CONSTRUYENDO BÓVEDAS TABICADAS II

BUILDING TILE VAULTS II

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Construyendo Bóvedas Tabicadas II

Building Tile Vaults II

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III. INTERVENCIÓN ESTRUCTURAL | STRUCTURAL INTERVENTION

Secretariat building (1914-1927) designed and built by Herbert Baker on the skirts of Raisina Hill, New Delhi (Vegas & Mileto, 2005)

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Guastavino in India[1]

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Abstract

This article reconstructs the history of the relationship between Rafael Guastavino Esposito and the British architect Herbert Baker during the project, execution and events that later took place in the dome of the Legislative Building, today's Indian Parliament in New Delhi, in the nineteen twenties. The epistolary correspondence related with the construction, visits to the site, plans and data allows us to analyse the origin of the contact between the two men, the commercial strategy of Guastavino & Co., the constructive details and the interesting relationship established with the acoustician Hope Bagenal for this project, for which they used the Akoustolith ceramic tiles developed by Guastavino with the by then late Wallace Sabine. The text reveals the unsuccessful efforts of William Blodgett and Rafael Guastavino to build their flat tile vault in the construction of the building, whereas Herbert Baker only wished to use the company's ware for the acoustic lining of the dome. The article examines the cross references between Lutyens and Baker about the use of dome in the design of the capital New Delhi and in their professional career. Finally, the investigation shows that the good results obtained from the use of Guastavino's Akoustolith tiles in the Indian Parliament encouraged Baker to use this material for his project for the Bank of England at London.

Keywords: *Rafael Guastavino Expósito, Herbert Baker, India, New Delhi, dome.*

Resumen

El texto reconstruye la historia de la relación entre Rafael Guastavino Expósito y el arquitecto británico Herbert Baker durante el proyecto, la ejecución y los sucesos que tuvieron lugar más tarde en la cúpula del Edificio Legislativo, hoy Parlamento indio en Nueva Delhi, en la década de 1920. La correspondencia relacionada con la construcción, las visitas a obra, planos y datos nos permiten analizar el origen del contacto entre estos dos hombres, la estrategia comercial de Guastavino & Co., los detalles constructivos, y la interesante relación establecida con el ingeniero acústico Hope Bagenal para este proyecto en el que se usaron las rasillas Akoustolith creadas por Rafael Guastavino y el entonces ya fallecido Wallace Sabine. El texto revela los esfuerzos infructuosos de William Blodgett y Rafael Guastavino para construir las bóvedas y cúpula del edificio con bóveda tabicada, frente a Baker que solo deseaba emplear el material acústico de la compañía para el revestimiento del intradós. El artículo examina las referencias cruzadas entre Edwin Lutyens y Herbert Baker en torno al empleo de la cúpula en el diseño de Nueva Delhi y en su carrera profesional. Finalmente, la investigación muestra que los buenos resultados obtenidos con el Akoustolith en el Parlamento indio sugirieron a Baker el empleo de este material en su proyecto para el Banco de Inglaterra en Londres.

Palabras clave: *Rafael Guastavino Expósito, Herbert Baker, India, Nueva Delhi, cúpula.*

Introduction

Most of the work of Rafael Guastavino & son was carried out in Spain and the United States. But their archives contain references to up to a dozen countries. Among these works, it is worth mentioning especially their participation in the construction of the Legislative Building (1919-1928) in the future capital of India, New Delhi. This building, designed by the British architect Herbert Baker (1862-1946), is one of the monumental new public-building complex erected in the city, together with others like the Secretariat Building (1914-1927) (fig. 1), also by Herbert Baker, and the Viceroy's House (1914-1929), Jaipur Column (1915), the All India War Memorial Arch (1921-1931) and the King George V Memorial (1936), all of which were designed by the architect Edwin Lutyens (1869-1944), also British.

The history of the design and construction of the new capital of India by the duo of architects Lutyens and Baker is well-known and has been abundantly studied by other authors (Shoosmith 1931; Irving 1981a; Irving 1981b; Morris 1983; Volwahsen 2002; Nath 2002; Singh 2006). These two architects met while collaborating as young men in 1887 in the studio of the architect Ernest George. Like other contemporary European architects, their language evolved from vernacular romantic style to classicism.

Edwin Lutyens, with an extraordinary instinct for attracting the right clients, became famous in England thanks to the private residences he designed for the upper classes. Apart from his undeniable merits, due to his inexperience in urban development and public buildings, his appointment as the architect to design New Delhi was a great surprise that can only be accounted for by his contacts with the authorities and his marriage to Emily, daughter of the Earl of Lytton, the previous viceroy of India. For his part, Herbert Baker made his reputation by designing several buildings in South Africa, where he worked between 1892 and 1912, among which the government buildings of Pretoria deserve special mention. His appointment in 1913 as an architect for the new capital New Delhi with Edwin Lutyens, apparently at the latter's suggestion, was readily accepted thanks to the expertise and solid experience he had previously shown in his important commissions (London Indian Office 1913).

The discrepancies between them that arose in 1916 regarding the siting of Raisina Hill, which deprived Lutyens's Viceroy's House of importance as the centre of the composition slowly coming into view as one walked along the central avenue, and gave equal status to Baker's Secretariats, put an end to their friendship and made the whole process more difficult (Baker 1916; Lutyens 1916; Lutyens 1980, 187-9). Lutyens never accepted defeat, stating he had "met his Bakerloo", and from then onwards never missed a chance to demean or humiliate his colleague Herbert Baker.

Figure 1. *Secretariat building (1914-1927) designed and built by Herbert Baker on the skirts of Raisina Hill, New Delhi (Vegas & Mileto, 2005).*

The Legislative Building

The creation of the Legislative Building, known today as Rashtrapati Bhavan and the current headquarters of the Indian Parliament, a building adjudicated to Herbert Baker, was a last-minute decision with regard to the whole site for which Lutyens chose a secondary position at the foot of Raisina Hill. After the Montagu-Chelmsford reforms in 1919, it was a building that could hold a new system of government comprising three houses for an India that was crying out for a greater and greater say in decision-taking regarding its country.

Baker's first two designs, one rectangular and the other triangular, both crowned with a high central dome symbolising a united India (Baker 1921a), were rejected, and the circular plan that Lutyens preferred was chosen instead[2] (Lutyens 1919; Lutyens 1920a; Lutyens 1920b). The addition of new office spaces made the circular cornice of the building rise so high that the central dome disappeared completely (fig. 2). Lutyens, in open antagonism towards Baker, managed to minimise the presence of this new building of Baker's in the urban setting and, at the same time, to hide Baker's dome in revenge for the disappearance of his own dome in the Viceroy's House, where Baker's opinion had prevailed (fig. 3).

