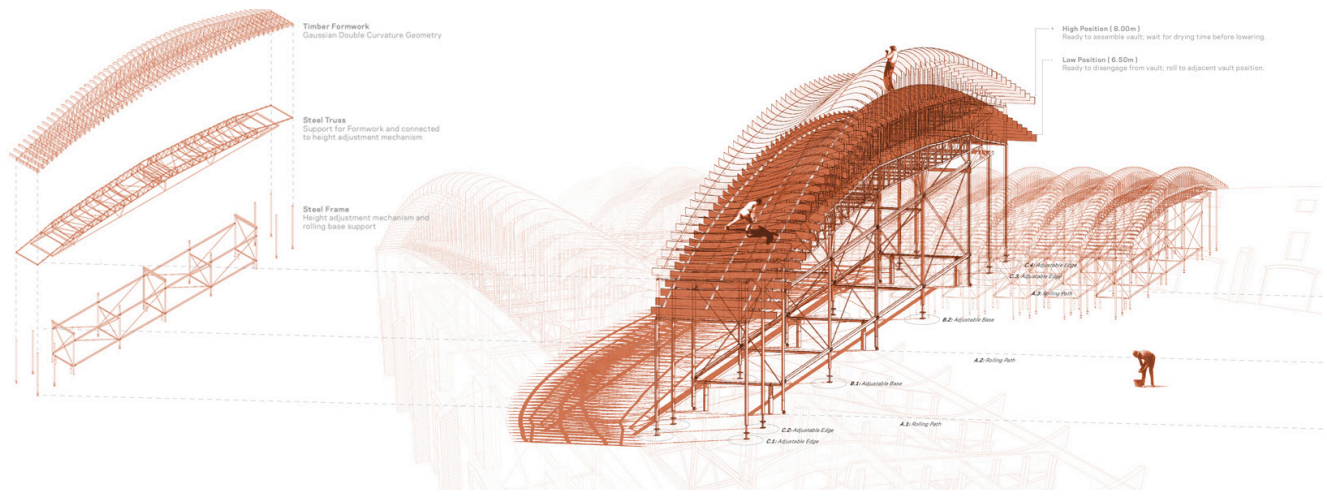


Figure 3. Encofrado used to construct the long-span, shallow gaussian vaults of the Julio Herrera y Obes Warehouse. Computer model by Alexander Boerema, images by author.

Completed nearly twenty years apart, the shallow, long-span vaults of the Church (1958-60) and the Warehouse (1977-79), were designed and constructed to absorb the horizontal thrust of forces differently than the Silo, which counteracts the thrust of grain through its custom foundation and continuous high-rise vault. A typical long-span vault is made from the intersection of rising and falling catenary arches with parallel “S” curves that flatten towards the spring points of the vaults (Figure 2). Catenary arches—an ideal curve defined by its own weight when it is supported at its ends—define the compressive strength of the vault, while the curvature of the “S” profile increases the resistance to bending and diminishes the horizontal thrust at the ends of the vault. To pre-tension the construction system, steel tendons connect the ends of each vault, adding rigidity to the structure. In the Church, these steel tendons are invisible, embedded into the material assembly of each vault, located at the low, flat valley where curved walls meet curved vaults. The steel tendons of the warehouse are exposed, establishing a horizontal datum line that also serves as the location for artificial lighting. In both cases, the geometry of the vaults result in a surface that is capable of resisting bending by operating in both compression and tension. In addition to pre-tensioning, the tensile strength of the vaults is based on the material assembly of the system and its internal, two-way steel reinforcement. The assembly is driven by bovedillas, or traditional hollow-clay bricks, which are typically 25x25x10cm. The overall thickness of the system is usually between 18 and 25 cm—and in many cases, like the Warehouse, spanning up to 150 feet (Figure 3).

