Geometric Improvisations Leading to a Musical Instrument - *thesis document*

by: Sari B. Khoury

Thesis submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

< Master of Architecture >

Thesis Committee

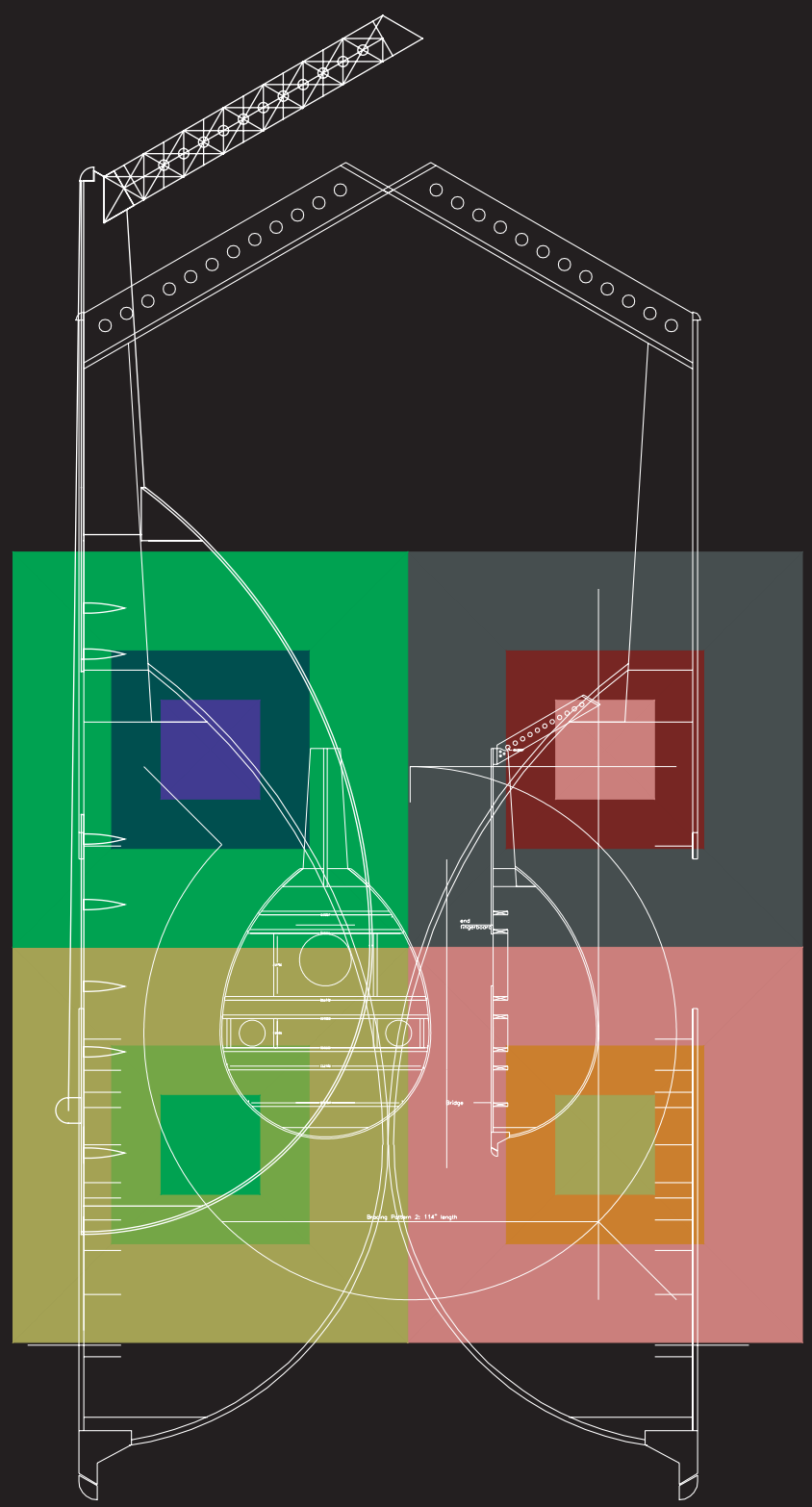
William Galloway
chairman

Mark Schneider
member

John Bryant
member

Date of Defense: April 30th, 2004
Blacksburg,Virginia

Sound preceded Light,
Silence preceded sound,
This silence, knew
LIGHT.



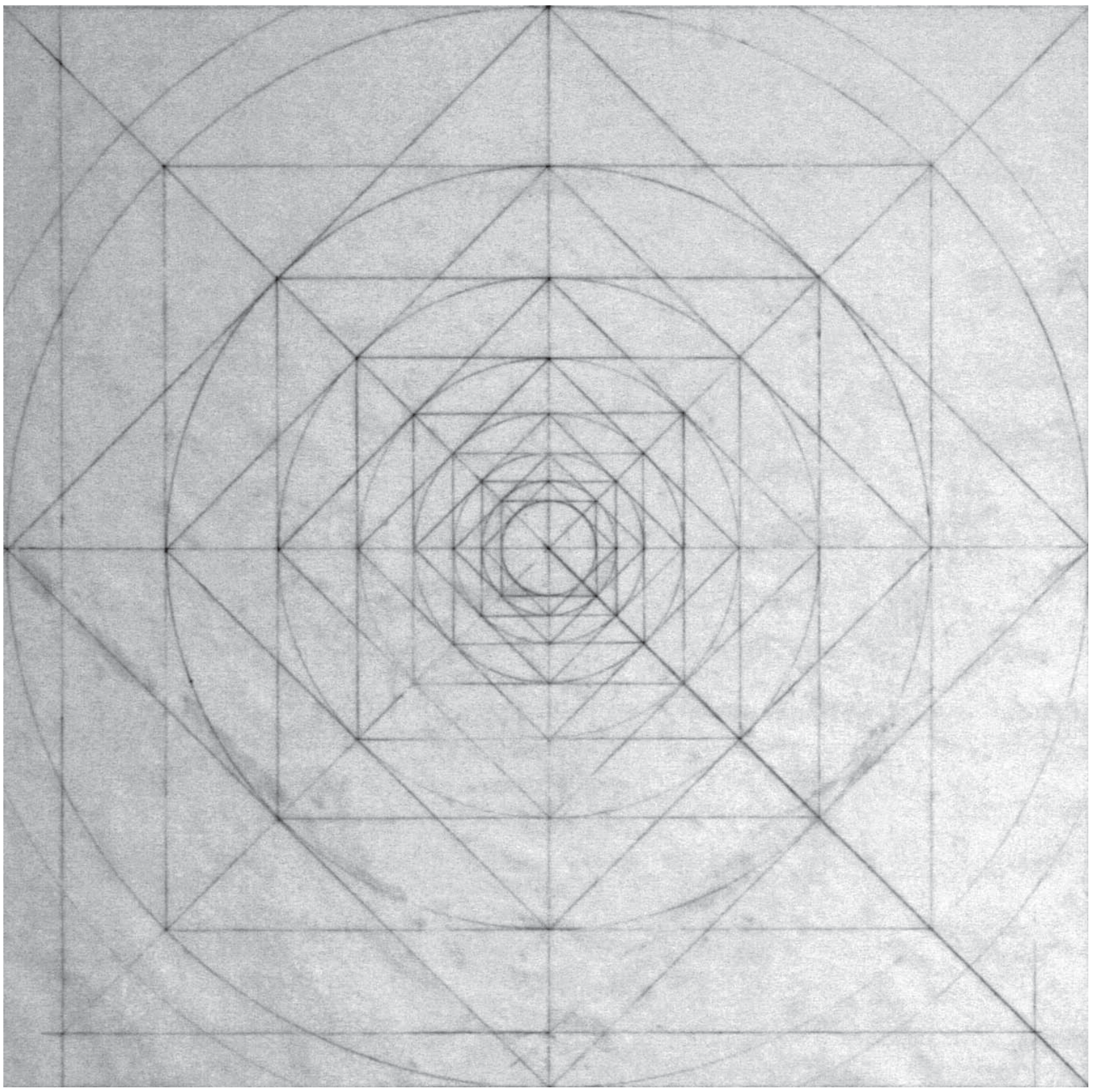
Geometric Improvisations Leading to a Musical Instrument

Sari B. Khoury

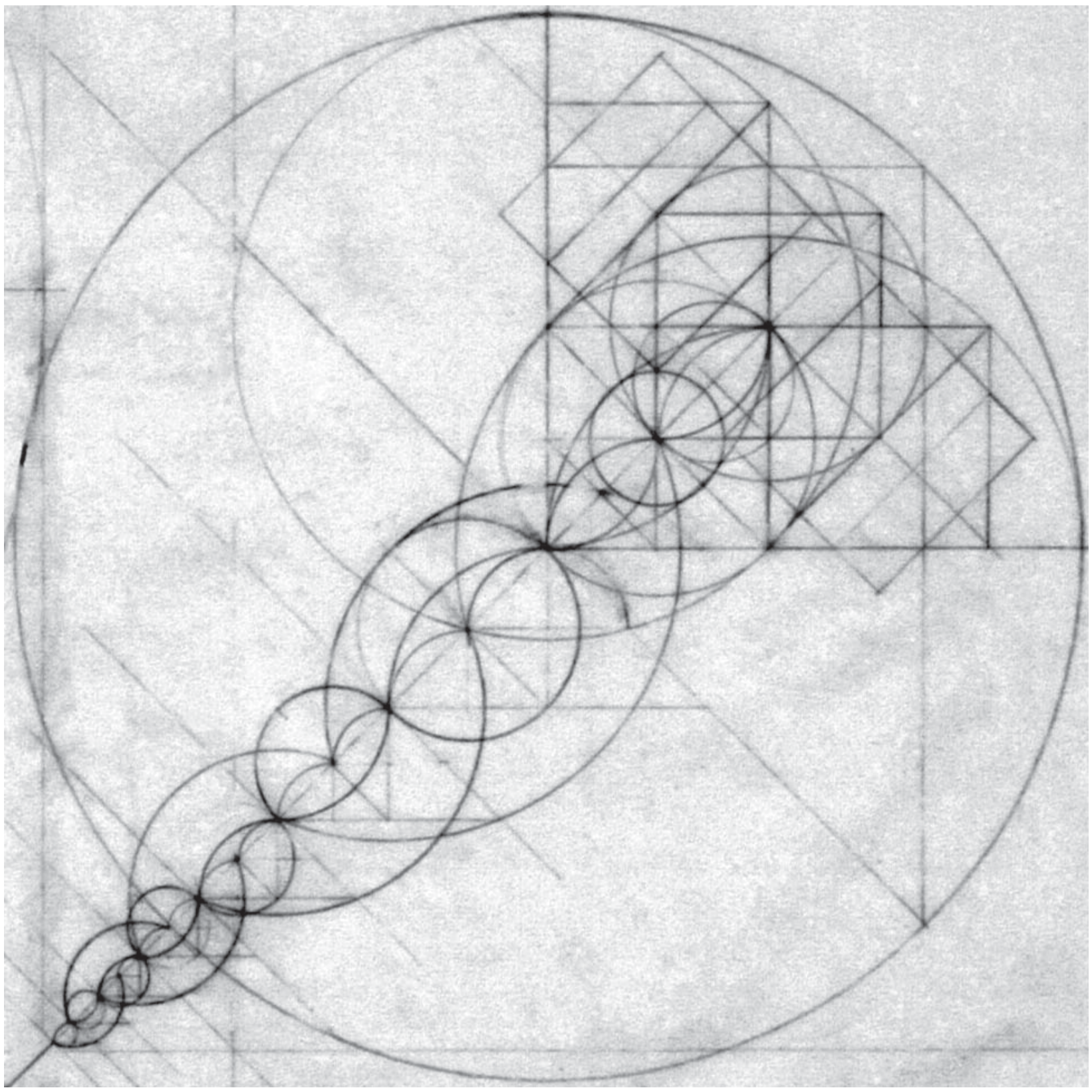
Architecture is a world of external phenomena. The work of an architect fluctuates between non-material and material dimensions. The closest link between these two realms becomes the drawing. Drawings are a first step towards material reality, a two-way threshold through which ideas transform into matter, matter dissolves into idea, and architecture takes place.

The object of this thesis is to apply through design a geometric template. This geometry was a by-product of a series of meditations over the course of one and a half years. In this case, the state of mind through meditation was carried over to the drawing table. Spiritual renewal was necessary and was met with a desire to renew design strategies. This resulted in the bringing together of compass, table and paper, three tools of which there is still much to explore.