For all these reasons, Baker designed a Legislative Building with a plan in the shape of a wheel with three spokes, each containing one of the three houses of parliament: the Legislative Assembly, the Council of State and the Chamber of Princes; a porticoed perimeter housing offices and a main hall in the centre crowned by a large dome where the three houses could hold plenary meetings (fig. 4). This unusual plan seems to have been inspired by some visionary project of Claude-Nicolas Ledoux (1736-1806), such as the Sawmill or, even more likely, the cemetery for the town of Chaux, whose large central dome clearly crowns the composition (Ledoux 1804, 102, 195). And, strangely enough, it seems to have inspired the shape of the spaceship in Stanley Kubrick's film 2001: *A Space Odyssey*[3] not such a far-fetched idea if we take it into account that the writer of the screenplay, Arthur C. Clarke, spent over fifty years of his life living in India and greatly admired its culture (Jonas 2008).

Figure 2. *The addition of new office spaces made the circular cornice of the Legislative building (1919-1928) by Herbert Baker rise so high that the central dome disappeared completely (Vegas, 2006).*

Figure 3. *During the coordination meetings, Lutyens managed to minimise the presence of Baker's Legislative building in the urban setting and, at the same time, to hide its dome in revenge for the disappearance of his own dome in the Viceroy's House (Vegas, 2006).*

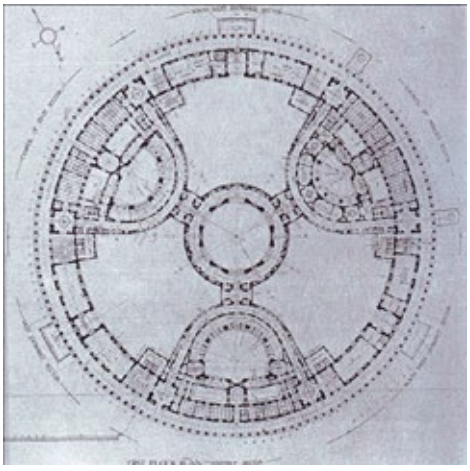

Figure 4. *The plan of the Legislative Building in the shape of a wheel with three spokes, each containing one of the three houses of parliament: the Legislative Assembly, the Council of State and the Chamber of Princes, with a porticoed perimeter housing offices and a main hall in the centre crowned by a large dome (Byron 1931: fig.7)*

Enter Guastavino Co.

Concerned about the acoustic problems that could arise from the circular shape and the dome (Baker 1944, 76), Herbert Baker decided to contact experts in the field to advise him. He had probably heard of Guastavino Co. in 1921 from his overseas friend the architect Bertram Grosvenor Goodhue (1869-1924) (Goodhue 1921; Baker 1922). The latter had worked with Guastavino Co. in many buildings.[4] Goodhue, along with Ralph Adams Cram (1863-1942) and Frank Ferguson (1861-1926), had been one of the first to use Rumford tiles with acoustic properties in St Thomas's Church (1913), and was a personal admirer of the efficacy of the products of Guastavino Co. in acoustic absorption (Pounds, Raichel and Weaver 1999, 33-9). At the inauguration of a church that Goodhue designed on his own, he wrote the following to Guastavino:

"On Easter Sunday I attended the dedicatory service at the First Congregational Church at Montclair. To the best of my knowledge and belief no such acoustical result has ever been

achieved before except possibly by accident. To you and Dr. Sabine all credit is due and it is difficult to express my satisfaction with the result of the years of patient effort spent by you both in the perfecting of this wholly new material. Please accept my thanks and congratulations" (Goodhue 1916).

Also, we don't know through whom, Herbert Baker got in touch with the acoustic expert Hope Bagenal (1888-1879). Bagenal originally began to study engineering at Leeds University, but gave it up to study architecture at the Architectural Association of London (Bagenal 1984). Since he was interested in acoustic problems in architecture, he contacted Wallace C. Sabine (1868-1919) in 1914 to get information for a text he was writing for *RIBA Journal* called "Acoustic Relative to Architecture" about acoustics in auditoriums,[5] although it was never published. Bagenal published his first article about acoustics in 1919 (Bagenal 1919) and, from then on, began to work as an acoustic consultant for cinemas, theatres, offices, etc.

At the same time, Baker heard about the opening of the Public Auditorium in Cleveland (Ohio) on 15th April 1922 and asked to be sent a leaflet published for the inauguration (Anonymous 1922), which, among other things, explained the acoustic virtues of the auditorium thanks to the use of an acoustic gypsum called Macoustic Gypsum, produced by the Mechanically Applied Products Co. of Cleveland. Besides, probably through Hope Bagenal, he heard about the acoustic gypsum that the by then late Wallace C. Sabine had developed in the United States and that he had called Sabinite.

After the first contact step made by Baker, at the end of 1922, the firm Guastavino Co. wrote to Baker to propose the construction of all the vaults and domes in the building that would later be covered with Akoustolith tiles. Guastavino Co. proposed to send their employees to New Delhi to make the tiles on site in order to avoid transport costs (Baker 1923a). Baker never understood the process very well and was loath to trust it from his own experience, for he said to his engineer in New Delhi, "I don't know whether you know that it has been a custom in America, invented in California I believe (sic), to build large domes structurally of two or three layers of flat small tiles like English roofing tiles without any support other than a tie at the base" (Baker 1923b).

With rare exceptions, Baker had never used domes and vaults in his work prior to New Delhi. Apparently, it was the lack of this tradition in South Africa that led him to use lintel-like solutions above all. However, India had a long-standing tradition of that sort of structure. In 1912, before being appointed architect for New Delhi, Baker wrote an article for *The Times* (Baker 1912) discouraging direct imitation of any Indian or orthodox classical style for the new capital (Metcalf 1989) and suggesting that it would be better "to build according to the great elemental qualities and traditions, which have become classical, of the architecture of Greece and Rome (…) and to graft thereon structural features of the architecture of India as well as decoration expressing the myths, symbols, and history of its people". In this text, in seeking common elements that would represent the essence of both cultures, he mentioned the dome, pride and joy of Indian architectural tradition, with its most outstanding example in St Paul's cathedral, designed by his venerated architect Sir Christopher Wren (1632-1723). During his first visit to India in 1913, following the advice of the Viceroy Lord Hardinge, Baker and Lutyens visited several ancient cities and monuments in the north and centre of the country, among others, the Mughal monuments in Delhi, the Taj Mahal and the sacred hill of Sanchi with its famous domes. Baker read several texts about Indian art and architecture in an attempt to trace the genealogy of the dome in the subcontinent. Lord Hardinge urged them to use the pointed Mughal horseshoe arches, whereas Baker and Lutyens were more inclined to use the round arch (Lutyens 1980, 103-4), following Wren's doctrine that said that only simple geometric forms possessed "the Attributes of the Eternal" (Baker 1944, 71-2; Lutyens 1980, 113). Due to his interest in discovering the origin and development of vaulted forms in India, Baker studied several books (Baker 1944, 70) and even went to a lecture[6] and wrote to the person who was then considered the greatest expert

in Islamic architecture, Sir K.A.C. Creswell (1879-1974), who kindly replied explaining the genealogy of the double-shell dome in India (Creswell 1914).