Gaussian vaults are constructed using encofrados (formwork/scaffolding). Traditionally, each encofrado is made of three sections, which enables a series of movements—performing both as scaffolding for people and formwork for materials. Starting in the 1970s, with the construction of the Silo and Warehouse, the base of the encofrado was made of reusable steel tubing, which is assembled into a rigid frame (Figure 3). Above the frame, a steel truss is connected to a dense timber truss that is lined with wood planks, which define the double curvature of the vault. The timber and steel truss slide up and down the rigid steel frame to disengage from each vault after its construction. The encofrado is lowered and then moved to the adjacent vault. This was the method of construction for the Julio Herrera and Obes warehouse. It took each vault an average of two working days to be completed and dry enough for the encofrados to be lowered, moved, raised up, and set in place for an adjacent vault to be constructed.

In addition to establishing the particulars of form, the encofrados defined the material world of each of these structures through their corresponding spans and their relationship to natural and artificial light. This world orbited around workers, which this paper argues is a precondition for all of the technical information summarized in this section of the paper. Essential to the on-site choreography of bodies and materials, encofrados translated numerical calculations into the repeatable, double curvature forms that resulted in the large, clear-spanning gaussian vaults of the Church, Silo, and Warehouse.

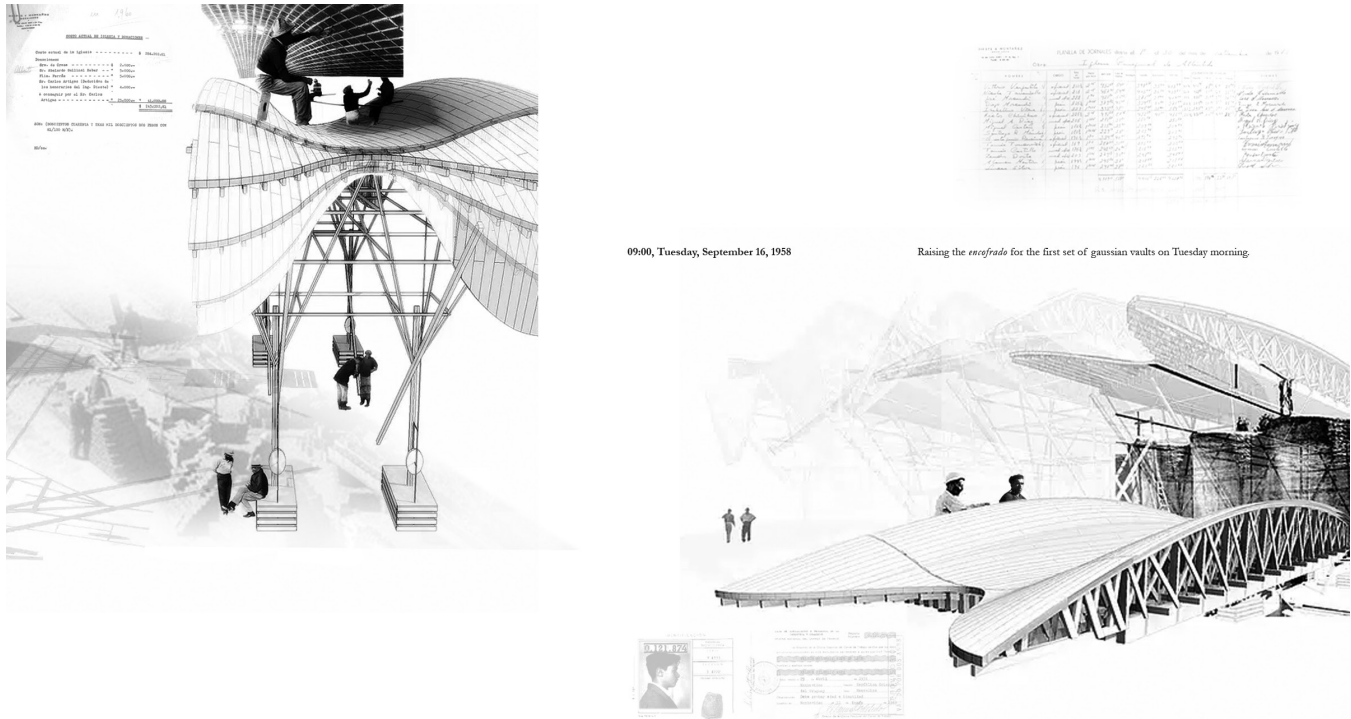
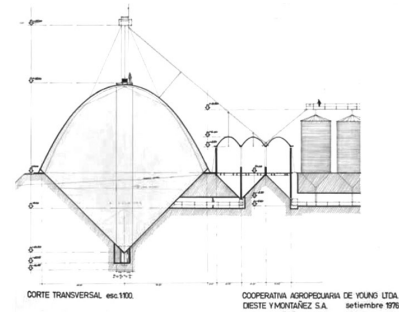
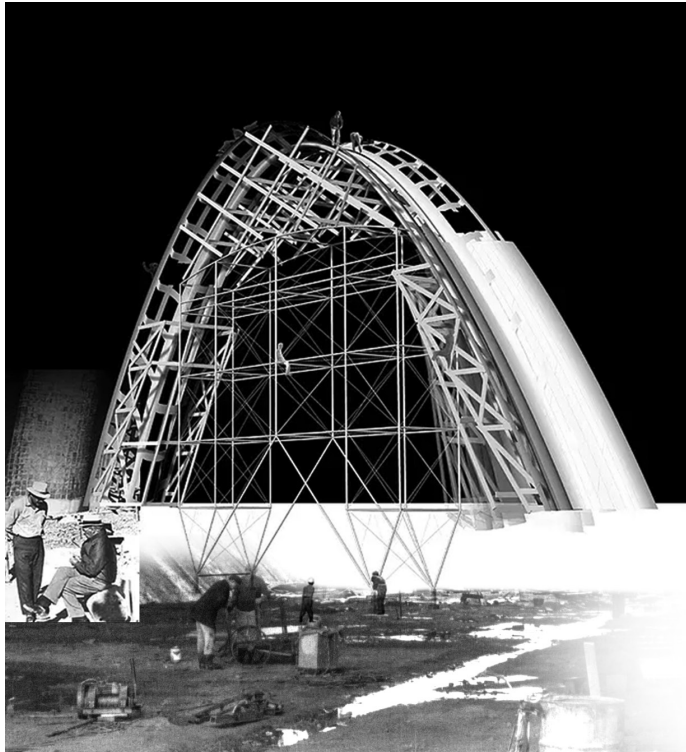