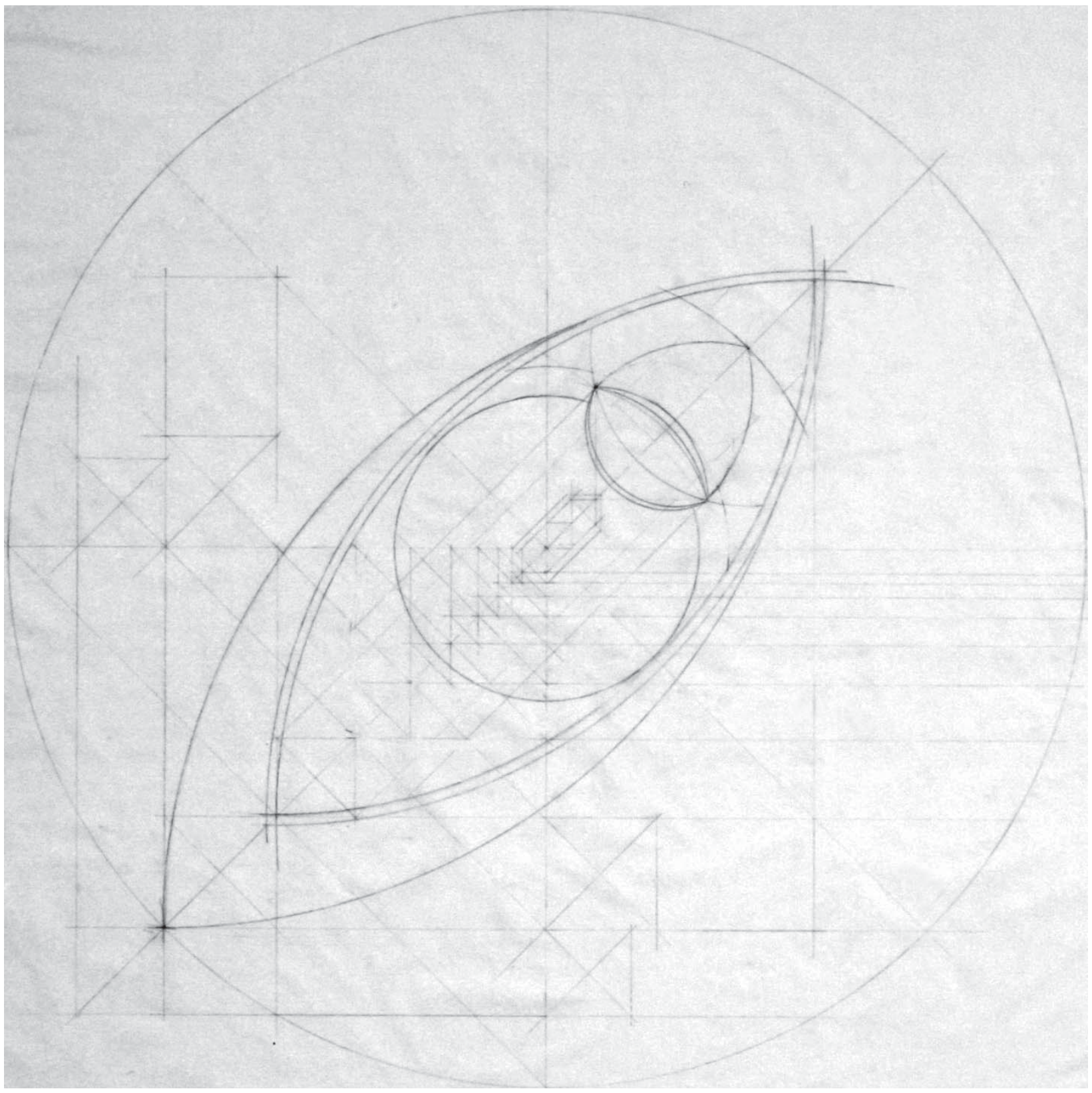
The geometric template consists of a field of points, generated by an expanding pattern, a repetition of square within circle, creating points of intersection and regulating lines. Its merits here are investigated in the form of a stringed musical instrument, the Oud (Al-'Ud), of ancient Middle and Near-East origins. The Oud serves as a vehicle for exploration and study, not as an end, but as a way by which form, geometry, matter and mind may come together within the parameters of drawing, making and learning.



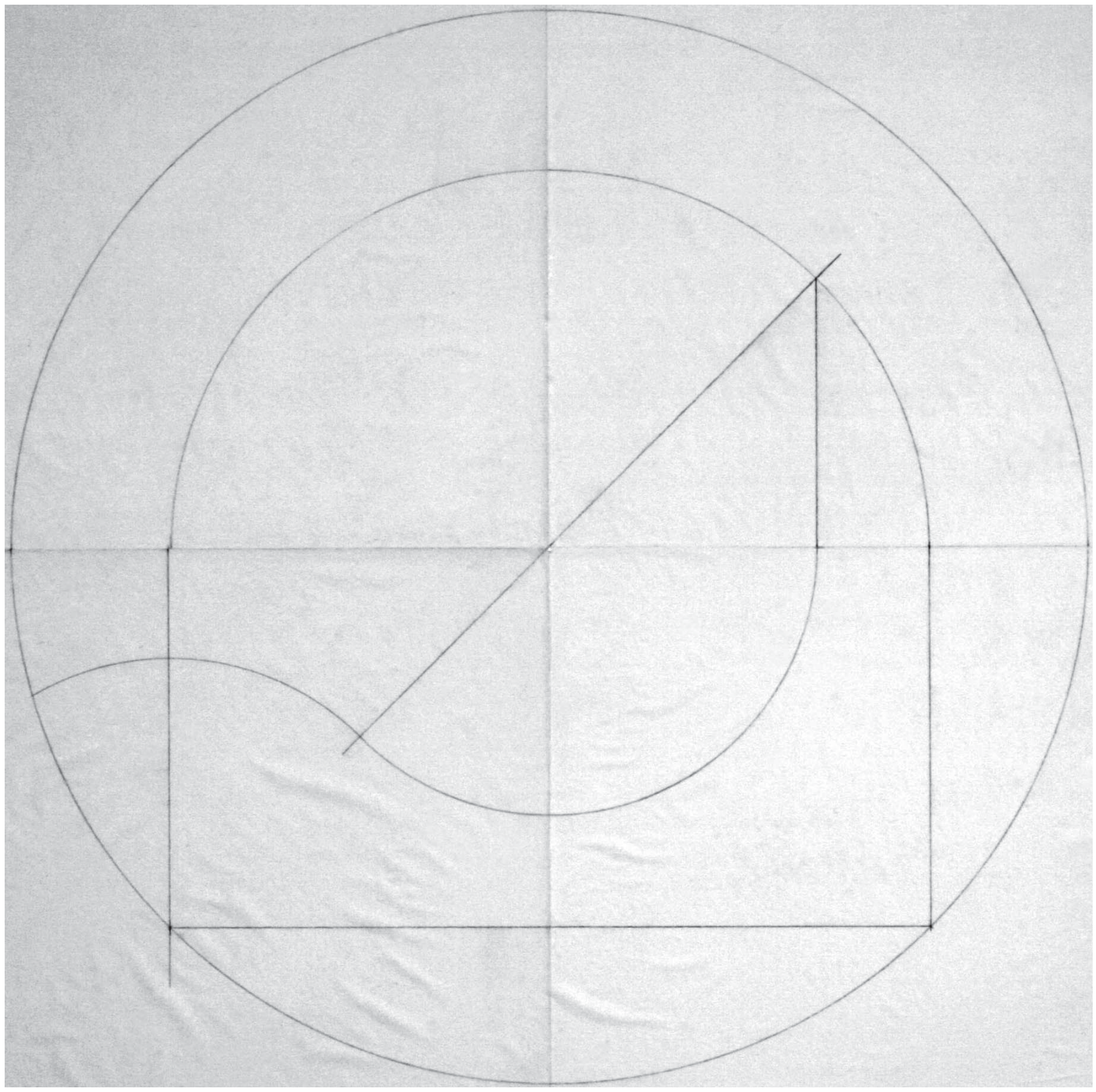
"Geometry furnishes many resources for Architecture."
Vitruvius



"Beauty will result from the form and correspondence of the whole, with respect to the several parts, of the parts with regards to each other, and of these again to the whole; that the structure may appear an entire and complete body, wherein each member agrees with the other, and all necessary to compose what you intend to form."
Andrea Palladio



"The eye is the most powerful tool of the architect"
Leon Battista Alberti



"As to beauty, this is always present when you have proportion;.. and proportion costs the land lord nothing, it is at the charge of the architect."
Le Corbusier

Arc:Text

Geometric improvisations:

The significance of drawing to architecture, the very nature of these drawings as representations and a form of communication, coupled with a personal appreciation for drawing as an art, begins a formulation of ideas on design language/tools. What are the essential constituents of an architectural drawing? The thesis establishes a formal structure over which a drawing may evolve. This consists of three inter-related concepts: the use of points and lines, as a drawing's most basic elements, the establishment of geometric relationships that correspond to general conditions of proportion and boundary, and lastly measuring with the eye.

Point and Line:

The method of drawing with points and lines is derived from the theoretical treatise "On Painting" . Alberti's description of essential elements in the making of a drawing bridges a conceptual gap between hand drawings on the one end and CAD drawings on the other, in terms of their shared formal qualities: *"A point is a sign which one might say is not divisible into parts. I call a sign anything which exists on a surface so that it is visible to the eye. No one will deny that things which are not visible do not concern the painter, for he strives to represent only the things that are seen. Points joined together continuously in a row constitute a line. So for us a line will be a sign whose length can be divided into parts, but it will be so slender in width that it cannot be split. Some lines are called straight, others curved. A straight line is a sign extended lengthways directly from one point to another. A curved line is one which runs from point to point not along direct path but making a bend. If many lines are joined closely together like threads in cloth, they will create a surface. A surface is the outer limit of a body which is recognized not in depth by width and length, and also by its properties. Some of these properties are so much part of the surface that they cannot be removed or parted from it without the surface being changed."* (Book 1: "On Painting", L. Alberti)

Harmonic Possibility: sensitivity in design decisions

The application of a geometric pattern, as underlying structure to an architectural design, is derived from a series of thoughts (long term study) concerned with proportional relationships in the urban environment, between built form and urban space. This has thus far been in terms of discovering building boundaries and buildable areas within a medium-density urban condition, as well as recognizing what surrounding, potentially transitional spaces there are for use in the public-spatial domain. The harmonic possibility is aiming at a precept of design in architecture- a design tool. It was conceived in the form of line types, as a continuation of the work on drawing language.

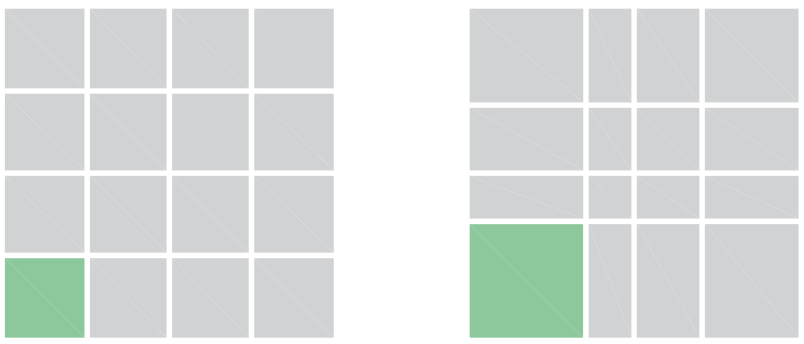
1.The **urban line**: the extension of existing lines found on site, leading to the discovery of external boundary conditions of a built proposal with respect to existing urban structures and elements.

2.The **geometric line**: (geometric template) a device proposed to regulate the end product.

3.The **free line**: proposed as a possibility, but has not yet been explored.