This fascination with vaulted spaces persisted after his time in India and can be seen in his sketches for Kenya government buildings in 1925. Speaking about this project, T.E. Lawrence (1888-1935), better known as Lawrence of Arabia, a close friend of Baker's[7] (Baker 1944, 206), gave him interesting advice about this project in a letter, which, consciously or otherwise, seems to suggest flat brick vaults: "Do not fall into the Khartoum fault of wide streets. In tropics, air (fresh or foul) is an enemy. Also sunlight. You want houses of immense height and vigorous overhang. Streets like alleys, half dark, and full of turnings to exclude the wind. All pavements should be covered over with light vaulting" (Baker 1944, 107).

In any case, throughout his life Baker concentrated mainly on the form of these vaulted spaces without paying any type of special attention to the construction, as we can gather from his own work, where vaults and domes were mainly built on metal lathing hung from flat concrete slabs or metal structures or occasionally on concrete shells like in some parts of Salisbury cathedral (Rhodesia) or the Ninth Church of Christ Scientist in Westminster (England).

It's a real shame that the proposal of Guastavino Co. to build a tile vault in the four large spaces of the Legislative Building literally aroused hilarity in Baker, an architect of metal structures and concrete in classical style. It's a pity that this possibility, apparently advantageous from an economic point of view, was not even considered, because otherwise they would have built a great central dome 60 feet in diameter and three semicircular cupules with a radius of 70 feet in the same building, a feat that would have become part of the history of architecture.

Acoustic tests

With the data at hand, Bagenal immediately rejected Macoustic gypsum (Baker 1923c). One month later, showing proverbial dedication to the building's acoustics (Bagenal 1929, 851-2), Bagenal studied all the options and finally recommended the Akoustolith tiles made by Guastavino Co. rather than Sabine's acoustic gypsum (Bagenal 1923a). Nevertheless, from the outset and up to the time the design was well under way, Herbert Baker preferred acoustic gypsum to acoustic tiles, perhaps because of the neutral character of the plaster in comparison with the rougher appearance of the tiles. Maybe for that reason, it was decided to carry out acoustic absorption tests at the Building Research Board in London in order to decide for one or the other solution once and for all (Chief Engineer N. Delhi 1923). Due to the danger of losing this contract, Guastavino Co. began to make experiments with acoustic absorbing render and finally patented one product of his own, that apparently was never used in the Legislative Building (Guastavino 1925).

Baker, who seems to have had his doubts from the beginning about Guastavino Co. or the long distance from United States to India, intended to compare prices and have a second option to fall back on in case of failure in the delivery of supplies from the States (Baker 1923d). In a letter dated 12th April 1923, Baker wrote, "I have felt after my interviews with Blodgett of Guastavino Company that although the prospect of using his tiles seems very hopeful yet there might be *many a slip between cup and lip* of your entering into a satisfactory contract" (Baker 1923e). For his part, Bagenal felt it was a waste of time to carry out these experiments from scratch, seeing as Guastavino's products had seen the light after many years of toil and had already proven their worth.

Half-way through the process, Baker even consulted other experts in acoustics, such as Richard Glazebrook (1854-1935) and the Nobel prize William Bragg (1862-1942), who had given him lectures as a student at London University (Baker 1923f; Baker 1923g; Baker 1923h; Bragg 1923a; Bragg 1923b). Finally, it was decided to perform tests on Akoustolith's absorption properties at the Building Research Board in London, as he was not convinced of the 40% absorption factor that Guastavino Co. claimed in the official documents. So, they

contacted Guastavino Co.'s representatives in England, Building Products Ltd.

With its offices in a late 19th century building at 44-46 Kings Road, Building Products Ltd., managed by the engineers J. Chapman and A.G. Huntlye, looked after the affairs of Guastavino Co. around the nineteen twenties. Although the initial idea was to build an Akoustolith acoustic tile factory in England (Blodgett 1923a), in fact, apparently, they only intervened in the construction of two buildings: the Legislative Building in New Delhi in India, and the cladding with acoustic tiles in the main hall of the Ironmonger's Company in Shaftesbury Place, near the Barbican, in London, completed in 1925. Today, this little-known building in which Guastavino Co. collaborated is still standing, and the hall, surrounded by a wooden wainscot, lit by leaded windows and walls tiled with Akoustolith, is successfully used for banquets and wedding parties, thanks to its virtues of acoustic absorption.

The participation of the representatives of Guastavino Co. in Baker's Legislative Building was limited in principle merely to sending off on 25th June 1923 (Chapman 1923) the results of the US acoustic tests, which included both Sabine's graphs and the results of the tests at the Federal Reserve Bank in Chicago, completed in 1922. The acoustic tests at the Building Research Board of London continued anyway, and they even contemplated the possibility of creating alternatives similar to Akoustolith tiles or Sabinite acoustic gypsum by copying part of the components (Weller 1923).

Suspecting the ploy, for a few months Guastavino Co. stopped sending samples of Akoustolith for acoustic tests in London that had already been tests at laboratories in the United States. Later on, Blodgett finally acceded to send the samples for testing, on condition that he received a copy of the results (Blodgett 1923b).

Mr. H.O. Welles of the Building Research Board in London, who can clearly be accused of having caused the conflict due to his tactlessness, went so far as to produce acoustic tiles of his own imitating Akoustolith, but they turned out to be softer and coarser (Baker 1923b), so that, according to Bagenal, they were harder to cut to make special pieces (Bagenal 1923b). During the whole process, Bagenal had to insist several times that it was impossible for other materials, both patented and otherwise, to outshine the acoustic virtues of Akoustolith (Baker 1923i; Baker 1923j).

Towards the end of 1923, Bagenal, in contact with the York & Sawyer architecture studio of New York, which was at the time constructing the Federal Reserve Bank in New York, wrote an almost complete copy of a letter from these architects praising the properties of Guastavino Co.'s Akoustolith and the acoustic gypsum patented by W. Sabine and sent it to Baker to ease his mind (Bagenal 1923c). Like Bertram G. Goodhue, the architects Edward York (1863-1928) and Philip Sawyer (1868-1949) had already worked with Guastavino Co. on a large number of projects.[8] In one of his letters to Baker, Bagenal even went so far as to say: "In regard to the question of using Akoustolith the evidence of York & Sawyer and Goodhue was generally to the effect that Akoustolith was used because it was a commercial product that was reliable from all points of view…" (Bagenal 1924).

Nonetheless, the tests and the manufacture of alternative copies of both the tiles and the acoustic gypsum continued until 1925 was well under way. In mid June 1926, the engineers in the New Delhi office were trying to make their own acoustic tiles to clad the Library Dome, based on their observation of the first lots of Akoustolith that had come from the United States (Baker 1926). Bagenal was compliant with the situation, but warned about the texture and colour of their home-made tiles in comparison with the Akoustolith made by Guastavino Co. with ground Italian pumice stone (Bagenal 1926).

