Number 1: "THE STORY OF ALTAIR DESIGNS AND JULES BOURGOIN," A paper by Roger Burrows for Bridges 2025.

Number 2: Altair designs are mathematical patterns constructed with arrangements of straight lines, line junctions, and line paths. The line junctions and the way they allow perceptions to switch from one pathway to another make Altair designs unique, creating a visual dynamic.

Number 3: The origins of the designs. In 1966, Ensor Holiday was given a copy of Albert Calvert's " Moorish Remains in Spain" and noticed the visual dynamic of design #151. He was also intrigued by the almost regular tessellation of 5-, 6-, 7-, and 8-sided rosettes. Noticeably absent in Calvert's book were illustration credits or any descriptions of design construction methods.

Number 4: This close-up of #151 design shows the four rosettes and octagon figures that compose the design. The odd and even numbered rosettes serve as visual junctions that direct the eye along multiple paths, creating a visual dynamic akin to an optical illusion.

Number 5: If you look carefully at a detail of #151, you will see the original lines of construction, including dotted circles that surround the 5-, 6-, 7-, and 8-sided rosettes plus an octagon.

Number 6: As Calvert's book did not describe the construction method, Ensor concluded that close-packing circles were the basis of the design method.

Number 7: Ensor distilled the #151 design down to 5 close-packing circles with centres positioned on the sides and vertices of a right isosceles triangle. This triangle, by reflection and rotation, creates the square tile of the design, which tessellates to cover the design area.

Number 8: Keeping the visual flow of the original rosette design, Ensor added straight lines to the 5-circle arrangement: tangents at circle contact points, lines connecting circle centers, internal polygons, internal stars, and combinations. The straight-line arrangements have the same odd and even line junctions as the original design and, visually, keep the same perceptual path variations. now 4-, 5-, 6-, 7-, 8-sided polygons—where the square replaced the octagon of the original rosette design. Ensor's straight-line patterns were named Altair designs in about 1970.

Number 9: To see the perceptual changes, allow your eyes to roam over the designs. Try tilting your viewpoint to see how your perceptions change.

Number 10: There is a perceptual phenomenon of perceiving meaningful forms in random arrangements of lines or shapes, called pareidolia—although Altair lines are not random, they

still conjure the same imaginative perceptions. Pareidolia applies to such things as cracks on a wall, clouds in the sky, or tree branches moving against a night sky. These illustrations show some classic examples, including Giovanni Schiaparelli's canals on Mars. As a species, we are always looking for patterns and predictable events.

Number 11: I began working with Ensor in 1967 to further develop the designs. When we transitioned from my hand-drawn designs to computer-generated drawings on a Calcomp plotter, we found that computer operators often took printouts home for their children to color, with excellent results. This led to the publication of the Altair designs by Longman's publishers as coloring books. In about 1971, the London Times ran an Altair coloring competition that revealed the diversity of how people perceived the designs. We received many hundreds of colored designs from 4-year-olds to 99. The illustration shows types of perceived design where any shape can be found repeatedly, rotated, reflected, or translated.

NUMBER 12: Animation: unlike pareidolia perceptions, any shape perceived can be found repeatedly, rotated, reflected, and translated.

Number 13: Animation: any shape perceived can be rotated around any point of symmetry. In this case, in quarter-turn, 90-degree, and half-turn, 180-degree increments (as is the case, revolving around the midpoint of the square-tile side).

Number 14: Animation: concentric shapes can extend past the unit square tile.

Number 15: Animation: pattern building with rotation, reflection, and translation.

Number 16: Animation: from 1967, my contribution evolved from hand-drawing the designs to exploring close-packing circle and sphere arrangements, please see my bridges papers. This is an early animation of a five-circle-close-packing sequence. The animation shows sixteen different 5-circle close-packings within a right isosceles triangle where circles are allowed under certain constraints and priorities to change size and position, moving from one close-packing to another.

Number 17: This is a 30-/60-degree right triangle with 8 circles, 9-, 7-, 6-, and 4-side figures. The rotations are one-sixth and one-half turns, 60-degree increments, or 180-degree increments around the hexagonal-tile side.

Number 18: Animation: four-circle packing within a 45-degree right isosceles triangle. 8-, 6-, 4-sided figures.

Number 19: These colored designs are more complex and based on 4-, 5-, and 8-circle packings in 45-degree right isosceles triangles and 30/60-degree right triangles. From the London Times

competition, we received complex compositions such as these as well as many more straightforward colored renditions and even just scribbles over visual hot spots in the designs by 4-year-olds.

Number 20: Ensor did not know that Calvert had featured the artwork of others without giving any credit. Calvert's #151 was taken from plate 163 of Bourgoin's " The Elements of Arab Art. " Jules Bourgoin was a French architect and extraordinary character based in Alexandria, Damascus, and Cairo. He was on a mission to preserve Islamic designs, which were falling into disrepair. Bourgoin either derived or found sources for the design methods he used. Architectural structures and surfaces lacked the precision possible today, so it is impossible to confirm the design methods used for any one creation, such as a door or window, unless lines of construction are visible. An exception is the Topkapi Scrolls. Also, given the spread of Islam, there must have been local techniques used to produce similar designs. That said, Bourgoin's methods correspond well with early Islamic art geometric designs.