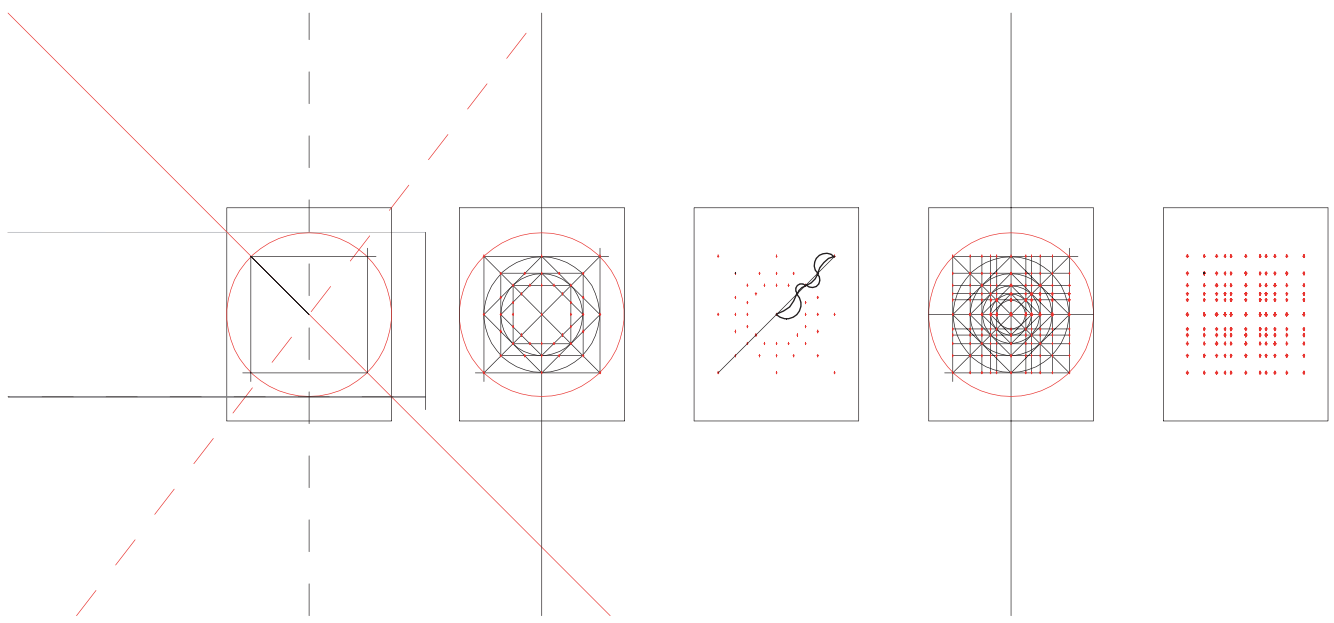
The design of a musical string instrument is shown as an application of one line type, the geometric line.

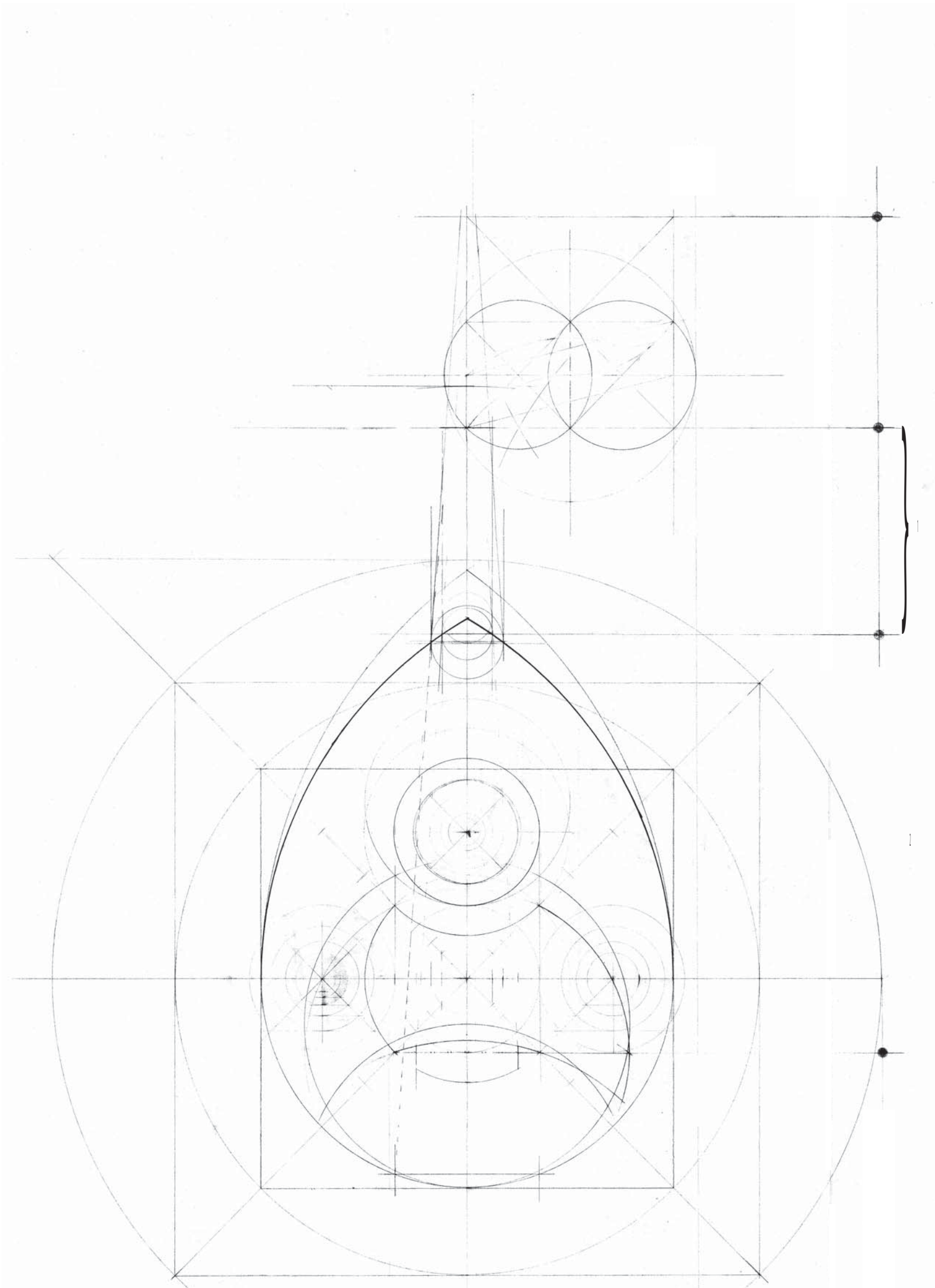
(above) urban site of medium density, the urban line (red) type is a projection of lines over a proposed site, relative to existing surrounding structures. The projections can be used in deciding the boundaries of a new building proposal. Hypothetically, the process can be also be used when considering building heights, but applying a similar set of lines in the vertical dimension. Combined, the horizontal and vertical create an additional volumetric comparison. In both horizontal and vertical study situations, the idea is not to contain possible new structures through the dimensions of previous structures, but rather a way to understand, and build within the urban fabric.



(above) observations on Town of Blacksburg, VA) taking the idea of a grid of sixteen blocks to create a town, and the geometric line as formed by the pattern of squares within circles. What are the potential implications of change in rhythm on designing city blocks ?

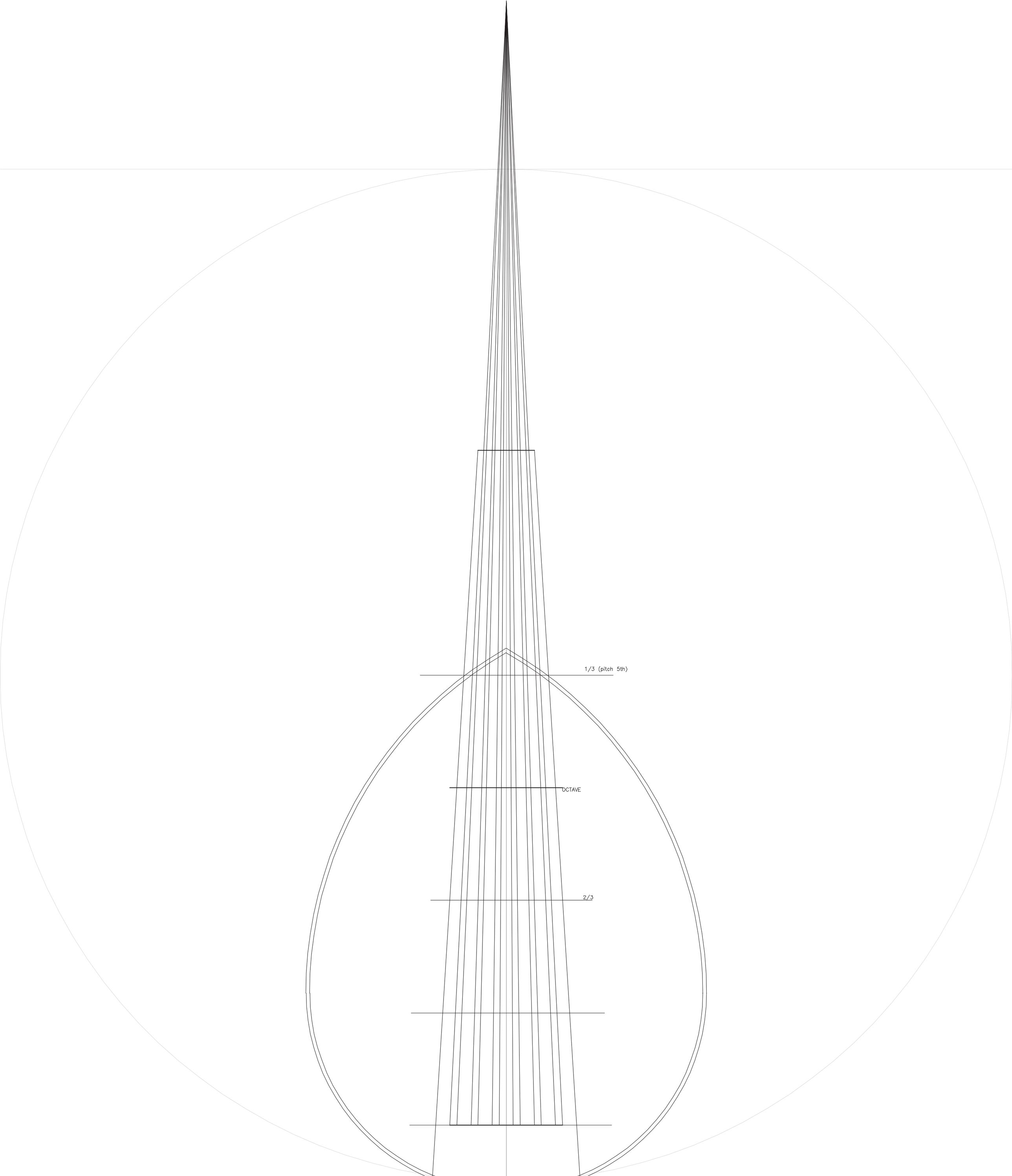
(below) a series of diagrams: establishing a proportional relationship between the boundaries of a drawing and the surface over which it occurs. Similarly, a pattern of two rotated squares within a circle creates a field of points over which a design is resolved. The example shows a symmetrical relationship whereby the center of the drawing is the center of the drawing surface.