The application of Akoustolith on the Legislative Building

In the midst of this turmoil, Herbert Baker sent the first plans of the Legislative Building to the Boston office of Guastavino Co. on 15th August 1923 in order for them to prepare an estimate for the acoustic tiles required (Baker 1923k; Baker 1923l). They were not only to supply the tiles, but all the mouldings, edgings,

Figure 5. *Summary of construction details of various chambers and the number of tiles needed drawn by the R. Guastavino Co. (11/26/1923). Guastavino Fireproof Construction Company architectural records, 1866-1985, Avery Architectural & Fine Arts Library, Columbia University.*

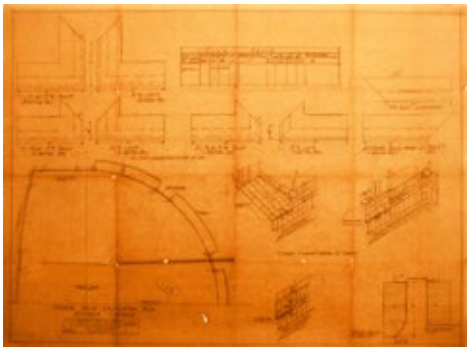

Figure 6. *Plans and sections of the Assembly Chamber at the Legislative building and the number of tiles needed drawn by the R. Guastavino Co. (12/16/1924). Guastavino Fireproof Construction Company architectural records, 1866-1985, Avery Architectural & Fine Arts Library, Columbia University.*

cornices, etc. necessary to tile the space. Their detail and precision aroused Blodgett's admiration, and he praised their beauty and accuracy (Blodgett 1923a).

Unlike other works tiled with Akoustolith where the pieces were of diverse format, Baker asked for uniform pieces of 6"x12" for large surfaces and for the manufacturing of special pieces in order to make the mouldings and even decorative latticed Akoustolith panels, imitating traditional Indian *jalis*. Besides reminding him of the pressed system used for manufacturing Akoustolith, Blodgett explained to Baker how these mouldings were made by carving a timber model and casting it in plaster and then emptying it to make a mould. On the other hand, Guastavino Co. didn't think it possible to make these perforated decorative panels with Akoustolith, probably because they would have been too fragile.

Since Baker insisted the material be produced on site or at least in England, Blodgett suggested the possibility of making the plain tiles outside the United States but mentioned the huge difficulty in making the special pieces for the moulding, since they required great precision. Another interesting point is Baker's initial insistence that Guastavino Co. tile the dome with Akoustolith, to which Blodgett replied that it wasn't a matter of building a tile vault and that any good builder could put the acoustic tiles in place.

This remark was to have important consequences afterwards, as we shall see below. Baker wanted to eliminate, annul or camouflage the presence of the joints as much as possible, but Blodgett told him that even Guastavino Co. hadn't found a way of eliminating the joints either in the ceramic bricks or the Akoustolith, so that in his opinion the best solution was to place them in a herringbone pattern. Finally, Blodgett recommended that the Akoustolith pieces, which weighed only 4 or 5 pounds per square foot, be applied with a lime mortar with a lime/aggregate proportion of 3:8, with a small amount of Portland cement added to the mixture.

Based on the plans sent by Baker, Guastavino Co. drew up plans of the detail and measurements of all the pieces needed, and some of these plans are conserved in the Avery Library archives.

The precision and exactitude of these plans, like those of other projects performed by the company, once again confirms their professional competence in carrying out these works, even those commissioned thousands of kilometres away from their headquarters. The plans conserved are dated between November 1923 and December 1924, which gives us an idea of the length of time required for counting, checking and making the pieces, apart from the problems arising in checking the acoustic material (figs. 5, 6).

In November 1923, Baker asked for the size of the standard tile to be reduced from 6”x12” to 5”x10”, apparently because they would be easier to handle and assemble. Blodgett made no objections to this change, considering the number of pieces to be made and the fact that the price per square foot would be the same. Besides, it was to be expected that having a smaller size would mean that fewer pieces would break during transport, although it turned out to everyone’s dismay that up to 15% of the pieces in each shipment broke during the journey (Baker 1924a).

When Blodgett offered to make Akoustolith in slightly different shades, Baker again stated that he wanted the tiles to look like plaster, so he begged they would all be exactly the same colour (Baker 1923m). Finally, in an attempt to control even the slightest detail, Baker asked Blodgett about the problems involved in tiling a curved surface. Blodgett replied that it wouldn’t be a problem, especially if the projecting joints he had recommended were used, since the projecting parts between the joints would be absorbed by the curvature (Blodgett 1923c).

After performing some tests applying the tiles with no mortar at the joints, with flat mortar and projecting mortar, Baker decided to apply the acoustic tiles without mortar at the joints for acoustic and, above all, aesthetic reasons. Blodgett sent Baker a drawing explaining how to apply the tiles to avoid rough edges and stains on their absorbent surface (fig. 7) (Blodgett 1923d; Baker 1924b). This decision would also have its consequences as a result of the incident described below. The Akoustolith tiles

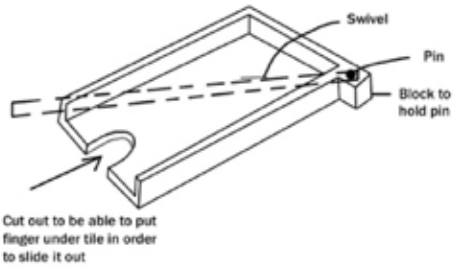

Figure 7. *Drawing sent by Blodgett to Baker explaining how the Guastavino Co. applied the Akoustolith tiles to avoid rough edges and stains on their absorbent surface (redrawn by the authors from the Blodgett’s letter to Baker, December 28th 1923, RIBA, V&A. BaH/61/1).*

were applied on a metal lathing hung from the metal structure of the dome, a strange solution for Guastavino Co., nevertheless very similar to the employed system on those years by York & Sawyer in the Federal Reserve Bank of New York, with whom Bagenal had contacted in order to confirm the efficiency of the Guastavino Co. acoustic products (see Jalia’s text in this book, figs. 9, 15).

“When I die you will find the words ’Acoustic tiles’ engraven on my heart”

These were the words of the architect Herbert Baker (1923n) in the midst of the controversial hiring of Guastavino Co. for the Legislative Building in New Delhi. The building was inaugurated in January 1927 by Lord Irwin, the new Viceroy of India, who spoke through a loudspeaker, quite a novelty at the time (figs. 8, 9). Happy that the work was finished, Baker presented the Viceroy with a golden key with which he opened the gate and declared the building inaugurated. Baker had no idea about the troubles that still lay ahead, precisely with the acoustic tiles.

