Brunelleschi and the Origin of Linear Perspective

Adapted from Joseph W. Dauben, The Art of Renaissance Science. (www.crs4.it/Ars/arshtml/arch1.html)

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Sixteenth-century renaissance artists like Leonardo da Vinci and Michelangelo Buonarotti were able to clearly recreate the three-dimensional physical reality of the human form on two-dimensional surfaces.

One key to their achievement lay in understanding the underlying, hidden structure of the human body. Renaissance artists did this through careful observation of nature, including studies of anatomical dissections, enabling the artist to produce realistic representations of observed objects. But close observation of the natural world was nothing new, nor unique to renaissance artists. Medieval artists were also good observers, especially in the period just prior to the Renaissance.

What was new in the fifteenth century, was a corresponding observation of three-dimensional physical space, and the means by which the artists represented that space on a on two-dimensional surface. This system, called "**perspective**," produced a greater sense of "realism," and a correspondence between the physical reality of nature and the representional reality created by the artist. This was all made possible through **mathematics**.

Portait of Brunelleschi

The Florentine architect and engineer **Filippo Brunelleschi** was the first to carry out a series of experiments leading to a mathematical theory of perspective.

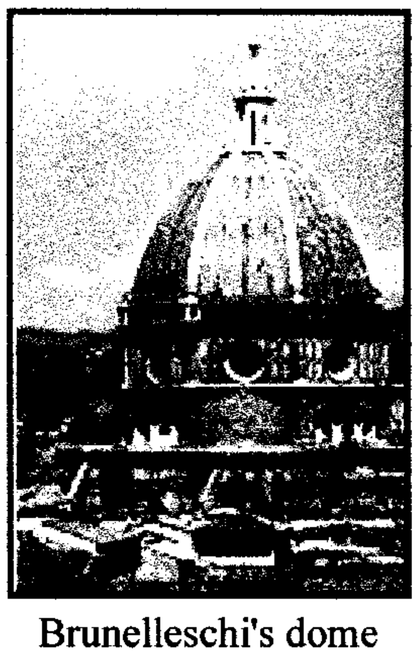
Brunelleschi began his career as an architect, which seems to have led him to his perspective studies.

His most stunning accomplishment in architecture is the dome which crowns the Cathedral in Florence (right), a work that occupied him intermittently from 1417 to 1434.

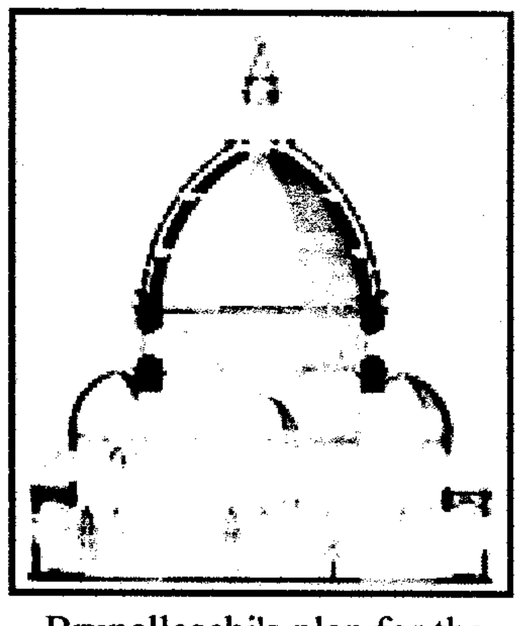
Brunelleschi's dome

The technical difficulties involved in erecting the new dome underscored an important aspect of his talents: he was a daring innovator, with a solid knowledge of mathematics and mechanics.

Perfectly in keeping with such interests are the experiments Brunelleschi performed on the subject of **mathematical perspective**.