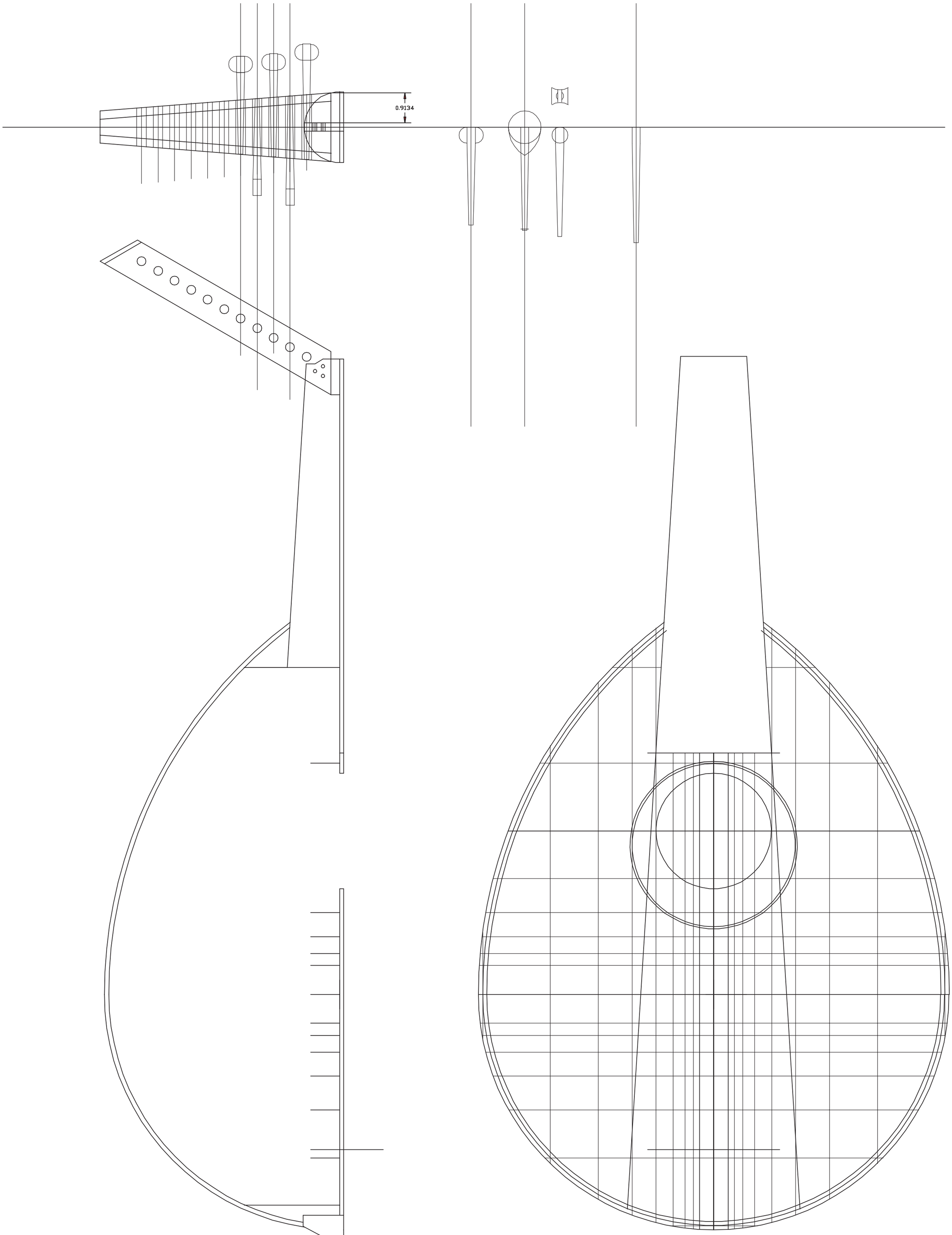


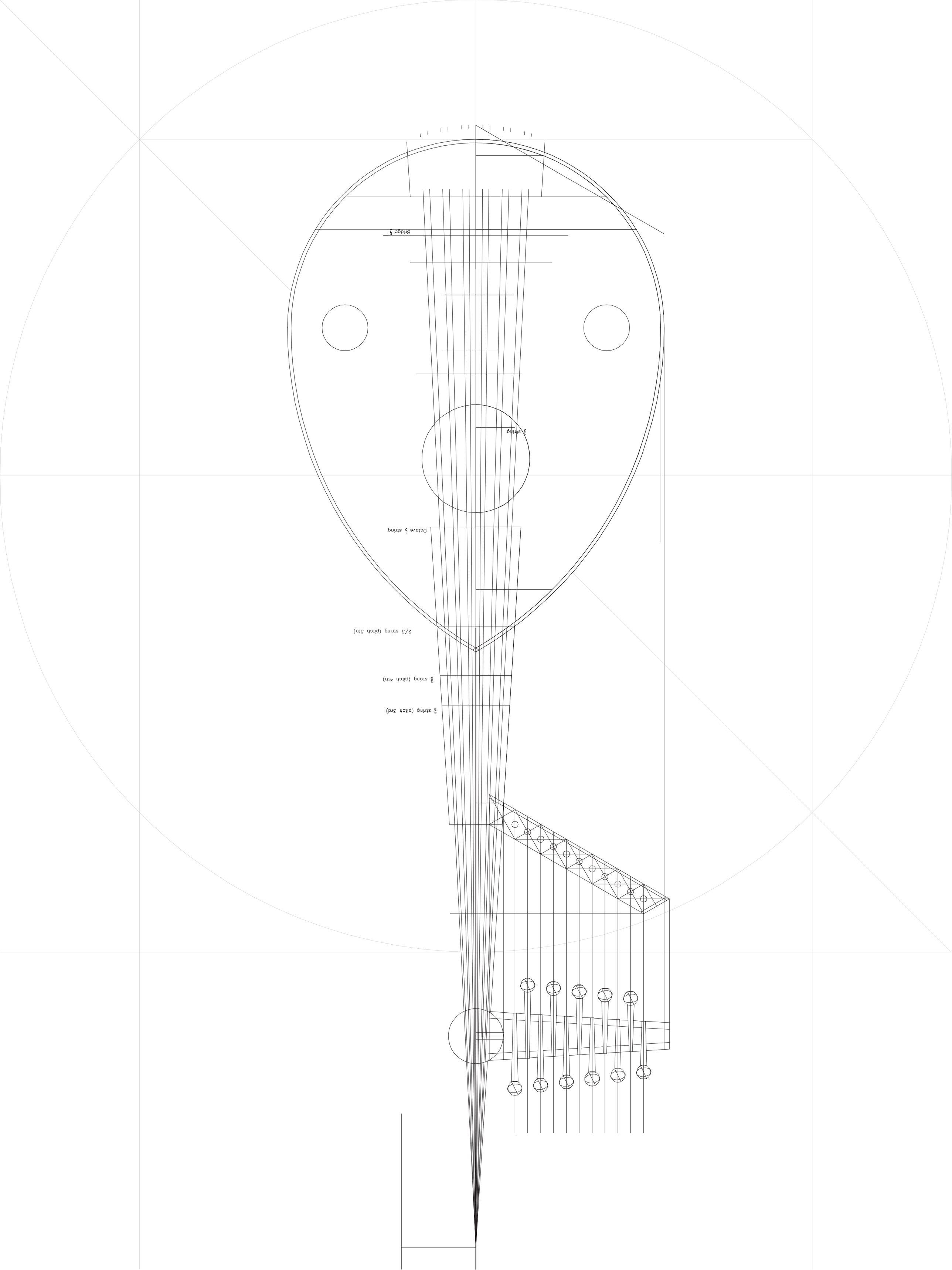


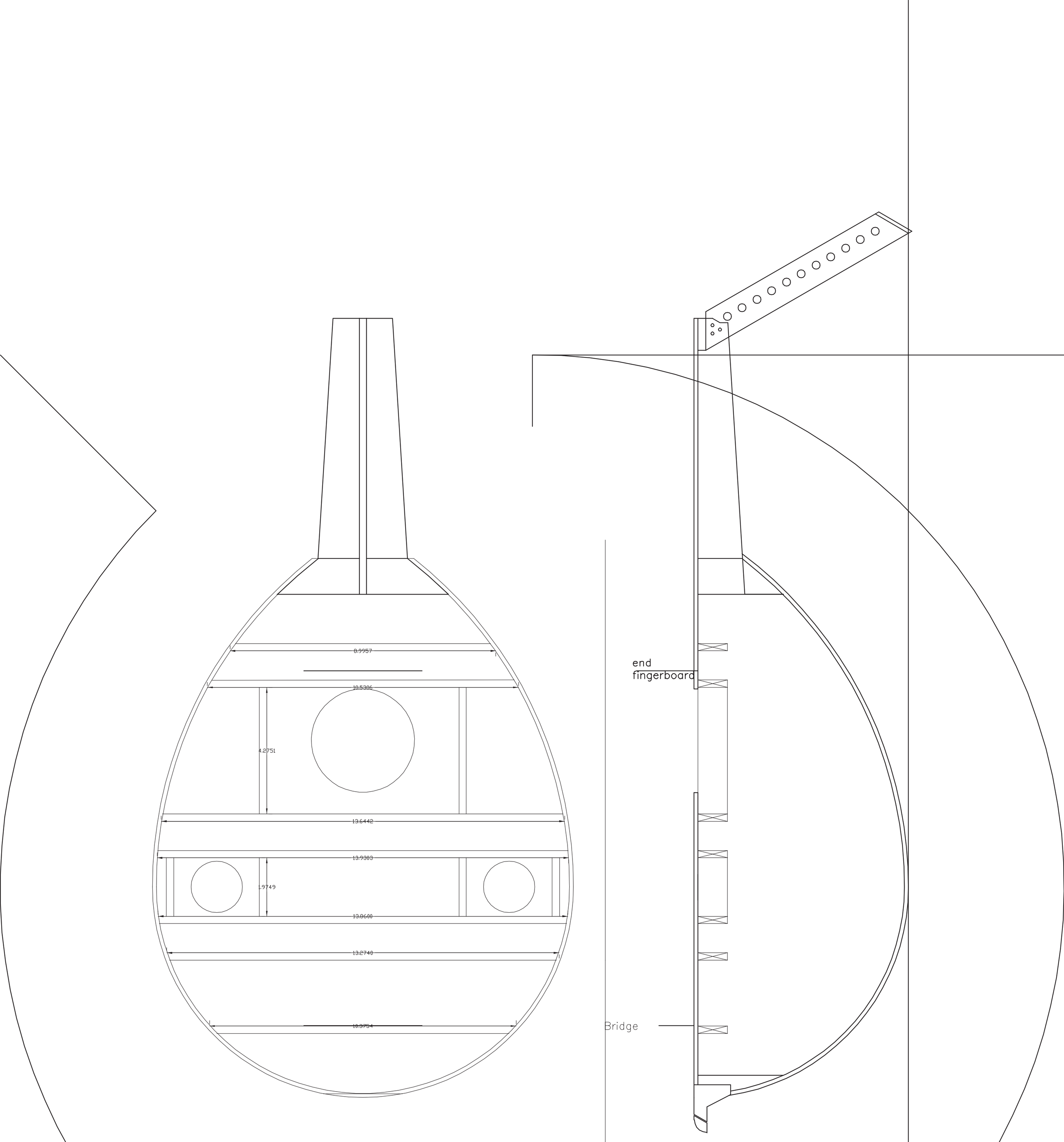
Measuring with the Eye:

The following drawings were either executed, or made to be reproduced in full scale to the built object, in an effort to realize some essential qualities of the object, its proportional relationships in terms of parts and whole, and its true dimensional questions as they relate to the process of making, material characteristics and eventual usefulness/functionality of the final product. The drawings are not final/revised drawings, but stages of a design-build process. They are also an exercise in "measuring with the eye", (an aesthetic condition), applied within reason where it was possible, placing geometric resolution over numeric guidelines. In a sense, they are no more than studies of geometric proportion through regulated placement of point and line. The drawings were reproduced for the pages of this book in half-scale.