On 15th March of that same year, an acoustic tile fell from the dome and nearly hit the commander-in-chief. Investigations began immediately to discover the cause of the accident and

Figure 8. *The Council Chamber at Baker's Legislative Building (Baker 1944: 72).*

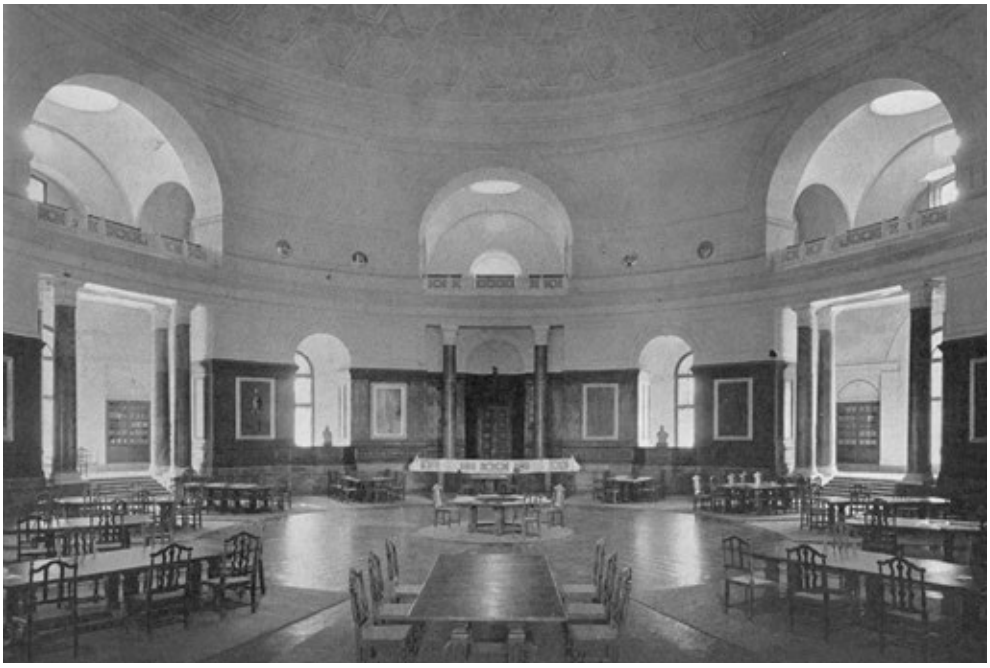

Figure 9. *The central dome at Baker's Legislative building, clad-ded with Guastavino's Akoustolith tiles (Baker 1944: 73).*

the likelihood of similar incidents in the future and the way to avoid them, and the possible liability of the architect, engineer, builder and/or Guastavino Co. as a subcontractor. The engineer Rouse, the project manager, was asked to draw up a report (Rouse 1927). To find out the state of the building, first he set up scaffolding taking advantage of the fact that the members of parliament had a few days' holidays, and tapped a large number of acoustic tiles, whereupon he discovered a few that sounded hollow and two that were about to come loose altogether. They removed the ten least secure tiles although they needed two hefty screwdrivers to prise them loose.

The report on the incident drawn up by A. Brebner, chief engineer of the Simia Imperial Circle (Brebner 1927), provided data about the cement mortar rendering on the metal laths with cement/aggregate in 1:3 proportion, and about the mortar adhering the acoustic tiles, with a very high proportion, 1:1, much stiffer and diverse than that recommended by Guastavino Co. (fig. 10); it deems unfortunate that the tile cladding tests had been performed on a brick vault when they knew the definitive solution would be to adhere them to a metal lath; and it criticises Baker for choosing an acoustic tile cladding without repointed joints both for aesthetic and acoustic reasons.

In view of the apparently good adhesion between the tile and the mortar, the following possibilities were considered: that the mortar coat on the lath had been completely dry when the tiles were attached; that due to the absorbent nature of the material, not having been soaked in water, the tiles might have absorbed the water in the cement mortar; that the thermal movements of the metal lath might have affected the ceramic cladding; or that not having scraped the mortar cladding to increase coarseness might have caused the tiles to adhere less firmly (Architect's Office 1927a). The examination carried out from the scaffolding revealed that quite a few acoustic tiles were broken or cracked, although they were still firmly stuck in place, due to the expansion of the metal lath base and the rigidity of the cement mortar (Architect's Office 1927b).

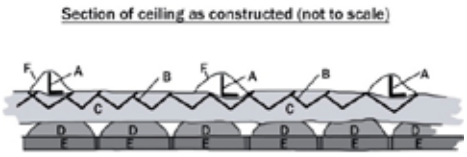

Figure 10. *Detail of the final construction of the vault (not to scale):*

A. Light steel angles riveted to steel work in roof to carry the expanded metal lathing.

B. Expanded metal lathing (tied by wire F to A).

C. Rough coat of 3 to 1 sand and cement plaster to form a base for the Akoustolith tile.

D. 1 to 1 cement plaster (the spaces between D and D were due to the fact that the 1 to 1 mortar was put on each individual tile as it was laid, the idea being to avoid having mortar between the vertical joints of the tiles.

E. Akoustolith tile fixed on to coat C by cement plaster D.

An examination of the ceiling showed that in some cases there was a tendency for separation to take place between d & E and between C & D due to the adhesion being imperfect (redrawn by the authors from A. Brebner's drawing in his report, March 22nd 1927, RIBA, V&A. BaH/61/1).

It soon became evident that the cause of the incident had been that the surface of the base of the tile had not been wet enough and that perhaps the base was too smooth (Baker 1927). Furthermore, the documentation of the works was examined, and it was found that Guastavino Co., after making it clear that they wouldn't cover the spaces with tile vaults, had entrusted the application of its Akoustolith tiles to any good local workman.

In any case, after consulting Guastavino Co. about the matter, Blodgett said nothing like this had ever happened before with Akoustolith tiles, except for some coming loose during the work: but never months later. Blodgett recommended setting up a moveable scaffold and tapping the tiles systematically to find out their state and adherence from the sound. Finally, Blodgett, who had visited New Delhi in November 1926 on a trip around the world, was sorry he had visited the building before the incident and not afterwards,

because he could have helped clear up the reasons for the tiles coming loose (Blodgett 1927).

The engineer Rouse wrote a confidential letter to Baker about this incident (Rouse 1927b), reminding him of a letter dated 25th October 1923 and affirming that not only would they find *his* heart engraved with the words "Akoustolith tile" but also those of the other collaborators and engineers at the technical office in New Delhi. The yellow press took the opportunity to forecast the ruin of the building and mindlessly criticise its acoustic virtues (The Pioneer 1927). The incident apparently died a natural death without more ado.

Tests were performed by hanging up to 100 kg dead weight per tile from a large number of them, and proved with great satisfaction that they were perfectly adhered. A year later, the recent wound of this accident remained open and, while working on the design of a new bank in South Africa, Baker consulted Bagenal (Baker 1928) about the use of acoustic gypsum instead of tiles for the vaults. He probably felt wary about the material. Almost one hundred years later, currently, a net still protects the four big vaulted spaces of the building from any detachments of the tiles, which remain suspended in the air over the net.