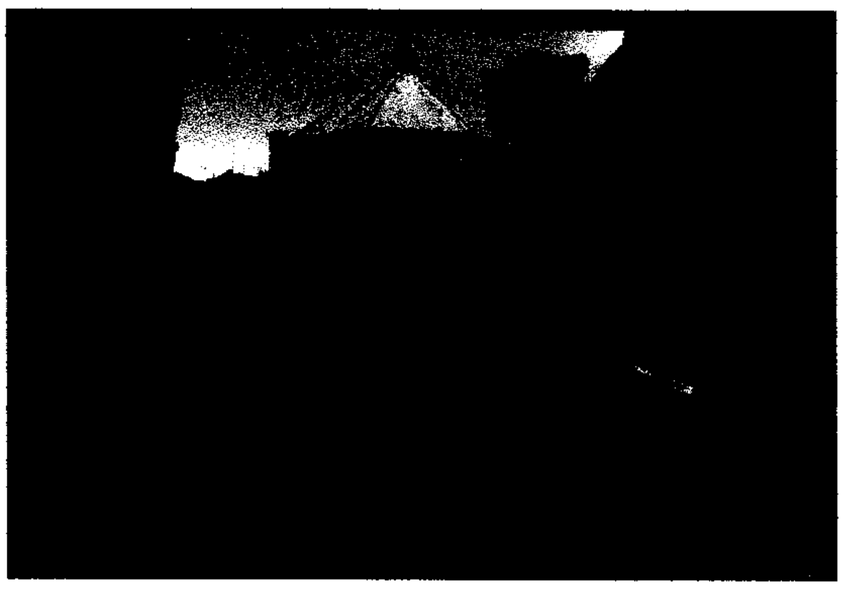


Brunelleschi's dome



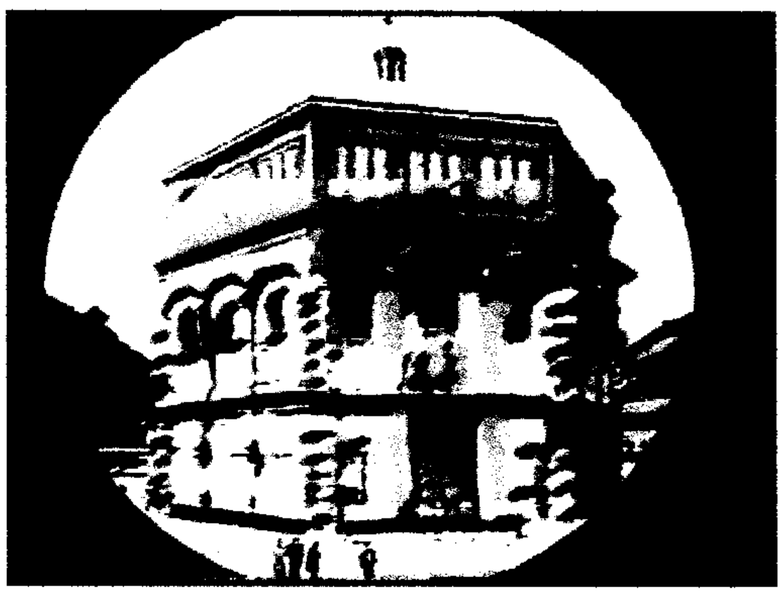
Brunelleschi's plan for the dome

Writing a century later, Brunelleschi's biographer, Antonio Manetti, describes one of these experiments, in which Brunelleschi painted the Baptistry in Florence (right), which stands directly before the famous cathedral that Brunelleschi would later dome.



The Baptistry in Florence

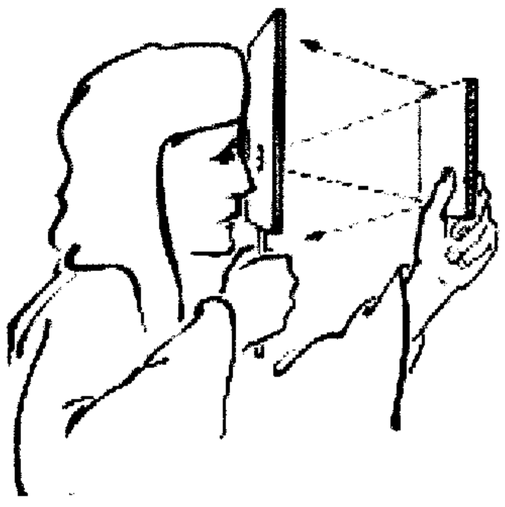
In 1415, Brunelleschi painted his picture of the Baptistry on the surface of a small mirror, right on top of its own reflection. Unfortunately, this work has since been lost: it seems to have been intended to be used only in this experiment, not to be preserved.