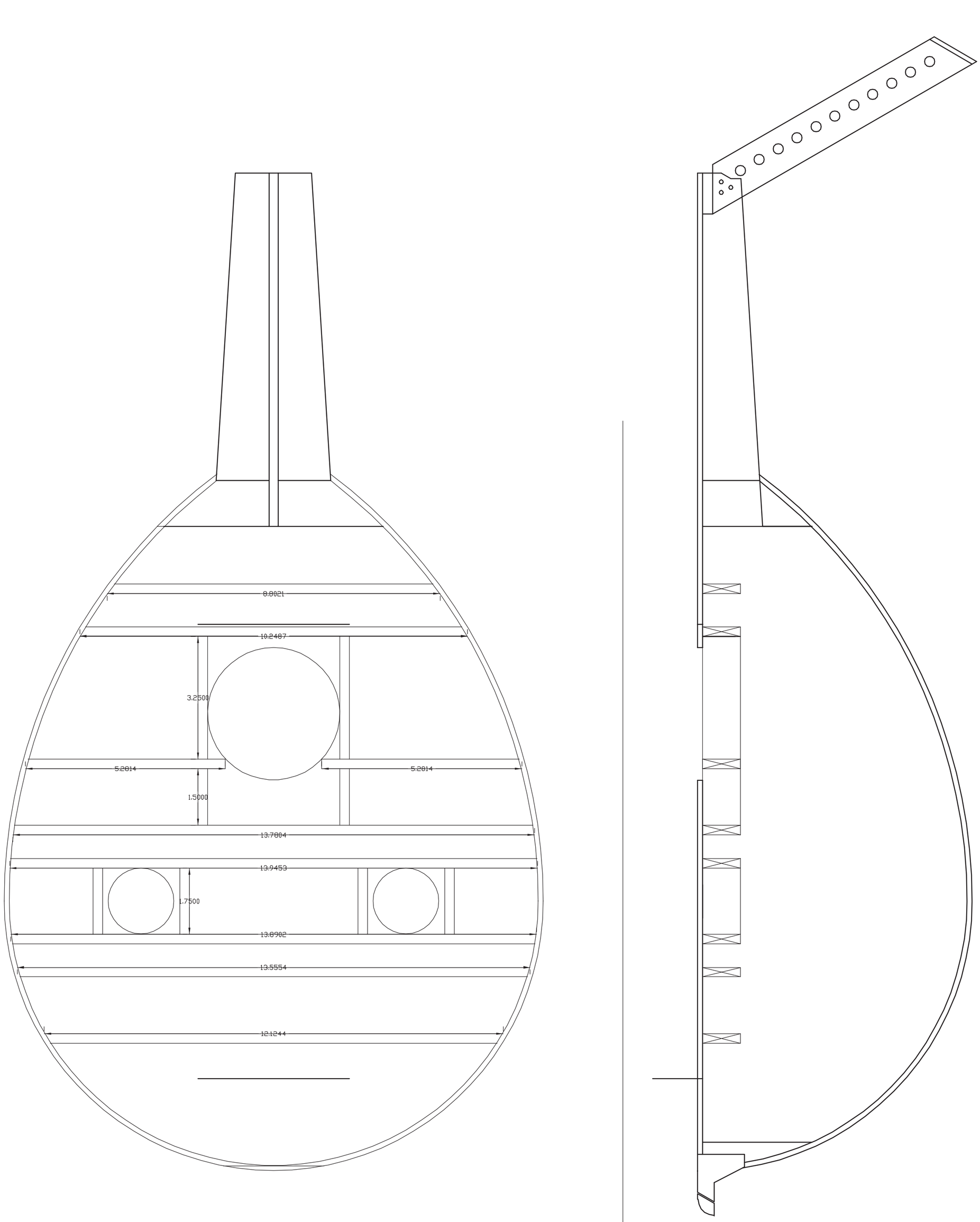

1/3 (pitch 5th)
OCTAVE
2/3


0.9134

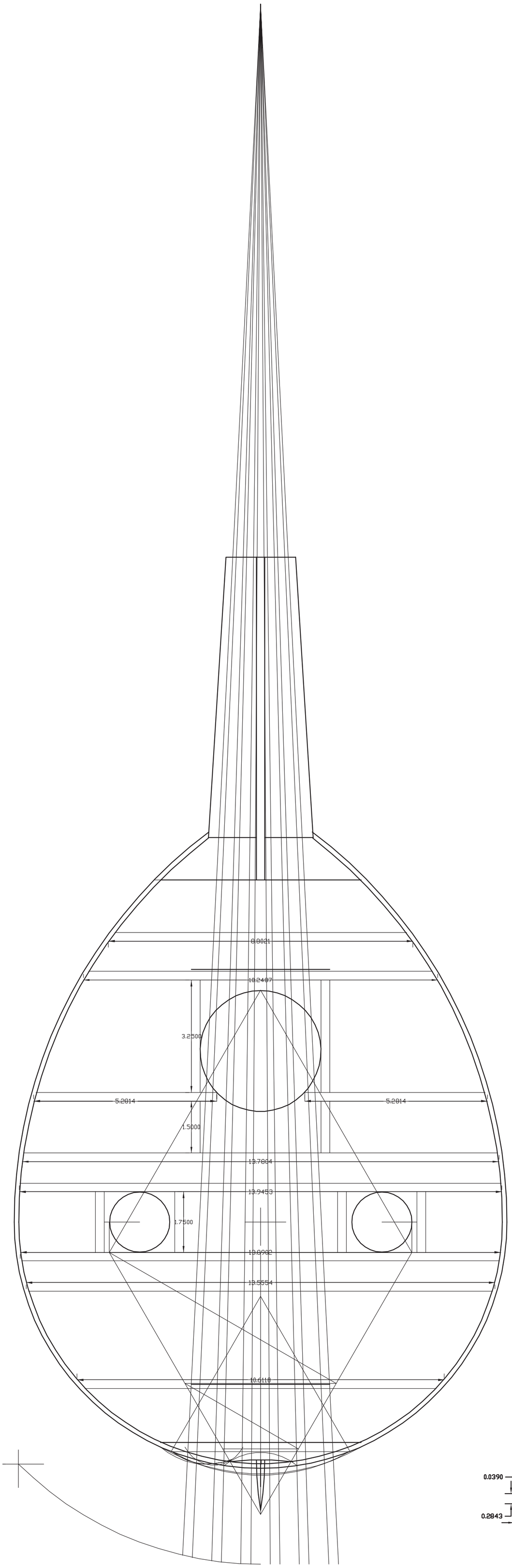

Bridge
3 string
Octave 2 string
2/3 string (pitch 5th)
4th string (pitch 3rd)
1st string (pitch 4th)

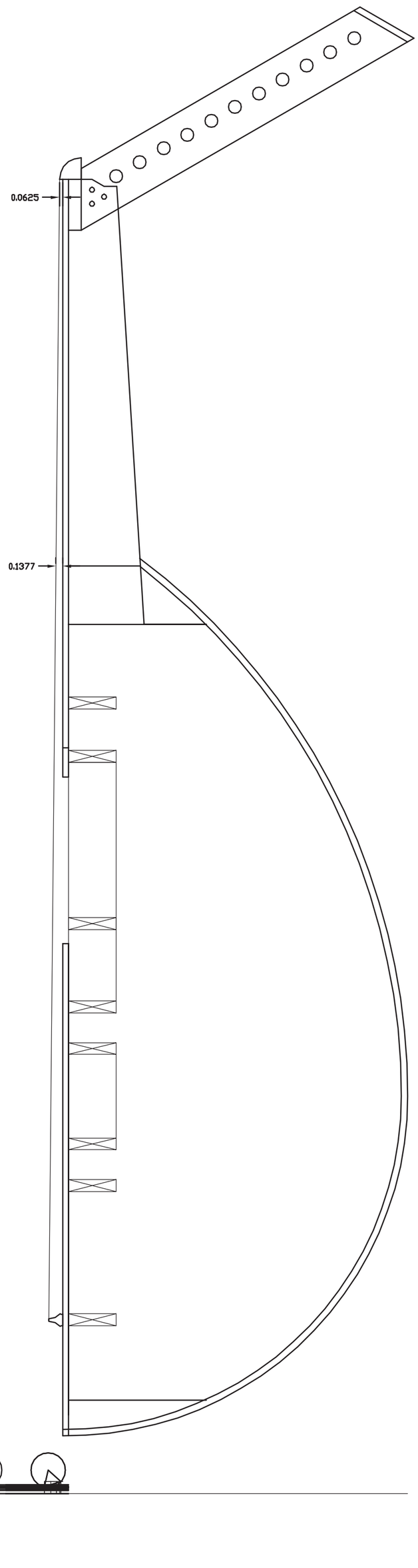


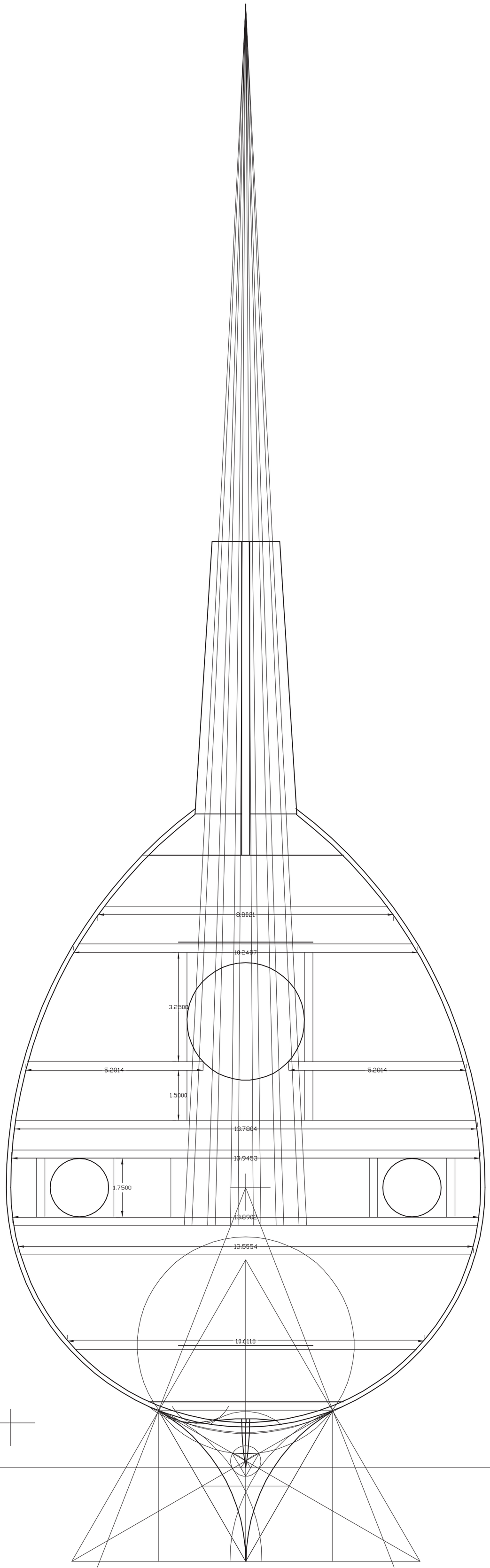
Bracing Pattern 2: 114” length

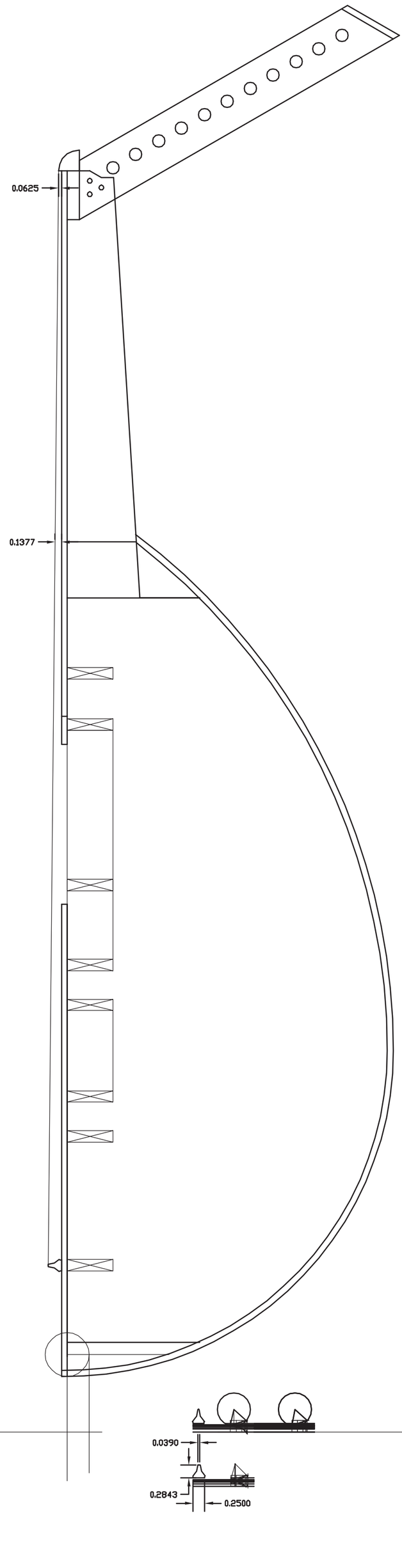


Bracing Pattern 1: 102” length


8.8021
10.2487
3.2500
5.2814
5.2814
1.5000
13.7804
13.9453
1.7500
13.8962
13.5554
10.6110