In his autobiography written years later, Baker didn't refer at any time his collaboration with Hope Bagenal or Guastavino Co., and only mentioned in passing Professor Sabine's acoustic principles, either because he still had bitter memories or because he didn't want to minimise his role in the design of the building, for he did mention other collaborators in this project and others. The hundreds of letters, negotiations and headaches arising from the purchase of Guastavino Co.'s acoustic tiles instead of hiring the company to build the whole dome were summed up in a single sentence: "The acoustics have proved, I believe, to be good" (Baker 1944, 76).

Figure 11. *Dome of the Durbar Hall designed by Lutyens in the Viceroy's House, New Delhi, comprising of three domes one on top of the other: the inside one made of thick brick fabric, the middle one a dome-shaped cone also made of brick and the outer one of reinforced concrete covered with waterproof copper sheets (Vegas 2006).*

Lutyens following in Guastavino's footsteps

The dome, 72 feet in diameter and 75 feet high, designed by Lutyens for Durbar Hall in the Viceroy's House (fig. 11) is an unusual structure comprising three domes one on top of the other: the inside one made of thick brick fabric, the middle one a dome-shaped cone also made of brick and the outer one of reinforced concrete covered with waterproof copper sheets. Lutyens didn't need to pay attention to the acoustics of the space as Baker did for the parliament building. Furthermore, considering the hatred he felt since the Bakerloo incident, he would never have used Guastavino Co. had he known he was already working with Baker.

We do have information about the smaller saucer domes in the Viceroy's House, made of gypsum-clad brick, built in a traditional local ancient method without any kind of prop or formwork. The foreman placed a gang of

workmen around the edge of the dome to be erected. In the first place, mortar was applied all around the edge and, at a signal – which often consisted in the roll of a drum accompanied by a few bars of music – all the masons affixed their brick at the same time, creating an instant circle of bricks that remained in place. Once the mortar set, the workmen repeated the operation until the dome was completed (Irving 1981, 270).

Lutyens would never have considered using a tile vault. There are several direct testimonies of his rejection of everything other than the solid assembly of bricks always laid flat and not on edge. For example, in 1927 when his disciple Arthur Gordon Shoosmith (1888- 1974) was designing St Martin's Church in New Delhi, he gave him the following advice: "My Dear Shoo: Bricks! A building of one material is for some strange reason much more noble than one of many. It may be the accent it gives of sincerity, the persistence of texture and definite unity (…) Don't use, whatever you do, bricks on edge or any fancy stuff. It only destroys and promotes triviality (…) Get rid of all mimicky Mary-Ann notions of brickwork and go for the Roman wall…" (Hussey 1950, 367-8).

He repeats his criticism of bricks laid on their edge throughout his career: "The thin walls are worth while, if only to watch your Client's face glow with joy at winning a few square feet of carpet" (Lutyens 1980, 255). And he criticised not only the construction but the effect of the bays on excessively thin partition walls. "They cannot afford or see the essential differences of an arch carried on posts of sufficient calibre B and those which have the bilious (thin) feeling A. Yet on paper in elevation they both look alike" (Lutyens 1915).

But, notwithstanding his rejection of the construction of tile vaults, Lutyens greatly admired the Guastavinos' work, even though he had no direct knowledge of their existence. This became evident when he travelled to the United States in April 1925 to receive the Gold Medal conferred on him the previous year by the Institute of American Architects and, at the same time, to accept the commission for the design and construction of the British Embassy in Washington (fig. 12) (Lutyens 1980, 218-20). Indeed, on his first visit to the docks at New York port when he disembarked, Lutyens saw Guastavino's characteristic tile vaults in Walker & Morris's Battery Maritime Terminal (1906-1909), which he confused with McKim, Mead & White's Pennsylvania Station (1902-1911). Lutyens stayed at the University Club (1918), another building designed by McKim, Mead & White, in which Rafael Guastavino collaborated by building the vaults.

The dinner in his honour was also held on the tenth floor of the University Club, with the presence of 40 architects, among whom was Cass Gilbert. One day later, his visit to Pennsylvania Station to catch a train to Washington impressed him greatly, to such an extent that he compared it to Caracalla Thermal Baths. During his visit to Washington, among other buildings, he visited another two works by Guastavino Co. that were under construction: the Washington National Cathedral (1907-1990), by Frohman, and the National Shrine of the Immaculate Conception (1920-1962), by Murphy and Maginnis & Walsh (Lutyens 1925).

For the construction of the British Embassy in Washington, Lutyens chose a British-born contractor called Harry Wardman (1872-1938), a real estate developer and builder who specialised in dwellings and hotels, who in his lifetime built 4000 houses, 400 apartment blocks, 12 office buildings, but lost his fortune in the 1929 Wall Street Crash, before he had time to finish the embassy. As far as we know, Wardman didn't work with Guastavino, but the matter is worth investigating. However, the architect associated with Lutyens in charge of interpreting the plans, Frederick H. Brooke (1876-1960), did work with Guastavino Co.[9] What is more, it was Brooke who took Lutyens to see the two churches with Guastavino vaults during his visit to Washington in April 1925.

In fact, Brooke, who studied architecture at Yale and Pennsylvania Universities and later at the École des Beaux Arts in Paris (1903-1906), was the author together with Horace W. Peaslee

Figure 12. *British Embassy at Washington D.C. (1925-1930) designed by E. Lutyens and construction supervised by Frederick H. Brooke (Vegas & Mileto 2013).*

(1884-1959) and Nathan W. Wyeth (1870-1963) of the District of Columbia War Memorial in West Potomac Park in Washington, a Doric temple with a colonnade crowned by a dome 47 feet in diameter built by Guastavino Co. The intrados of the dome is apparently rendered with classical mouldings with shallow coffers. The initiative to build a monument to the participation of the United States in World War I dates from 1924, although the preliminary project is dated May 1925. Once funding was complete, the memorial was erected in 1931 (fig. 13).

Lutyens visited the United States on four occasions in relation with his project for the British Embassy in Washington. The first time, in April 1925, to receive the commission; the second and third, in October 1928 and September 1929, to make the only two visits to the site that he was able to (work had begun in January 1928); and the fourth, in May 1930, for the inauguration of the building (Stamp & Greenberg 2002, 129-46). The construction of the embassy was left largely to the architect Frederick H. Brooke. Lutyens's project, a cross between Georgian English and vernacular American style, is characterised by the predominance of trabeated architecture, except, of course, for the staircase. In fact the double staircase at the entrance has a very flat vault at the centre, which might suggest the presence of a stone-covered tile vault. Without examining in greater depth the archives or making probes on the building, neither of these possibilities can be confirmed.

The Bank of England: Baker, Soane and the frustrated participation of Guastavino Co.

