Leading practitioners of the day agreed with Guastavino Jr.'s assessment of the significance of the accomplishment, and the project received extensive coverage in science and engineering journals.[15] The dome measures 95 feet (29 meters) along each side its square base in plan, and 135 feet (41 meters) across the diagonal of the square. The radius of the dome of St. John the Divine is 66 feet (20 meters) and the thickness at the crown is only 4.5 inches (11.4 centimeters). To maintain the spherical dome geometry throughout, Guastavino Jr. created a geometrical guide with suspended steel cables to assist the masons. [Figs. 4.20–4.21]

In addition to the feat of building the tile dome, Guastavino Jr. described the recent improvements that the company had made to the "timbrel" vault, the signature structure whose name was coined by his father. At St. John the Divine, the company used steel bars between courses of tile for the first time, in order to structurally reinforce the material. According to Guastavino Jr., the steel reinforcement served to "update" the ancient construction technique to fit modern American building standards. The new tile-vault system would thus allow architects to build the soaring structures of Gothic cathedrals in a short amount of time: "It is evident that the Timbrel Vault in its adopted country has now reached a stage of development that compares favorably with any of the large and noble structures of ancient times."[16] In fact, judged by economy of materials and speed of construction, Guastavino's system outperformed the great structures of Europe. For example, the dome of the Basilica di Santa Maria del Fiore (1436) in Florence, by Brunelleschi, weighs over ten times more than Guastavino's dome for St. John the Divine, and required fourteen years to build, in comparison to Guastavino's fifteen weeks. [Fig. 4.22]

The placement of steel bars in areas of tension illustrated Guastavino Jr.'s more complete understanding of structural behavior than that of his father. It also acknowledged that the tile vaulting did not have significant strength in tension, an important departure from his father's assertions. Guastavino Jr. received a patent in 1910 for the company's method of reinforcing the thickness of the vault in the dome.[17] [Fig. 4.23–4.24] Though reinforced masonry had been patented in France in the nineteenth century, Guastavino's patent foreshadowed the more widespread development of thin-shell concrete structures in the early twentieth century. As a lightly reinforced masonry dome, St. John the Divine demonstrated the possibilities for tremendous economy of materials in thin-shell structures.

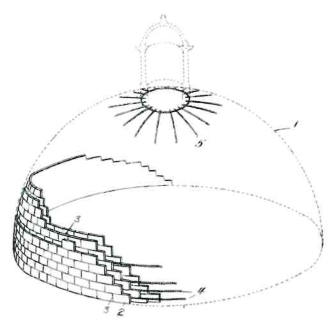

Fig. 4.24
Patent for reinforced masonry, Rafael Guastavino Jr., 1910

Ceramic Arts

Following the success of the City Hall Subway Station (1904) and St. Paul's Chapel in New York City in the early 1900s, the Guastavino Company built increasingly sophisticated decorative patterns in its vaulting. This was accomplished by adding the exposed layer of tile *last*. In other words, masons constructed the vaulting with a rough interior finish, and then applied a final decorative layer of tile from below. This allowed the creation of more complex tile patterns, while ensuring that the geometry of the pattern could be resolved in three-dimensional forms.

Traditional tile vaulting left the plaster of Paris layer of the vault visible from below, as in early projects like the Boston Public Library (1895). By 1910, the plaster layer was sandwiched between layers of Portland cement above and below. At this mature stage of development,