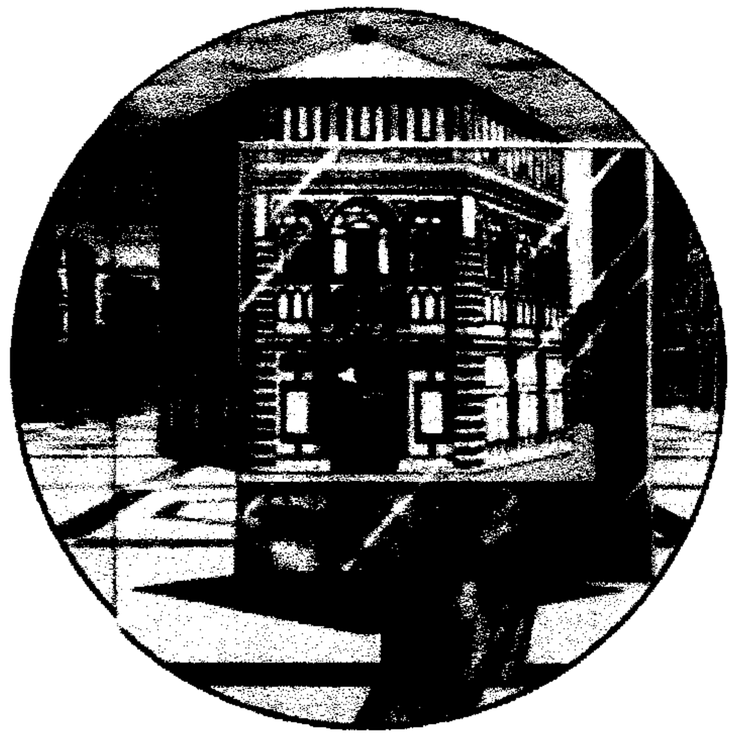
To demonstrate the fact that his painting was indeed an exact replica that could fool the eye, Brunelleschi drilled a small hole in the mirror and then stood directly in front of the Baptistry, looking through the peephole to see the real building.

He then held up a second, clean mirror in front of his painted panel. The second mirror blocked the view of the real building, but now reflected his painted version on the original mirror.

By moving the second mirror in and out of the way, Brunelleschi could check whether his painting was indeed an exact copy of the

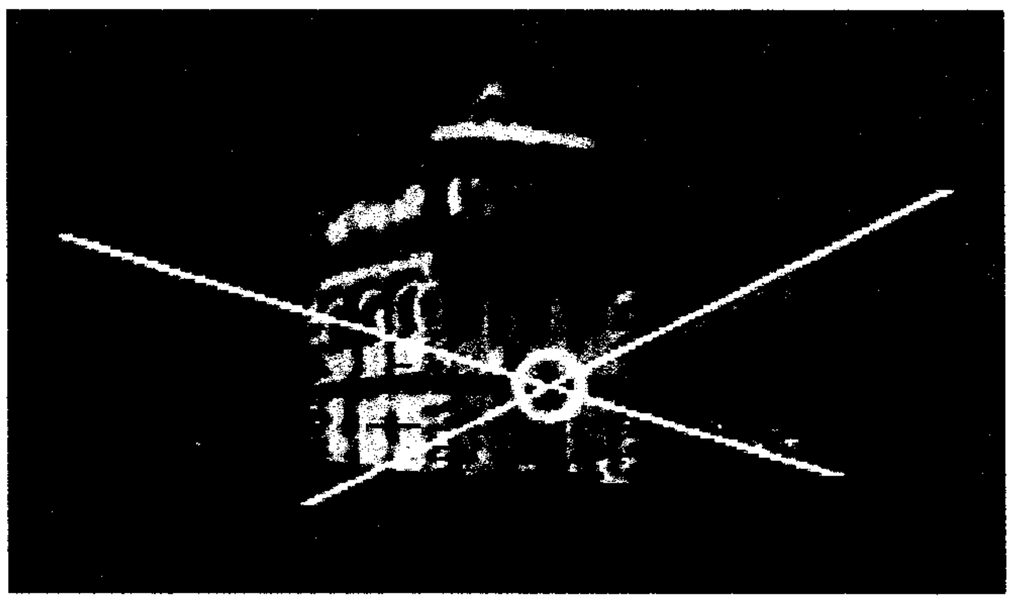


three-dimensional, octagonal building on the two-dimensional surface of his original mirror.