Baker also admired the work of Guastavino Co. during his visit to the United States in December 1929. His good friend Goodhue had died in

Figure 13. *District of Columbia War Memorial (1925-1931) in West Potomac Park in Washington D.C. designed by Frederick H. Brooke, Horace W. Peaslee and Nathan W. Wyeth, and built by Guastavino Co. (Vegas & Mileto 2013).*

1924, so it was Philip Sawyer, whom it seems he met through Hope Bagenal (Bagenal 1923c), who acted as his guide around the city. As he was engrossed in designing the Bank of England in London, Baker asked Sawyer to show him the banks he had built in New York in recent years, especially the Federal Reserve Bank (1924), which he had also shown to Alexander Thomson Scott (1887-1962), Baker's partner, on his earlier visit to New York to prepare the initial design. Besides, the Bank of England and the Federal Reserve Bank of New York had worked together during the 1st World War raising funds for the Allies and it was only natural that they held cordial relationships and exchanged ideas on their respective new buildings to be erected after the war (Abramson 2005, 205).

Apart from this bank, the York & Sawyer architecture studio had made a large number of banks in the city with the participation of Guastavino Co., among which it is worth paying special mention to: the Bowery Savings Bank Building (1922), the Broadway Barclay Building (1926), the Brooklyn Trust Co. Building (1926) and the Central Savings Bank (1928). In his memoirs, Baker says he visited the famous buildings in New York, Central Station and Pennsylvania Station among others, which he admired enormously and also compared them to Roman thermal baths (Baker 1944, 114). It is to be expected that he visited other works by McKim, Mead & White, especially considering that both Edward York and Philip Sawyer had been disciples and employees of this famous trio of architects.

Baker was also regaled with the hospitality of William Adams Delano (1874-1960), another architect who worked many times with Guastavino Co. on the Kyhuit Rockefeller Estate in Tarrytown (1916), on Oak Knoll, the Bertram G. Work Estate (1917), and on Oheka Castle, the Otto Hermann Kahn Estate in Huntington (1919), among others. During his trip in USA, Baker also stated his admiration for the Memorial Amphitheatre in Arlington National Cemetery (1914-1920), built by Carrère & Hastings with the collaboration of Guastavino Co (fig. 14). Baker's remarks and descriptions would lead us to believe he visited other Guastavino buildings, such as Rafael Guastavino Expósito's own house on Long Island, accompanied by Delano; some buildings of Harvard University in Cambridge ("admiring a beautiful small domed building") (Baker 1944, 119); and other buildings located in Washington, Boston or Philadelphia.

Despite all the foregoing and his sincere admiration for vaulted spaces, Baker clearly gave priority to the form and not the constructive force of these buildings or, rather, to the form without attaching too much importance to the constructive solution adopted, as he would make clear in his refurbishment of the Bank of England. Baker received this commission in the spring of 1921, when he was still busy with the design and construction of the New Delhi buildings. Edwin Lutyens had been promised

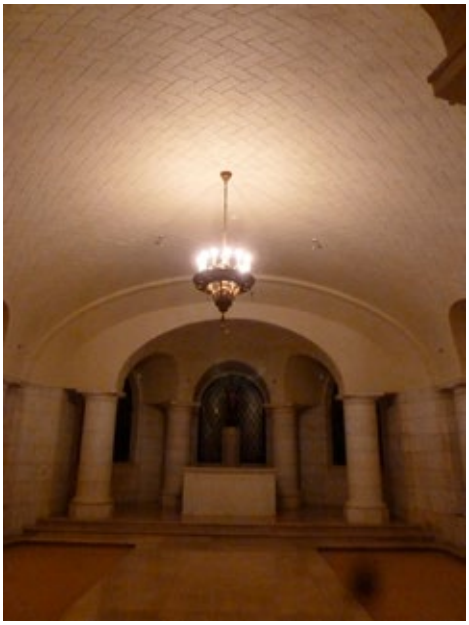

Figure 14. *Among other buildings with Guastavino vaults, Baker visited in 1929 the Chapel at the Memorial Amphitheatre in Arlington National Cemetery (1914-1920), designed by Carrère & Hastings and built and cladded with Akoustolith tiles by Guastavino Co., Arlington, VA (Vegas & Mileto 2013).*

the commission years before by the then governor of the bank, Lord Cunliffe (1855-1920), since dead, so that this affront was an addition to the enmity he already felt towards his rival (Lutyens 1980, 185).

The Great War had not only added more than a zero on to British national debt but had also quadrupled the number of employees in the Bank of England, which called for an urgent expansion of office space. The old Bank of England building (Abramson 2005; Bank of England Museum 2003), with the extraordinary vaulted spaces designed by John Soane (1753-1837) between 1788 and 1833, a veritable symphony of vaults and domes, of masses intermingled with light, was starting to be seen as a museum (Kynaston 1999, 22). Baker's blueprints for the Bank of England strove to respect "as much of Sir John Soane's famous building as may be possible without too great a sacrifice of other vital considerations involved" (Baker 1921). This initial intention of conserving the façade and a large amount of the bank's first outer bay with many of Soane's vaulted spaces lost force little by little due to the increase of built surface performed, caused by Baker's love of symmetry and geometric order and with the excuse that the old building suffered pathologies, and he eventually ended up demolishing Soane's work completely. The building of a line of concrete domes in Soane's style did not in any way compensate for this irreparable historic loss.

In general terms, the rebuilding process lasted between 1921 and 1942, but it continued even after Baker's death in 1946 in the design of some interior spaces that were left to his partner Scott to finish. Even though most of the photographs, plans and details are still kept in the bank and are not accessible to the public for safety reasons, some drawings dated 1947 are conserved and show that up to that time they were considering the possibility of covering over some false ceilings and vaults with acoustic tiles. Guastavino Co.'s files throw no light on the matter, either because it never actually materialised or because of the documentary secrecy involved in this sort of institution (Baker & Scott 1947).

One of the reasons Baker gave for demolishing Soane's work was the construction of a building with a fireproof metal and concrete structure, although Soane's work had been conceived and constructed precisely as fireproof to replace the wooden structures of his predecessor in building the bank, the architect Robert Taylor (1714-1788). Indeed, in keeping with the Roman building tradition that he so admired, for his vaults and domes Soane used bricks and lightweight hollow clay pots (Abramson 2005, 107), a unique building method that had been reinvented by the architects Jean-Far Eustache de Saint Fair (1746-1828) and Victor Louis (1713-1800), after the research on fireproof vaults carried out by Comte Félix François d'Espie (1708-1792) (d'Espie 1754). Furthermore, Soane showed

interest in this subject not only participating in the study of fireproof systems proposed by the Architects' Club (Abramson 2005, 107), but also creating fireproof jack vaulting floors for the New State Paper Office (1829-1834) (Palmer 2006; Watkin 2000, 270), which protected the underside of joists from fire, a solution extraordinarily similar to the one proposed by Rafael Guastavino in many of his works and patents, such as those commissioned for the Fire-Proof building (Guastavino 1888) or the Hollow Cohesive Arch (Guastavino 1892a).