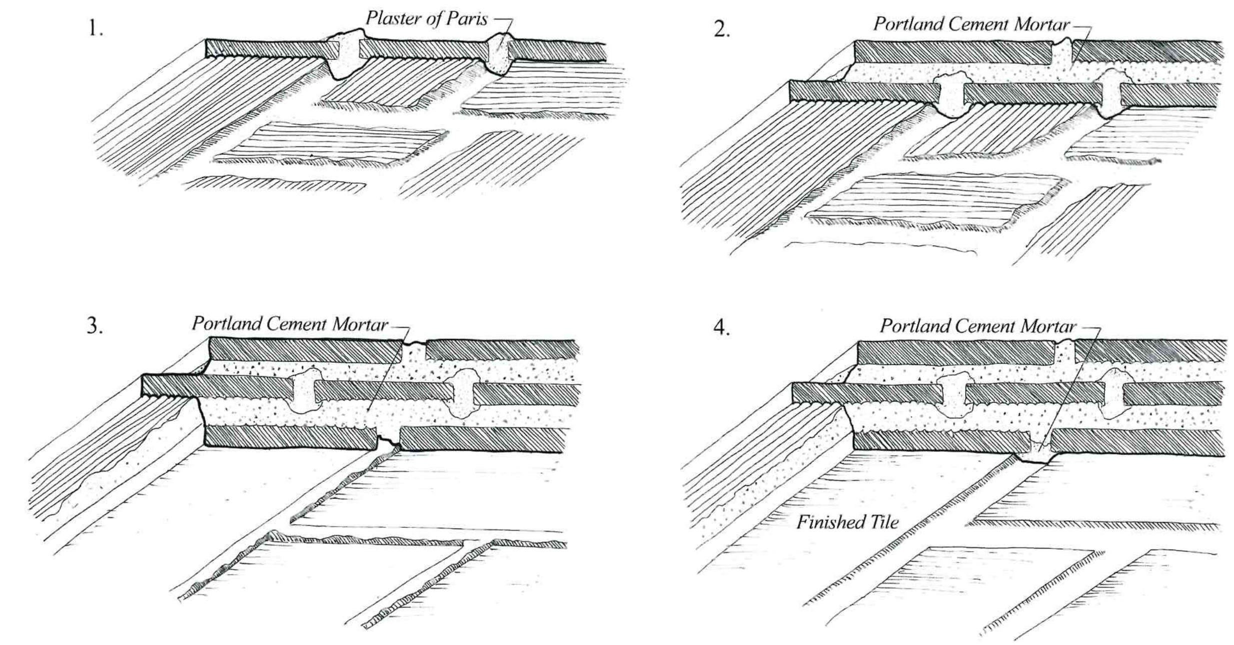

Fig. 4.25
Four stages of mature Guastavino tile construction procedure

masons working for the Guastavino Company built the vaulting in four main steps: (1) the first layer was built with fast-setting plaster of Paris to minimize formwork; (2) a second layer of tile was added on top with Portland-cement-based mortar; (3) a third layer of finish tile was added from below, again with Portland cement mortar; and (4) the joints were finished from below with an extruded Portland cement mortar. [Fig. 4.25] Additional layers of tile could be added on top depending on the required strength of the vault.

Thus, the finished vault is a matrix of tiles glued together with Portland cement, creating a thin, rigid shell of concrete. This also minimized the amount of plaster of Paris, which has lower strength and is more susceptible to water damage than the Portland-cement-based mortar. The process allowed the use of less expensive structural tiles—typically corrugated clay—on the interior, and reserved the final layer for a more expensive finish tile. The finish tile could be any type of Guastavino tile: an acoustical product, or a glazed ceramic tile of various colors. To resolve the tile patterns, the masons often worked from the top of the vault down to the supports. [Fig. 4.26]

Fig. 4.26
Adding final layer of Guastavino tile on underside of vault, National Shrine of the Immaculate Conception, Washington DC, 1958

Three Guastavino projects built in the period 1911–13 stand out for their innovative use of decorative tilework: the Holy Trinity Roman Catholic Church in New York (1911; for Joseph H. McGuire), the Della Robbia Room of the Vanderbilt Hotel in New York City (1912; for Warren and Wetmore), and the Forsyth Dental Institute in Boston (1913; for Edward T. P. Graham). For each building, the Guastavino Company developed a distinctly different design approach, illustrating their adaptability. The Holy Trinity Roman Catholic Church was designed in a Byzantine style in collaboration with architect Joseph H. McGuire (1865–1947). While the tile domes and arches are the load-bearing structure of the building, the tile patterns created an elaborate Guastavino interior. [Figs. 4.27–4.28] The geometric patterns of tile, the precision of the geometry, and the stylized protruding mortar joints could only have been