Figure 4. Raising the encofrado for the first set of gaussian vaults during the construction of Iglesia de Cristo Obrero. Images by Jocelyn Rothmeier and James Vanwesten.

INTRAHISTORIAS AND POTENTIAL HISTORIES

On a sunny afternoon in Montevideo, Uruguay, a film crew followed Vittorio Vergalito through tall, neatly stacked portions of baked earth. Gesturing with his arms to explain the structural characteristics of endless rows of clay bricks, Vergalito discussed his thirty-eight years as a job captain working with Dieste and Montañez S.A. The film, “Tradición y Innovación” (Tradition and Innovation) was produced in 2016 to celebrate the work of the late Eladio Dieste. It is fitting that Vergalito’s is one of the first voices heard in the film. After emigrating to Uruguay in 1950 from Campobasso, Italy, he coordinated and participated in the design and construction of encofrados, ruled surfaced walls and gaussian vaults, including the vaults at La Iglesia de Cristo Obrero (Figure 4). As mentioned at the end of the first section, encofrados were construction machines—every movement was geometric and measurable—made from the combination of scaffolding and formwork. The design of the encofrados reveal an intrinsic connection between the ideation of double curvature forms and the people involved in their construction. Vergalito worked in this conceptual and physical machine space for almost four decades.

In addition to Vergalito, Dieste praised his collaborations with other notable job captains, like Edio Vito Pacheco and Alberto Hernandez, who worked with Dieste for thirty-six, and thirty years, respectively. These three men recruited and organized local workers to complete dozens of structures across the Uruguayan countryside. In regards to the efforts of workers, Dieste remarked, “the relationship with workers is an essential component in distinguishing between what is important because of its size and cost and something that touches us in the most profound way because it expresses to us the force that produced it without feeling that force”.⁴ It is an understatement to say that Dieste prioritized the role of workers when labor-intensive practices were seen as a social and moral good. While this generalization diminishes the tensions associated within the politics of labor, it synthesizes the value of construction workers in Uruguay during the second half of the twentieth century. Dieste and his partner connected their practice with Uruguay’s working class to produce a unique set of labor conditions that reflected the reduced dependence on foreign imports through a national policy of Import Substitution Industrialization.⁵



14:00, Monday, August 8, 1977

Disengaging the encofrado and preparing to set the tenth vault on the east side of the silo



Figure 5. Disengaging the encofrado and preparing to set the tenth vault on the east side of the Silo CADYL. Images by Dakota Mathews-Schmidt and Tyson Vogt.

There is a simple question that underpins this paper: What and how do we teach-and-learn about the “invisible” people populating historical construction images, like the ones filling the Dieste and Montañez archive?

Fighting the blinding nostalgia for artisanal craft—and without reinforcing outdated forms of labor—this question suggests that how we perceive our material ingenuity should be based on deep bonds across people. Learning about these bonds is one way to connect construction techniques and architectural imaging with specific political economies. In this context, the previous question can be spliced with another question: What are the tools and construction mechanisms that accompany wage labor? Encofrados anticipate the completed building. Their machine world is the realm of the workers, whose physical agency resides in the temporality of the building site. Whether skilled or unskilled—often an ethnonationalist racial and gender distinction made by capitalism—workers’ historical subjugation should be confronted. While workers, like Vergalito, Pacheco, and Hernandez, are at the center of the means of production associated with Dieste’s work, they are at the edge of traditional architectural authorship. The study of encofrados can help redraw those boundaries.

The pedagogy described in this paper brings those edges closer to the center, or better yet, expands the historical center out, towards more labor-centric edges. Making images, a ubiquitous twenty-first century architectural process, is central to this expansion. Students combine archive materials, like construction images, wage documents, and schedules, with virtual computer models. Figure four presents an account of a two-day span of the construction of Iglesia de Cristo Obrero—on the morning of Tuesday, September 16, 1958—in which one of the teams of five workers, led by job captains Domingo Peta and Victor Retamar, seen on the right, began raising the encofrado to construct the first vault of the Church. Vergalito is simultaneously speaking with Dieste at the base of the encofrado on the left and finishing the underside of the vault, floating seven meters above the site. Without undermining the religious importance of the Church or Dieste’s own religious beliefs, which would be fruitless conceptual posturing, it is important to make an obvious point about the name of the Church. La Iglesia de Cristo Obrero or the Church of Christ **Worker**, invokes the figure of the worker, not as a metaphor, but as a sociocultural actor essential to its construction and the histories that shape its present. A rural Church built for workers by workers.