0.0625
0.1377
0.0390
0.2843
0.2500


8.0021
10.2487
3.2500
5.2814
5.2814
1.5000
13.7804
13.9453
1.7500
13.8992
13.5554
10.6118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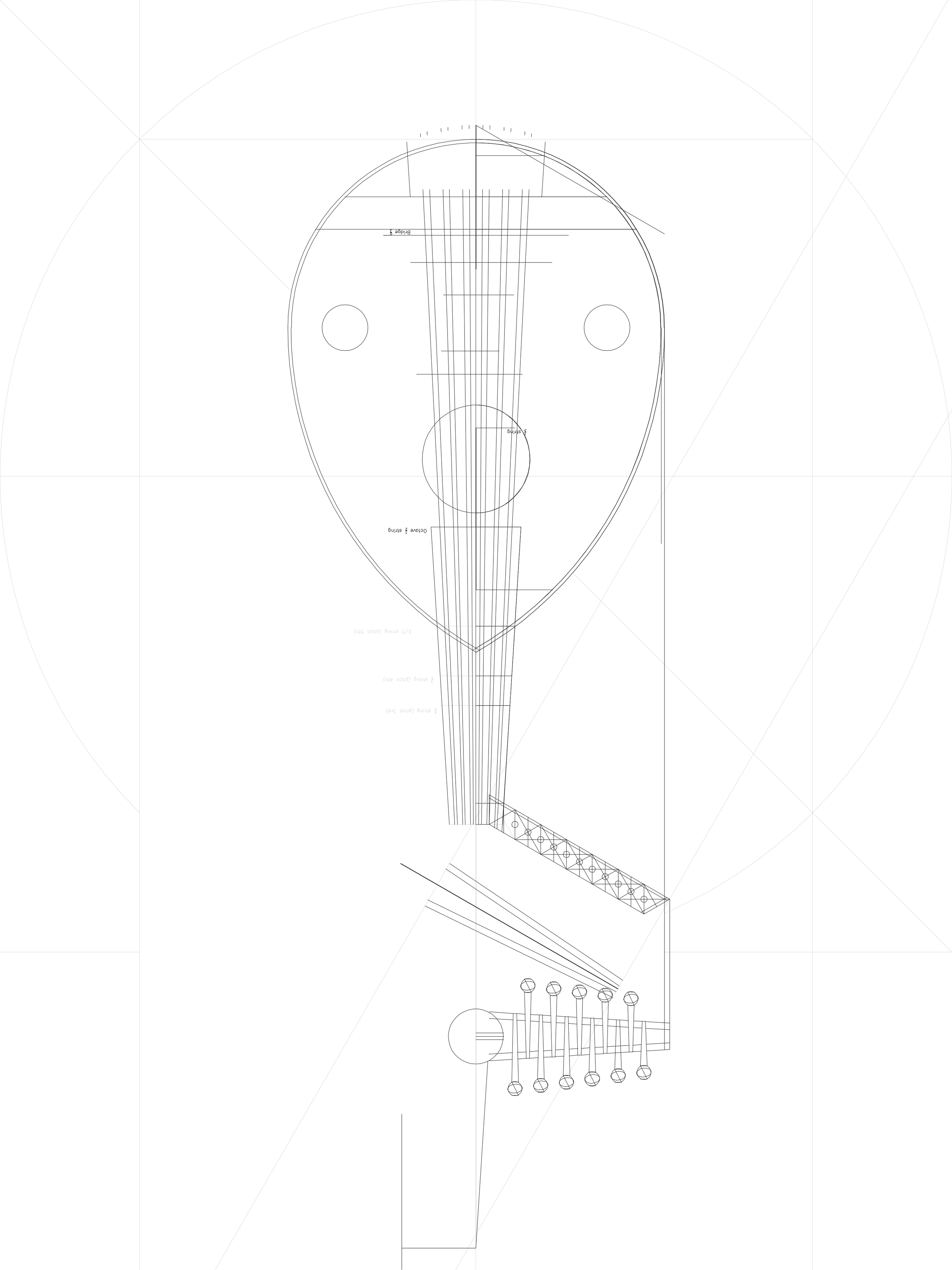
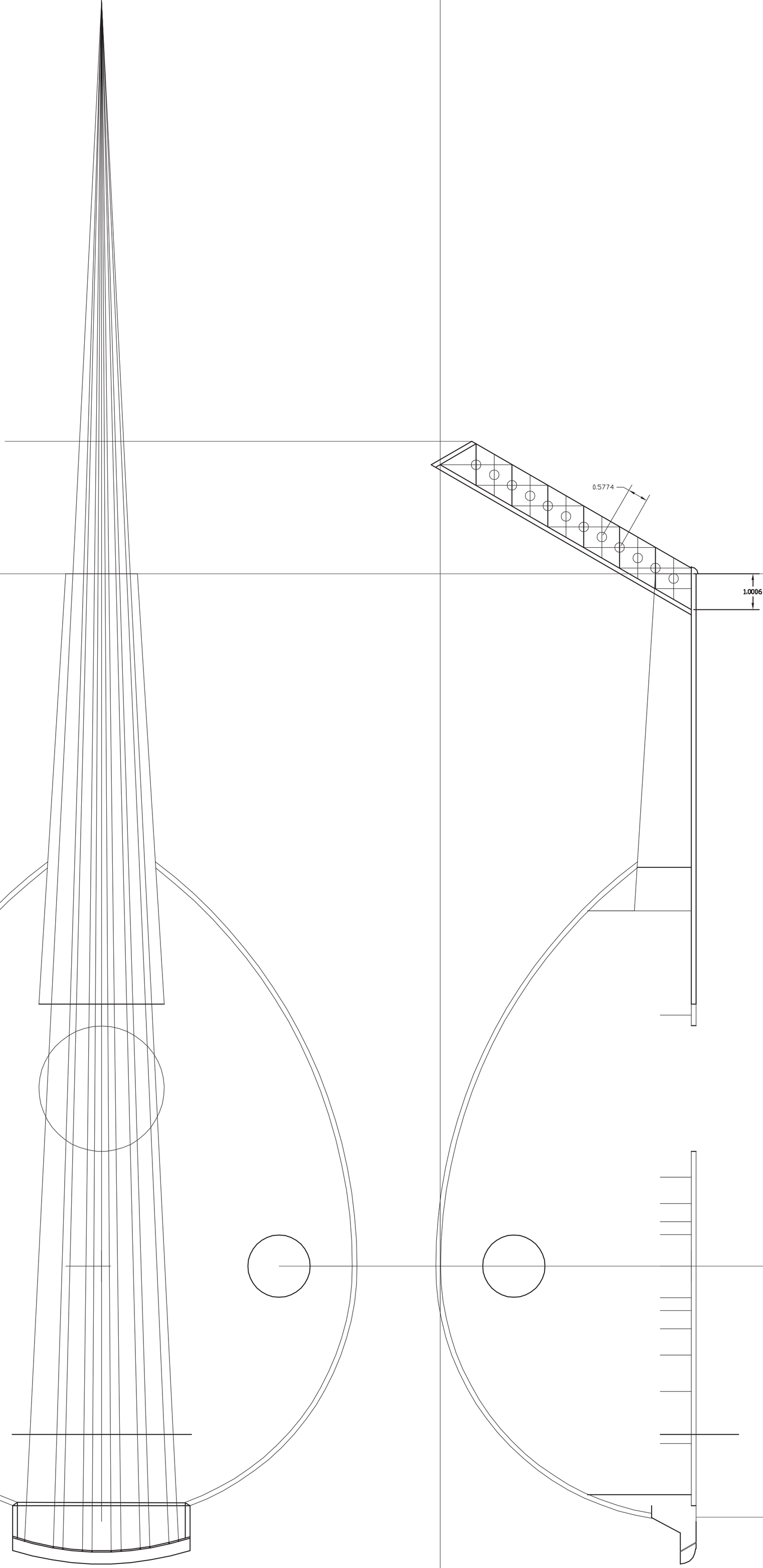
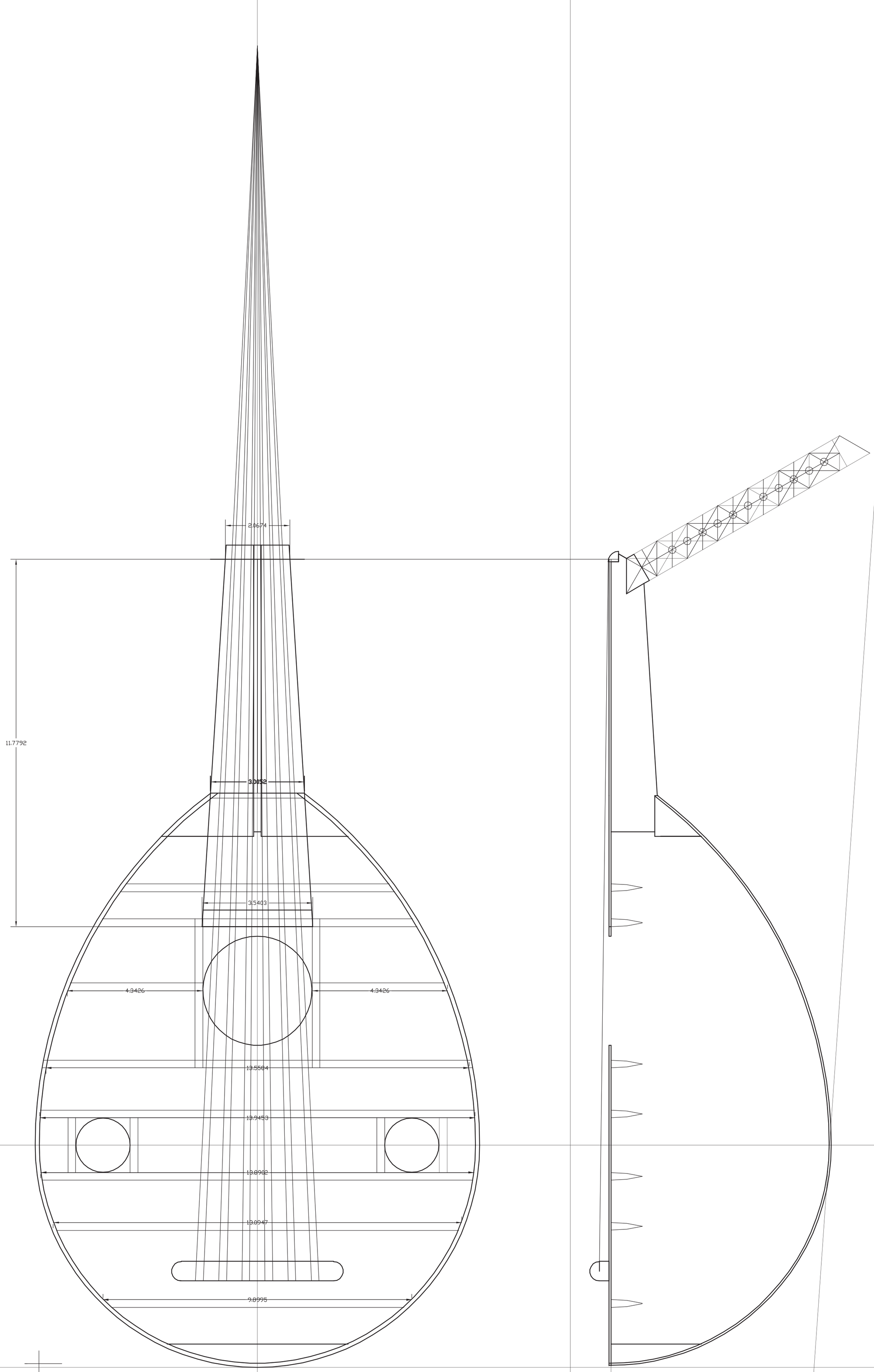
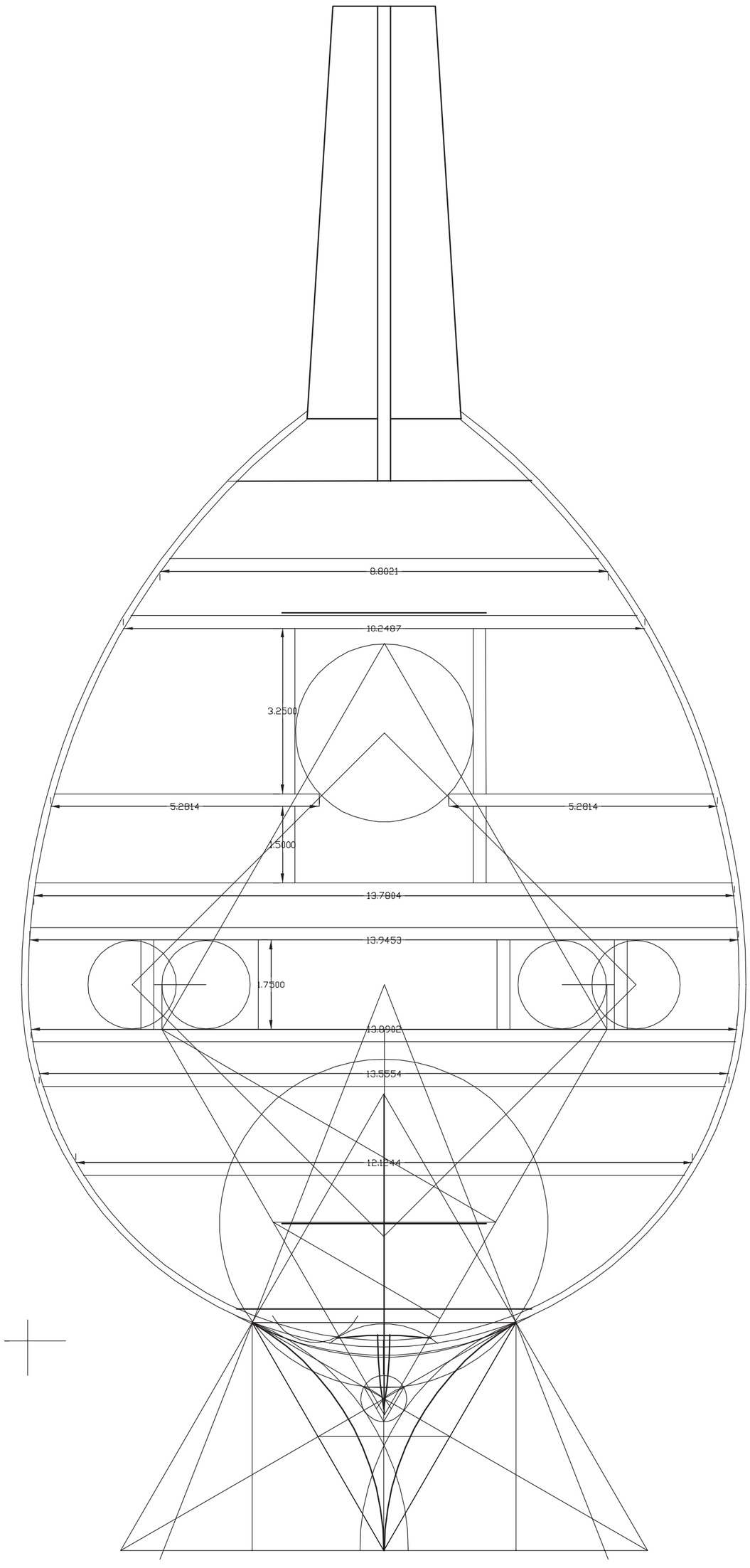
0.2843
0.2500