And the fact is John Soane and Rafael Guastavino had many points in common, although the latter apparently did not know about the former. They both took up architecture for reasons of family tradition (Abramson 2005, 96; Vegas & Mileto 2012, 132-56); they admired and tried to imitate Roman building methods (Richardson & Steven 1999, 62; Abramson 2005, 107, 226; Guastavino 1892b, 12-4; Guastavino 1895, 101-16); they invented self-supporting construction systems (Darley 1999; 130); they manufactured special ceramic pieces for the construction of their works[10]; they used Portland stone repeatedly because of its extraordinary resistant properties, either in its natural state or evoked in mortar with the same name of similar appearance and characteristics;[11] they developed fireproof systems for their structures; they were as fascinated by technological excellence as by architectural detail (Darley 1999, 50; Tarragó 1999, 227); they built beautiful domes and vaults that succeeded in dignifying and embellishing even the most mercantile or prosaic activities below them; they lit these vaulted spaces magnificently by inserting oculi, lunettes and thermal windows; they inserted metal ties and rings inside the fabric to conceal them from view and protect them from fire (Abramson 2005, 107; Huerta 1999, 334; Guastavino 1910). And, unfortunately, they both shared and suffered the disdain and incomprehension of Baker, who was incapable of preserving the work of the former or use the constructive potential of the latter in his great works, reducing his participation to the acoustic cladding of vaults.

Conclusion

History is always written by the victors. Lutyens lost his personal battle in New Delhi in the Bakerloo issue, but won the war in the end. Lutyens, an extraordinary architect but also the spoilt child of the English bourgeoisie and on excellent terms with *Country Life* and *Architectural Review Magazine* (Gradidge 2002, 147-148) managed to underrate and even wipe out the presence of Baker in the monograph about New Delhi written by Robert Byron for *Architectural Review* in 1931 (Byron 1931), being adjudicated the merits himself later in the publications of Nikolaus Pevsner (1951, 217-25) and the remarks of Le Corbusier[12] (Boesiger 1957, 50). Notwithstanding the architectonic quality of Baker's previous work in South Africa and New Delhi, this discredit was exacerbated too by his project for the Bank of England at London with the polemic and surprising demolition of John Soane's vaults. Both Guastavino Co.'s real collaboration in the Legislative Building in New Delhi and their potential participation in the new Bank of England, where, as well as the Akoustolith tiles, the tile vault would have established an extraordinary dialogue with John Soane's historical domes, were left in the background. It is no surprise, therefore, that the extraordinary participation in the acoustic absorption in these significative spaces by Guastavino Co., a firm that always stayed in the background behind the protagonists of the work, has gone unnoticed by the history of architecture, an unforgivable omission that this article hopes to amend.

Acknowledgements

We are thankful for the help received during this research to the personnel of the Avery Library of the Columbia University of New York, especially to Janet Parks and Katherine M. Prater, who has allowed us to reproduce the original drawings by Guastavino Co.; National Archives of India and the Spanish Embassy in New Delhi; RIBA library and archives; Victoria & Albert Museum of London; Sir John Soane's Museum Archives; to Teresa Vegas; and to the library of the UPV for getting us rare and old texts, articles and books.

Notes

1 This text is the content of a lecture given by the authors at the meeting organized by The Construction History Society of America (CHSA) at the Massachusetts Institute of Technology on November 3rd, 2012. See: http://web.mit.edu/cron/Backup/project/guastavino/www/chsa_papers.htm).

2 This was Lutyens' final victory: "Another struggle with Baker over the site of the Legislative Chamber, but I have got the building where I wanted and the shape I want it" (Lutyens 1920b).

3 Other people criticized the building's form and pointed this apparent movement of the whole, as the good friend of Baker's, Sir William Marris, who commented that this building was about "to go slowly turning round" (Irving 1981, 299). The Space Odissey comparison was first suggested by Volwahsen (2002, 221).

4 Among others; US Military Academy, cadet chapel in West Point (1903-1910); Goodhue's New York office (1905-1906); Calvary Episcopal Church in Pittsburgh (1906); St. Thomas's Church in New York (1906, 1911-13); South Church (now Park Ave. Christian Church) in New York (1910); First Baptist Church of Pittsburgh (1911); Laboratories at the Rice University in Houston (1912); Tyrone Railroad Station (1914-1918); St. Vicente Ferrer Church in New York (1915); California Building (now Museum of Man) in El Prado, Balboa Park in San Diego (1915); Henry Dater Residence (now Val Verde Estate) in Montecito (1917) (Wyllie 2007; Ochsendorf 2010, 226-40).

5 We have the answer to this letter (Sabine 1914).

6 The lecture took place at the end of March or beginning of April 1914 at the Royal Asiatic Society.

7 In his most clamorous years, Lawrence of Arabia hid in the attic of Herbert Baker placed in 14th Barton Street, where he wrote his book The Seven Pillars of Wisdom (Baker 1944, 206).

8 See among others: Gould Stable in New York (1902), New York Historical Society (1902), Rockefeller Institute for Medical Research (1908), Fifth Ave. Hospital in New York (1921), Bowery Savings Bank Building in New York (1922), and the already named Federal Reserve Bank in New York (1924) (Ochsendorf 2010, 226-40).

9 Several options were considered for the American partner for Lutyens in the British Embassy, among them, the architect Cass Gilbert, who had initially helped suggesting the choice of "a first class British Architect in conjunction with some reliable American architect". Cass Gilbert was finally rejected as possible partner of Lutyens to manage the building site due to its poor reputation as builder (Stamp & Greenberg 2002).

10 Soane did not only used especial lightweight hollow clay pots (Richardson & Steven 1999, 237; Darley 1999, 129), but also chose sometimes to produce and use white limey bricks for the main façade instead the usual red ferrous bricks due to aesthetical reasons, for example at the stables of Burnham Westgate (1786) (Darley 1999, 77). On the other hand, Guastavino also did it (Guastavino 1892b, 21). It must be remembered that Guastavino required "Spanish tiles" in order to build the Boston Public Library (Mroszyk 2004, 28-29). Besides, he finished to establish his own ceramic kiln at Woburn, Ma.

11 Soane often used Portland stone because of its strength performance at cantilevered staircases like the one at Letton Hall (1783), Tendring Hall (1784), Shotesham Hall (1785), Pitt's country villa at Holwood (1799) or at his own house at Lincoln's Inn Fields (1794), among others, much in the way the Prun stone is used in Verona and Vicenza to build cantilevered staircases, which he probably saw while visiting the area in September 1779 (Darley 1999, 50). He also used Portland stone to face some pillars and walls at the Bank of England. Besides, Soane was one of the first architects to use Parker's roman cement, a proto Portland cement developed during the 1780s and patented in 1796 by James Parker, in the Moggerhanger House (1790-93, 1806-12) (Dean 2007). Joseph Aspdin (1778-1855) patented Portland cement in 1824. We do not know if Soane used it in his last buildings, as he only retired in 1834, when he was aged 81. Guastavino defended the use of Portland cement (Guastavino 1892b, 21-23, 26-27).

12 "New Delhi, capital of Imperial India, was built by Lutyens over thirty years ago with extreme care, great talent and true success. The critics may rant as they will but the accomplishment of such an undertaking earns respect" (Boesiger 1957, 50).

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