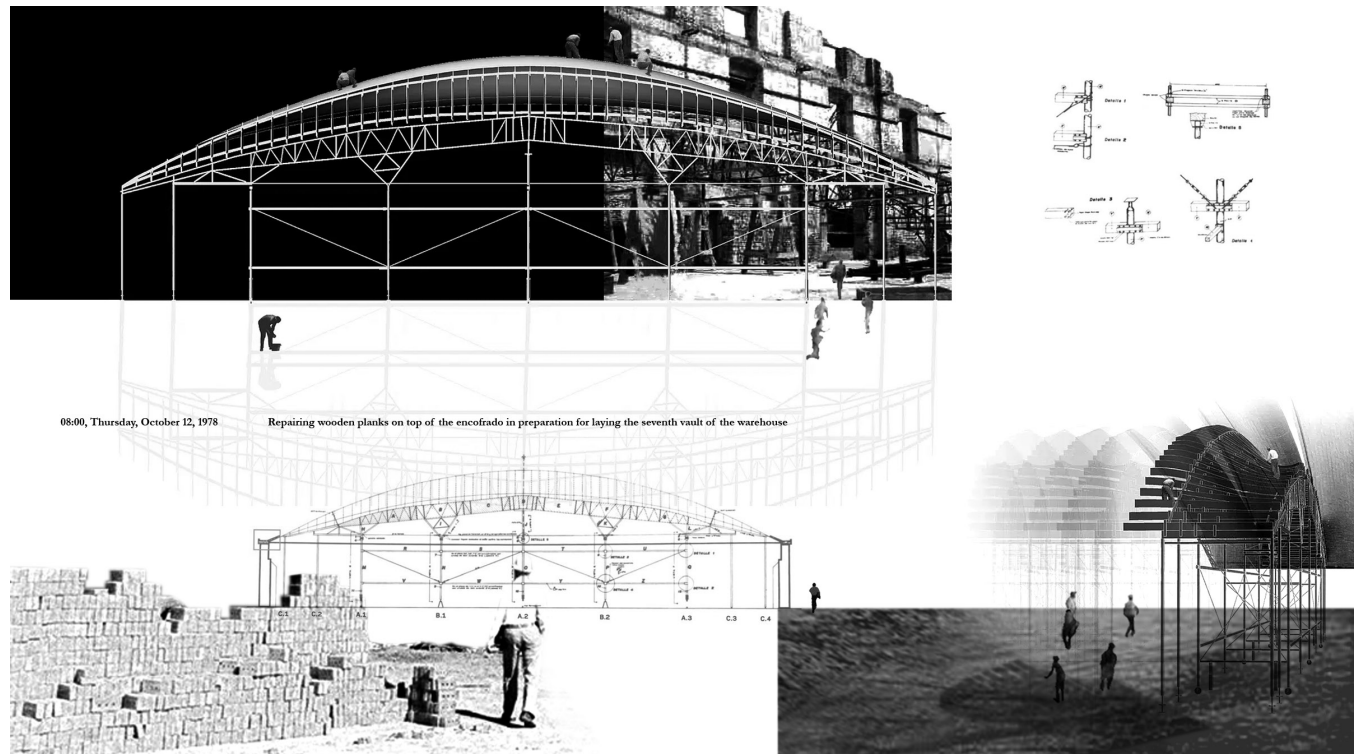


Figure 6. Repairing wooden planks on top of the encofrado in preparation for laying the seventh vault of the Julio Herrera y Obes warehouse. Images by Karianna Larson and Becca Woytassek.

Through an iterative imaging process, students unfold the idea of Intrahistorias as a way of addressing the temporal aspects of the construction site. The notion of Intrahistorias was introduced because it was a term used by the Spanish poet and philosopher Miguel de Unamuno, but more importantly, because Unamuno was an important literary figure in Dieste's life. The concept of Intrahistorias is connected to the production of history through what Unamuno described as the potential to uncover "anonymous histories", lesser known or invisible histories on the periphery of our collective knowledge.⁶

Postcolonial and decolonial studies bind Intrahistorias with ways of unlearning particular practices that have made the idea of technological progress an unstoppable capitalist force. Part of the framework of "unlearning" is thinking about how archives, like the Dieste and Montañez S.A. archive, can expand the context of the materials they collect. In her book, "Potential History, Unlearning Imperialism", Ariella Azoulay refers to this as a way to unlearn the archive. Azoulay claims that not all forms of knowledge relationships should be mediated by the static conditions of archival documents.⁷ Unfolding Hannah Arendt's distinction between work and labor—the visible traces of work (*homo faber*) and the reproductive