Bridge ♫
♫ string
Octave ♫ string
2/3 string (pitch 5th)
¾ string (pitch 4th)
½ string (pitch 3rd)


0.5774
1.0006



final bracing diagram


8.8021
10.2487
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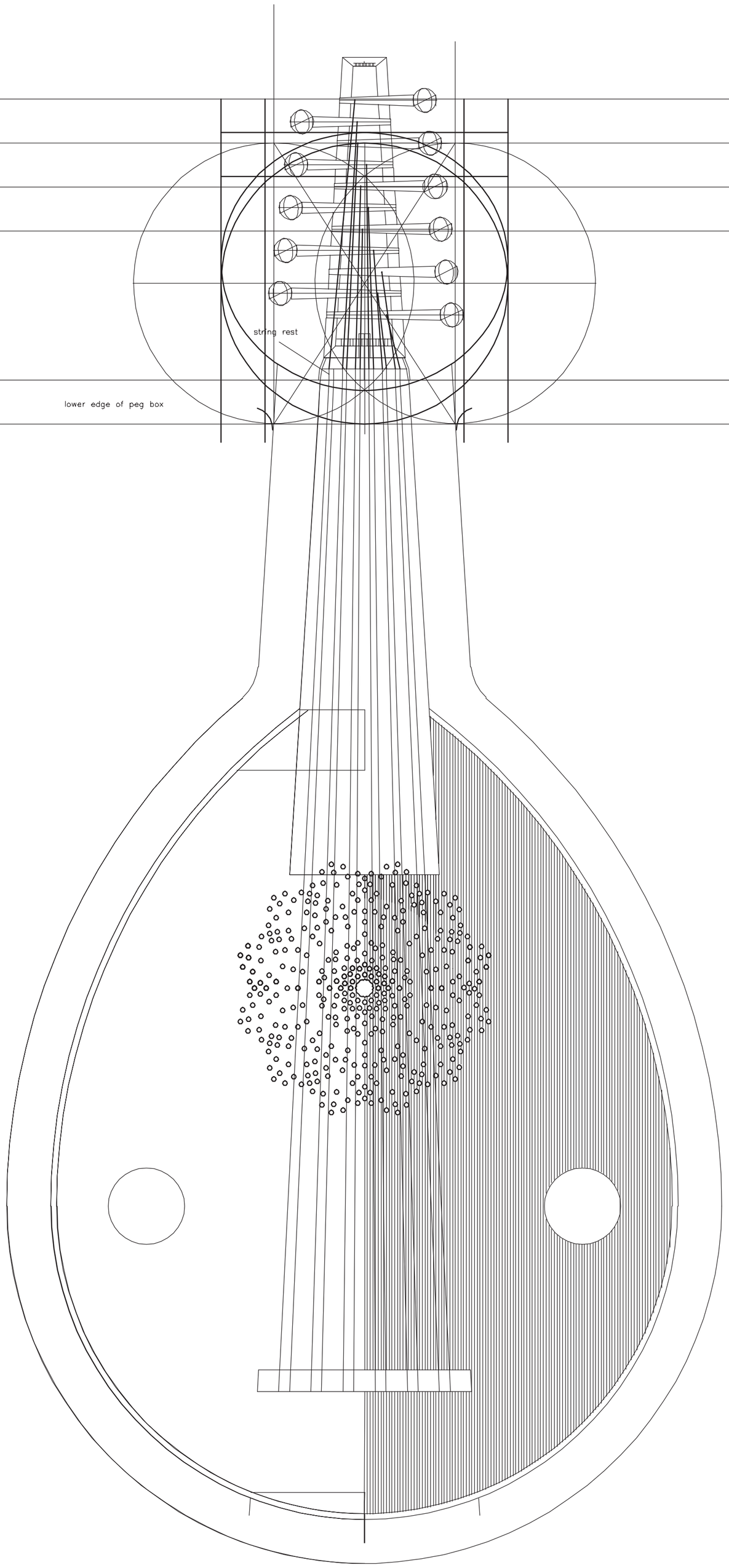
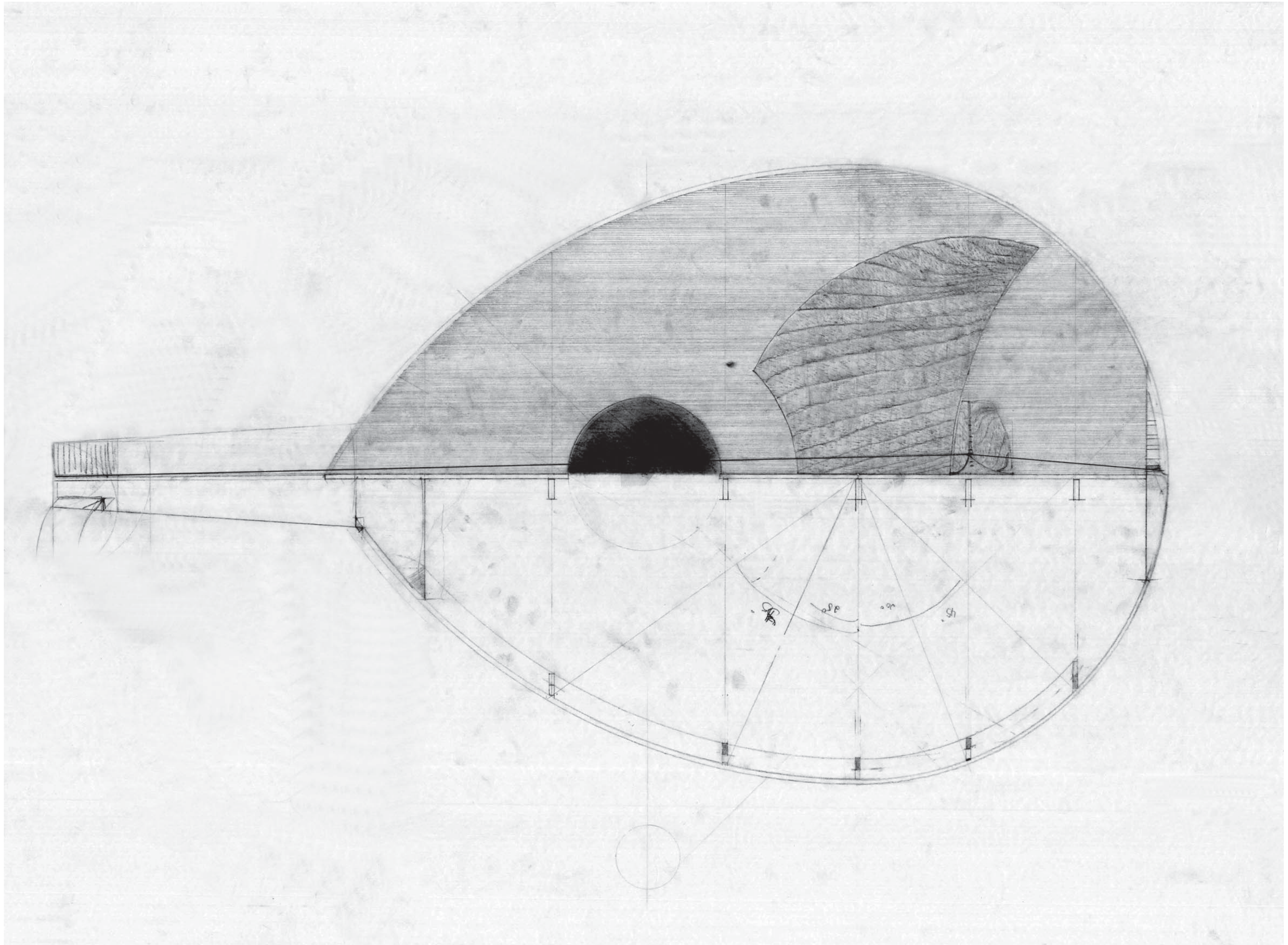
13.7804
13.9453
1.7500
13.8902
13.5554
12.1244


string rest
lower edge of peg box

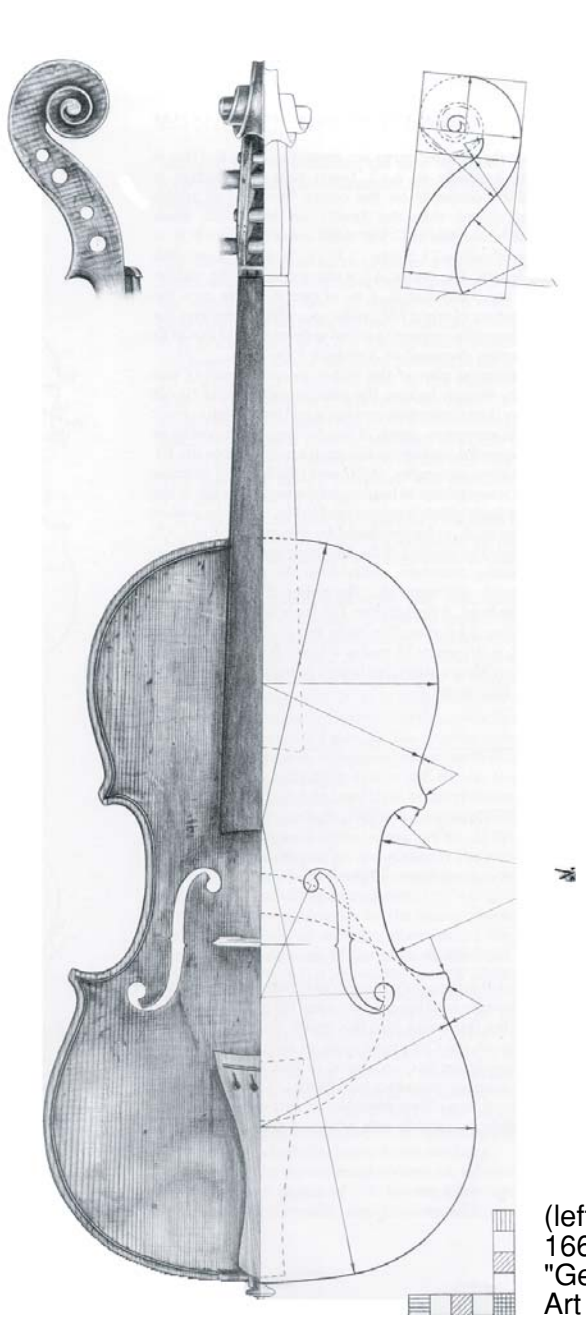

45°
30°
45°

Architecture is inspired by the hope to build

Parameters, design and construction:

A perspective on designing a musical instrument, or architectural design as a whole, is one that seeks a unity of form, a oneness of its art and science through the act of drawing and its supporting know-how and understanding on behalf of the architect. A first assumption was on the relationship of geometry and the eventual sound quality of the instrument, this is also expressed in Le Corbusier's notion of "visual-acoustics", and Plato's "Harmony of the Spheres" on the relation of good proportions in both the visual and audible realms of things. This question on placement and proportion was assisted by further research on the work of 17th-18th century luthier Antonio Stradivari, famous for his instruments of the violin family, revealing the following priorities (in order), as pertaining to the making of a good musical instrument.