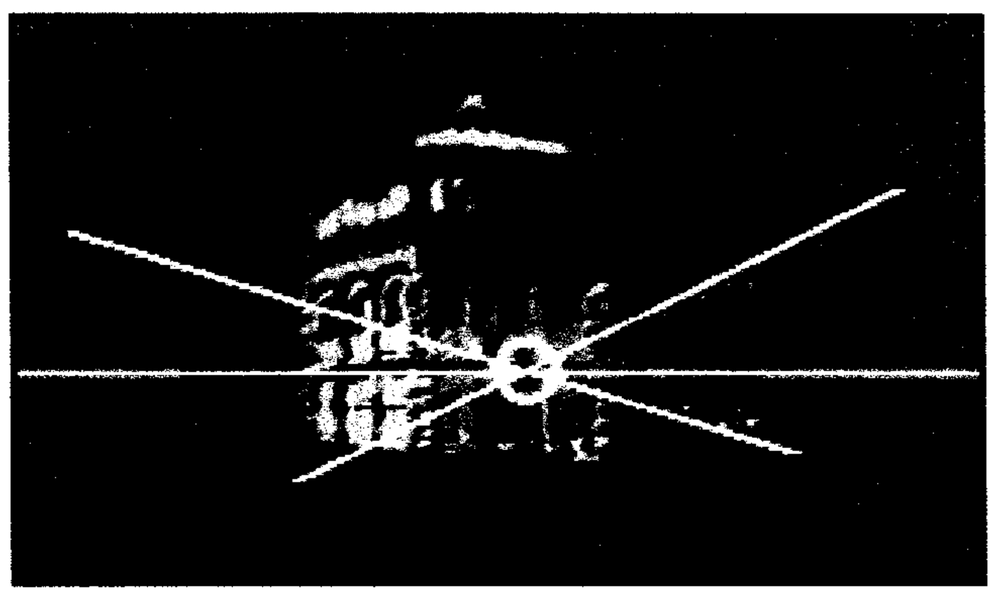
Once he had verified the accuracy of his painted mirror, it became possible for Brunelleschi to analyze the structure by which three dimensions was translated into two dimensions.

As Brunelleschi found, there was a mathematical system. It centered around the **central vanishing point**, inside the yellow circle in the graphic at the right, where all lines that were perpendicular to Brunelleschi's painted mirror (often called "**the picture plane**") would converge, like railroad tracks in the distance.



Brunelleschi's vanishing point

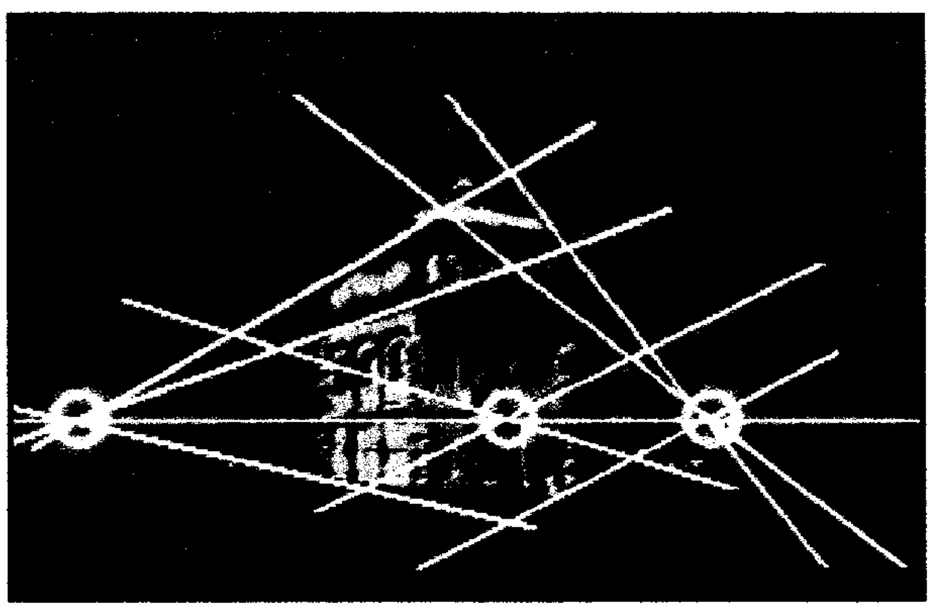
This point determined the horizon line, and was exactly opposite to Brunelleschi's own position standing in front of the Baptistry.