invisibility of labor (*animal laborans*)—Azoulay expands on the idea of "worldlessness", another concept introduced by Arendt in *The Human Condition*. Worldlessness, as a method or consequence of displacement, produces a detachment between objects and the communities that make them. To rewind and produce history is not about returning to idyllic moments in the past, but rather about visualizing and narrating overlooked spaces of worldlessness.⁸ Addressing spaces of worldlessness can produce necessary cultural reattachments. In the case of Dieste, the lack of stasis is already latent in the archive, in which there are few images of completed buildings or finished models. Instead, the collected images and documents always reference things in a state of becoming or under construction.

There are some practical challenges with the image-based archival methodology described in this paper. With some exceptions, the Dieste and Montañez archive does not have construction drawings of the encofrados or formwork. Because of this limitation, the first challenge was to identify images that feature encofrados and workers, then overlay those images onto other documents, such as wage labor documents, and worker interviews, like the construction of the Silo CADYL,

made for a Cooperative of Agricultural Workers in Young, Uruguay from 1976-1978 (Figure 5). Encircling this process are a series of production conditions that Michel Rolph Trouillot outlines in "Silencing the Past: Power and the Production of History". People participate in history as both **actors** and as **narrators**. This implies that history means both "facts of the matter", and "narratives or stories of those facts", essentially what happened and what is said to have happened.⁹ Trouillot claims that the first meaning emphasizes the sociohistorical process, while the second emphasizes our knowledge of stories of that process. Analogous to Azoulay's critique of the predominantly static notions of the archive, Trouillot asserts that there is plenty of historical production that exists in-between and outside of sociohistorical processes and stories of those processes. The space between facts, and stories of those facts is architecturally loaded. For architecture, this signals the potential to interrogate and participate in the production of history while challenging the rhythms of the traditional canon.

While the scale of construction of the Silo CADYL suggests a much larger labor force than the Church, records indicate that the construction was led by teams of ten to fifteen workers engaging and disengaging the *encofrado*, like the images from the afternoon of August 8 in 1977 begin to imagine (Figure 5). These images work as fictional moments in factual construction. Images that stripped of their historical context seem like only means to an end, but perhaps when examined closely they can expand the way we learn about architectural actors. For example, in the images of the Warehouse, Depósito Julio Herrera y Obes, the burnt masonry shell of the existing warehouse is the backdrop for the setup of a single *encofrado* used to construct fourteen, fifty-meter span vaults (Figure 6). The bottom-right of figure six anticipates the laying of brick tile that is already happening on the top portion of the image. Simmering on the surface of these images is the exact estimation (a media-based contradiction) of the computer models that attempt to extend the context of the construction and the people involved in this world. The computational nature of the images, the fact that computer models are used to extend the edges of archive images, undermines the improvisational character of the *encofrados*. As Dieste recounts, "some of what has been written about these structures—and certainly the most interesting—is the work of the builders. These people devised solutions and completed the process by testing ideas with trials on site."¹⁰ Vergalito, a worker and job captain, described this process while reflecting on his first experience working with Dieste and Montañez:

"I went to build a water tank in Las Piedras, where I got used to working on a team, before I joined the team at Cristo Obrero...I was not a job captain at the time but one of the current job captains gave me a lot of responsibility...Myself and another Italian started the construction of the double curved walls and the vaults."

Trials, improvisational adjustments and other revisions are rendered invisible in computer models. Still unresolved, the link between this technical media and students' learning, underlies the production of these images—and the potential to address the worldlessness of labor. All the images (Figures 4,5,6) anticipate construction without reconstructing the full scope of the event. The images are short glimpses of memory that are integral to the notion of *Intrahistorias*. As a set, the images focus on how potential histories can unfold around the three capacities in which people participate in the social process of history. According to Trouillot those three capacities are as **Agents, Actors, and Subjects**.