Number 21: This is the Bourgoin design from which Calvert extracted his #151.

Number 22: According to Bourgoin's descriptive text, the original design's construction method was not based on close-packing circles but on a ray method where angular intersections of the lines of symmetry of regular polygons determined positions for new sets, or 'cores,' of regular polygonal lines of symmetry. Bourgoin's description begins with 16 rays, the 8 lines of symmetry of a regular octagon, centered on the diagonal vertex of a square. I call Bourgoin's 16 rays an 8-core. Bourgoin then describes positioning a circle on that same vertex, sized to meet the intersection of the diagonals of the square. At the intersection of that circle with the base of the square, Bourgoin positions a 6-core. The intersection of the 8-core and 6-core on the diagonal fits a 5-core. The intersection of the 5- and 6-core positions the 7-core and the 7-core with the upper vertex positions an 8-core.

Number 23: Animation: here is a 'ray-method' animation.

Number 24: The method relies on near and exact correspondences between regular polygon lines of symmetry. Bourgoin acknowledged that positioning the cores often required some juggling to make the rosettes appear as regular as possible.

Number 25: The ray method is an interesting way of creating spatial positions from local symmetries and their intersections. These Bourgoin examples are within regular or semi-regular tessellations, but the method, as with close-packing circles, does not have to be so confined. As

with circles-to-spheres, both approaches, circles and rays, could be in three dimensions. Here are some other designs from the Bourgoin book that use the ray method. Two correspond with close-packing circles. The arrangements accommodate the following:

a) 24-and 8-sided figures.
b) 8-, 9-, 10-, 12-sided figures.
c) 12-, 8-, 6- sided figures.

Number 26: This design is based on the ray method within a 30/60 right triangle without any correspondence to close-packing circles. It generates 9-, 7-, and 6-sided figures. The ray method is an interesting way of ordering space. The ray concept is not limited to tessellating forms or two dimensions. In three dimensions, the ray cores could be the lines of symmetry of polyhedra. As said, the method often relies on near correspondences.

Number 27: Bourgoin analysed so many designs that I thought it would be interesting to show a few. This design is based upon an equilateral triangular grid, with three—and six-sided figures.

Number 28: This design is based on three close-packing circles within a right isosceles triangle with a subdivision within one of the circles (a triangular grid), used to create the key-like element. The design has 16- 8-, 6-sided figures.

Number 29: This design is based on a semi-regular tessellation of equilateral triangles and squares. The squares are subdivided into 16 squares, and the equilateral triangles are subdivided into 12 equilateral triangles.

Number 30: These are all Bourgoin illustrations:

The left drawing is based on intersecting decagonal stars, which create 3, 4, 5, and 10-sided figures. The upper right drawing is based on close-packing circles corresponding to a semi-regular tessellation of octagons and squares, creating 10-, 8-, and 4-sided figures on a classic octagon/square semi-regular tessellation.

The lower right is based on the ray method without a close-packing circle correspondence, creating 12-, 10-, 9-, and 8-sided figures.

Number 31: In 2015, I discovered from a fellow co-author, Daud Sutton, that Bourgoin had rendered #151 from windows in a 14th-century madrasa in Old Cairo. Bourgoin's ray method and the close-packing method both correspond well with the stone lattice window. Ensor would have been delighted that we had finally tracked down Altair's origins, as we often discussed where the original might be and what form it would have been in: on a door, a wall, a ceiling, or

a window. It also seems appropriate that the design was a feature of a school, given the educational value of the Altair designs.

Number 32: I have counted four windows in the madrasa with the design.

Number 33: With the Altair story, I found that "misunderstanding can be the mother of invention." In this case, close-packing circles instead of rays. The five-circles inspired research into spheres and 3D lattices with various space-filling applications; see my papers and books. I've counted over 30 Altair design and Altair design-inspired and associated books. I have brought along a few for you to look at if you would like.

Number 34: So, we have gone full-circle from a 19th century French architect, to a British 19th century adventurer, to a London chemist and psychologist, a misunderstanding of a construction method, the development of Altair Designs, and then all the creations and concepts that followed. Then with the help of Daud Sutton back to Bourgoin, who we can imagine sitting by Sarghatmish madrasa in old Cairo sketching an old stone window.

But a circle that can only be completed with knowledge of the 14th-century creator of the original design! *

Thank you for your time. Please do not hesitate to contact me during or after the conference if you would like to discuss the concepts mentioned further.

For more information or to discuss, please call, e-mail, text, or WhatsApp me.

*** NOTE:** Possibly a 14th-century Islamic polymath based in Cairo or Persia, as the amir Sarghatmish favored Persian designs and culture. Maybe someone who is linked to stone masons.