Brunelleschi's horizon line

The horizon line contained other vanishing points as well, where lines determined by structures that were not exactly perpendicular to Brunelleschi's mirror would converge.

For example, those lines determined by the oblique



Brunelleschi's perspective system

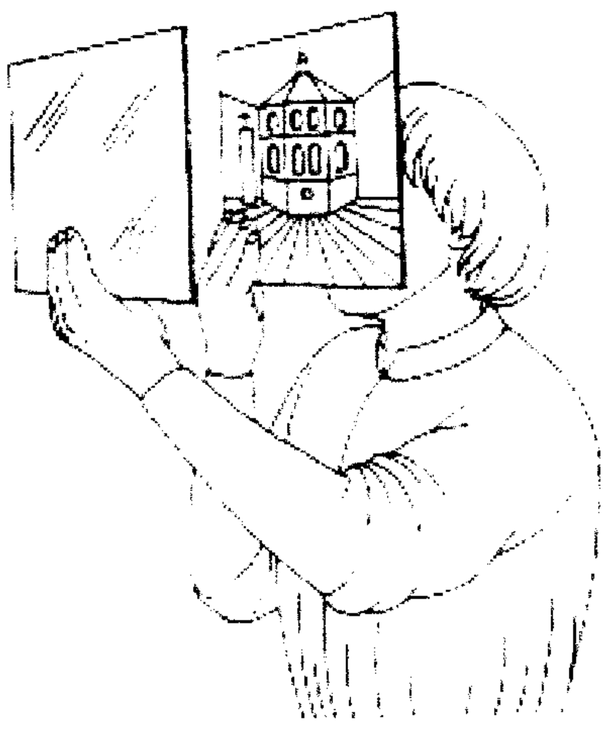
sides of the octagonal Baptistry converge at different vanishing points, which still lay on the horizon line (inside the yellow circles to the left and right of the central vanishing point).

What is clear from Manetti's description is that Brunelleschi used his painted mirror for careful calculations. His final result showed a logical, rational, mathematic system by which three-dimensional space could be rendered on any two-dimensional surface.

Once Brunelleschi devised and publicized this system of horizon lines and vanishing points, any artist could use it to create convincing spaces in their paintings, without using mirrors.

Part II: Applications of Perspective in Renaissance Art

Brunelleschi's Experiment: The Duplication of Sight



The scene in front of the cathedral on that August day in 1425 must have been puzzling. People were used to seeing Brunelleschi around the cathedral; its magnificent dome was then being constructed according to his design and under his supervision. But on that day he was not involved with the dome. A crowd of passersby stood in line. He gave each of them, one by one, a small mirror and a small painting. What each one did with the painting and the mirror seemed very strange. Each person put the back of the painting up to one eye and looked through a hole in the painting's center, then held a mirror in the other hand in front of the painting so that the painting itself was seen (through the hole) reflected in the mirror.

After looking through the painting at the reflected image of the painting in this way, each person inevitably lowered the mirror and stared at the building beyond--the ancient Baptistry of Florence--then, with obvious eagerness, raised the mirror and looked at the painting reflected in it again at least once more before reluctantly handing both mirror and painting to the next person in line. Everyone was obviously pleased and excited, especially Brunelleschi, who continually shrugged and laughed in enjoyment at the questions and comments surrounding his little experiment.

Brunelleschi wanted to demonstrate that his newly discovered rules of linear perspective could reproduce the exact "look" of things to the eye--the illusion of three-dimensional space on a two-dimensional surface. To show this, he had painted a small picture of the Baptistry on a wooden panel precisely according to his newly developed method.

After painting the building on the panel, he covered the area of the painting above the Baptistry with highly reflective silver leaf to produce a mirror like surface. then he drilled a hole in the painting. A person looking through the hole in the back of the painting at its reflection in the mirror held in front of it could then see more than the precisely painted image of the Baptistry; reflected in the silver-leaf surface surrounding it would be the sky and the moving clouds!

The scene seemed miraculously real. And its reality could be tested: by lowering the mirror while still looking through the hole in the painting, one could see the Baptistry itself--from exactly the same angle that Brunelleschi had drawn and painted it. The real Baptistry looked exactly the same as the painted Baptistry. The moving clouds were a dramatic touch of genius. A miracle, indeed, but a "miracle" of particular importance, because it fused art and science in a common achievement: an image that approximated how the world appears to the human eye.