Agents are occupants of structural positions that play a role. As actors, people's role is in constant interface with a context. And as subjects, people are aware of their own voice.¹¹ All three capacities described by Trouillot seem accounted for in Dieste's work. In most professional and academic discourse, workers, while they are visible subjects in the politics of construction, through unionization and the legacy of labor movements, they are largely voiceless in architectural education. Disinvestment in the subjective capacities of workers' labor is not just a product of contemporary concerns over automation, it is a consequence of the way architecture is taught and materialized.¹² When it comes to forms of labor, the affective means—representation, media, and rhetorical instruments—used to transmit architectural materialization are increasingly separated from their sociopolitical context. The process discussed in this paper and its resulting images follow the work of scholars like Christine Wall, whose interviews with British workers highlight their subjectivity, as well as the contemporary efforts of groups like "Who Builds Your Architecture?". The aim of this process is to place workers as immediate subjects of architectural history, instead of living (and dying) as invisible means to an end in the admiration of buildings. While these images are incomplete, they suggest a path to contextualize potential histories around construction labor. If they only present fictions or fragments of narratives—according to Trouillot the materiality of the sociohistorical process limits what fiction can pass for history—then those limits should be important for teaching and unlearning architecture.

Ultimately, these images are being paired with the construction of large-scale physical models of the encofrados, both of which are being used to mediate future conversations with workers. The development of these models, journals, and images are collected in a [website](#) dedicated to advancing the material and social knowledge of Dieste's work in the context of workers.

CONCLUSION

Construction labor is central to the discipline and profession of architecture—and it has been the subject of philosophical, economic, and societal concerns for centuries. This paper and the pedagogy described in it assert that the “building site” and the “archive” are places of personhood that can expand architectural knowledge.

As a engineering-construction practice, Dieste and Montañez S.A. was responsible for means and methods of construction, including the life and well-being of workers. The practice willingly (and contractually) embraced the responsibilities typically abdicated, through legal exclusion, by most contemporary architects and engineers in the United States. This was most evident in the design and construction of encofrados used to build gaussian vaults. Gaussian vaults are the most coherent formal expression of Dieste's innovations in Cerámica Armada. In the Cristo Obrero church, ruled surfaces and gaussian vaults meet in completely rational and mystifying ways. The pressure of grain thrusts against the continuous, high-rise vaults of Silo CADYL, sculpting a cavernous, rippling ceramic interior. Fourteen eyelids peel from the vaults of the Herrera y Obes warehouse filtering light into the columnless space. Encofrados define the intertwined worlds of these building sites.

Vittorio Vergalito designed the physical means of articulating the material junctures at Cristo Obrero in 1955 and participated in the subsequent construction of the Silo and Warehouse. Any implied dissonance between rational and mystical conceptions of the world are central to cosmic economy, the material philosophy introduced at the beginning of this paper. Sanford Anderson reflected on the ethical qualities of Dieste's work, describing cosmic economy as an intense link between scientific epistemology and poetry.¹³ This link guided Dieste's worker-centric labor practices, enabling him to bind structural innovations with the hands and minds of the people constructing them. Rational and mystical, scientific and poetic, for Dieste, the dichotomy between these competing visions of the world was false. There is no better example to illustrate this attitude than his regard for the work of the Spanish

poet Miguel de Unamuno. Unamuno believed that dominant epistemological mechanisms eliminated the collective power of people and their invisible histories. He referred to these invisible histories as Intrahistorias. Azoulay invokes potential histories through strategies of unlearning, which echo Trouillot's process of historical production as the collection of silences—a potential constellation of loud Intrahistorias. In this paper and in architectural pedagogy, it is important to consider that the history of construction labor is filled with silences. In an age of rapid technological changes, it is not fashionable to talk about workers or the physical and social labor that underlies architectural imagination at the edges of worldlessness. Without preserving anachronistic forms of labor, let us study, and teach about practices for which labor was not a means to an end, but rather an intrinsic working condition.

ENDNOTES

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