1. Varnish/surface finish and definition.
2. Geometry and quality of construction.
3. Material.



(left) geometric study on early 1666 Stradivari violin
"Geometry, Proportion, and the Art of Lutherie", Kevin Coates

The incorporation of learning in a design-build project:

Within the framework of architectural education, the making of a musical instrument necessitates a significant measure of individual research and analysis in the art of luthiery. Previously set, the thesis is a question on drawing and proportion. Design execution challenges the architect to exchange roles and to investigate a process of making. This related to a fundamental and intimate exploration of wood as a traditional material of choice, as well as the connections between the processes of construction/making as such, and how they relate to the available resources and means. Within the cycle-triangle of drawing, making, and learning, the question set before time is on the limits of architecture.

Though the design of the object was an exercise in placement and proportion through geometric rules, the commitment *to make* sets its own constraints and requirements, and includes knowledge of materials and tools, as well as skill of execution. This opens up a constant potential for new learning experiences in terms of better understanding the Oud, as design and construction, but more importantly, increasing the ways in which knowledge of building processes, materials and tools, eventually enlivens future design processes. This is a direct proportionality and/or dialogue between questions of what and how. The relationship between the made object and the process of making is dependant on discovering connections amongst means of execution and necessities of design. The process as such is relative, and was subject to available machinery, tools and materials.

Further observations on the constant occurrence of learning:

1. Subtlety of learning through a tactile/responsive experience.

2. Reading the material (wood). Developing an understanding for orienting the material in relation to the seasonal rings found in the wood. Carefully considering the process of fabrication, function/strength of material and shift-patterns.

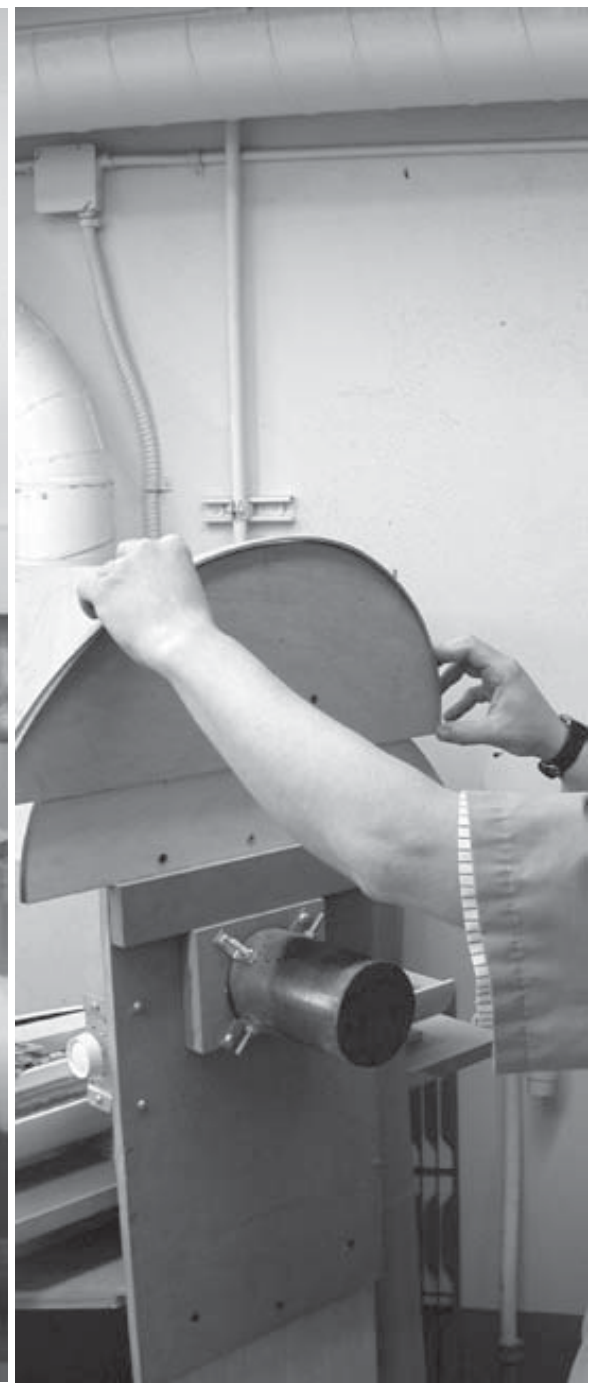
3. Making and the machine: developing a curious edge for (natural inclination towards) the machine, discovering wheels, gears, axes, metal, etc. Machinery and machine design as extension of architecture.

4. The re-informing of the drawing through the making process.

5. The occasional need to make one's own machine parts or tools.

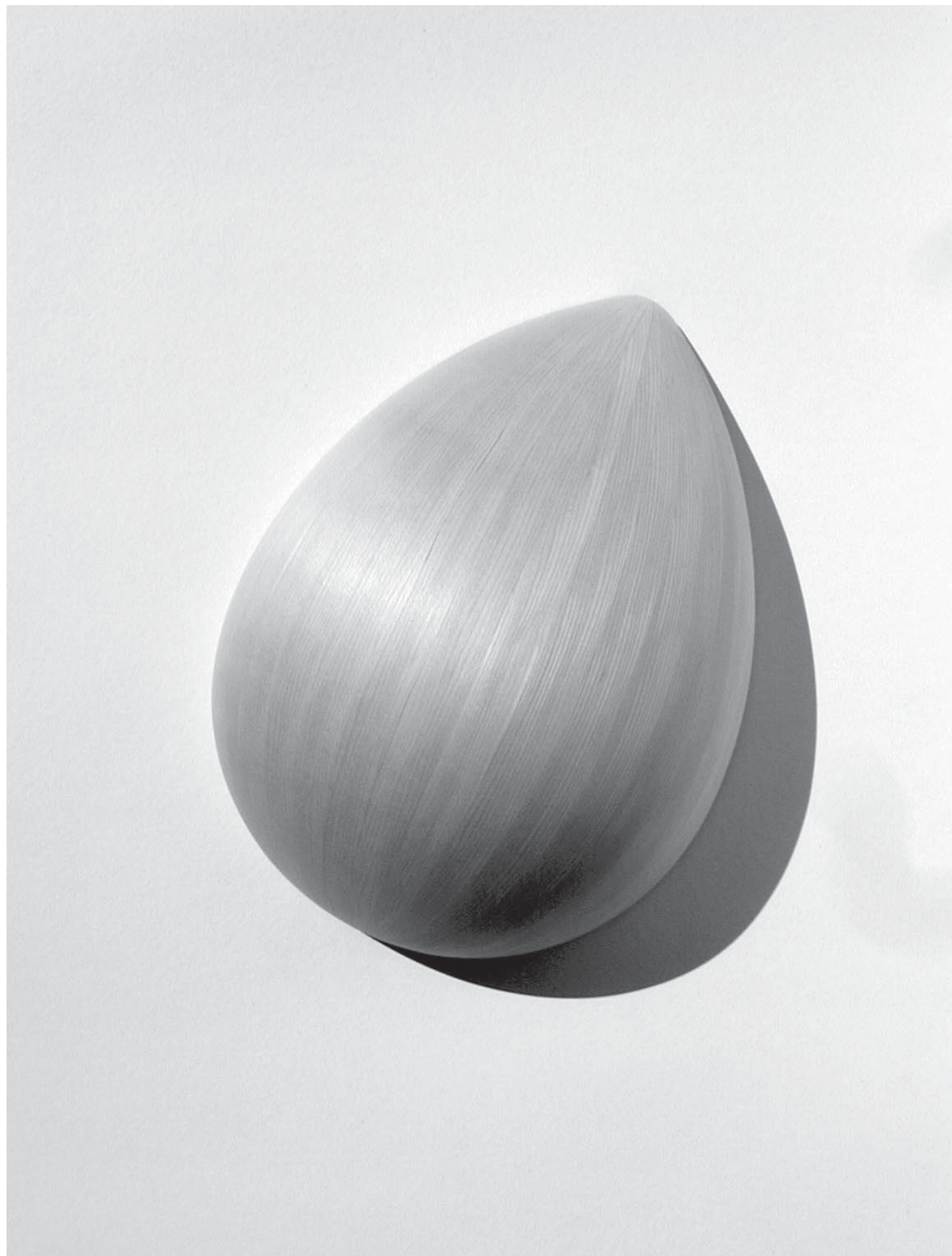
6. Increasing the strength of proportional/visual awareness in design. Measuring with the eye as skill.

7. Observing the work environment/woodshop in terms of spatial and ethical necessities.

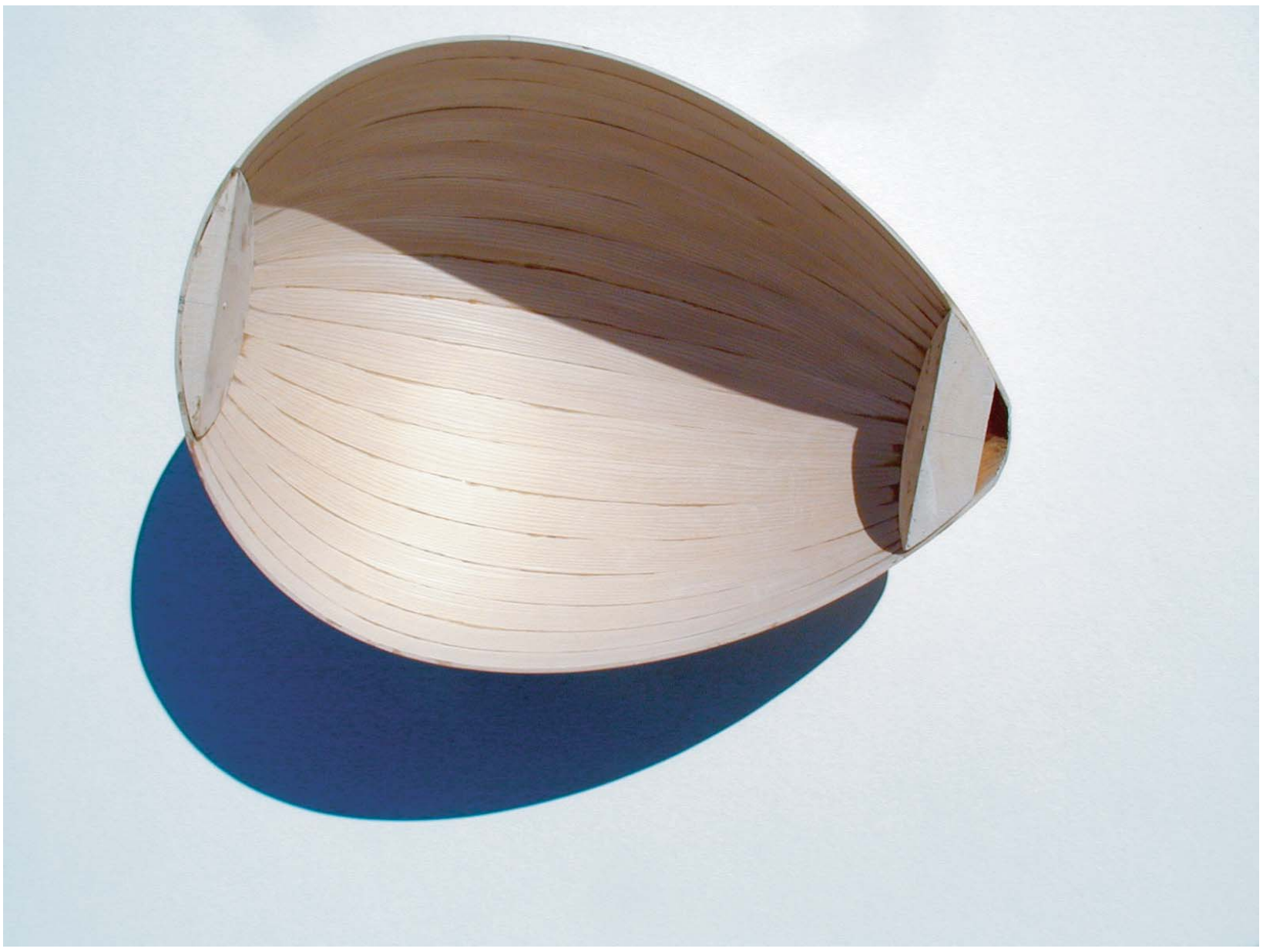


Staves of quarter-sawn maple wood are soaked in water, then bent over a hot iron into the desired shape.

The back of the instrument consists of 18 staves, these are of similar shape, and create a semi-circular/half-pear shape. The staves are glued against each other using hide glue and specially designed wooden clamps (*courtesy of Mr. John Bryant*). The clamps exert a force whereby the staves are drawn together under pressure for a more secure glue joint.



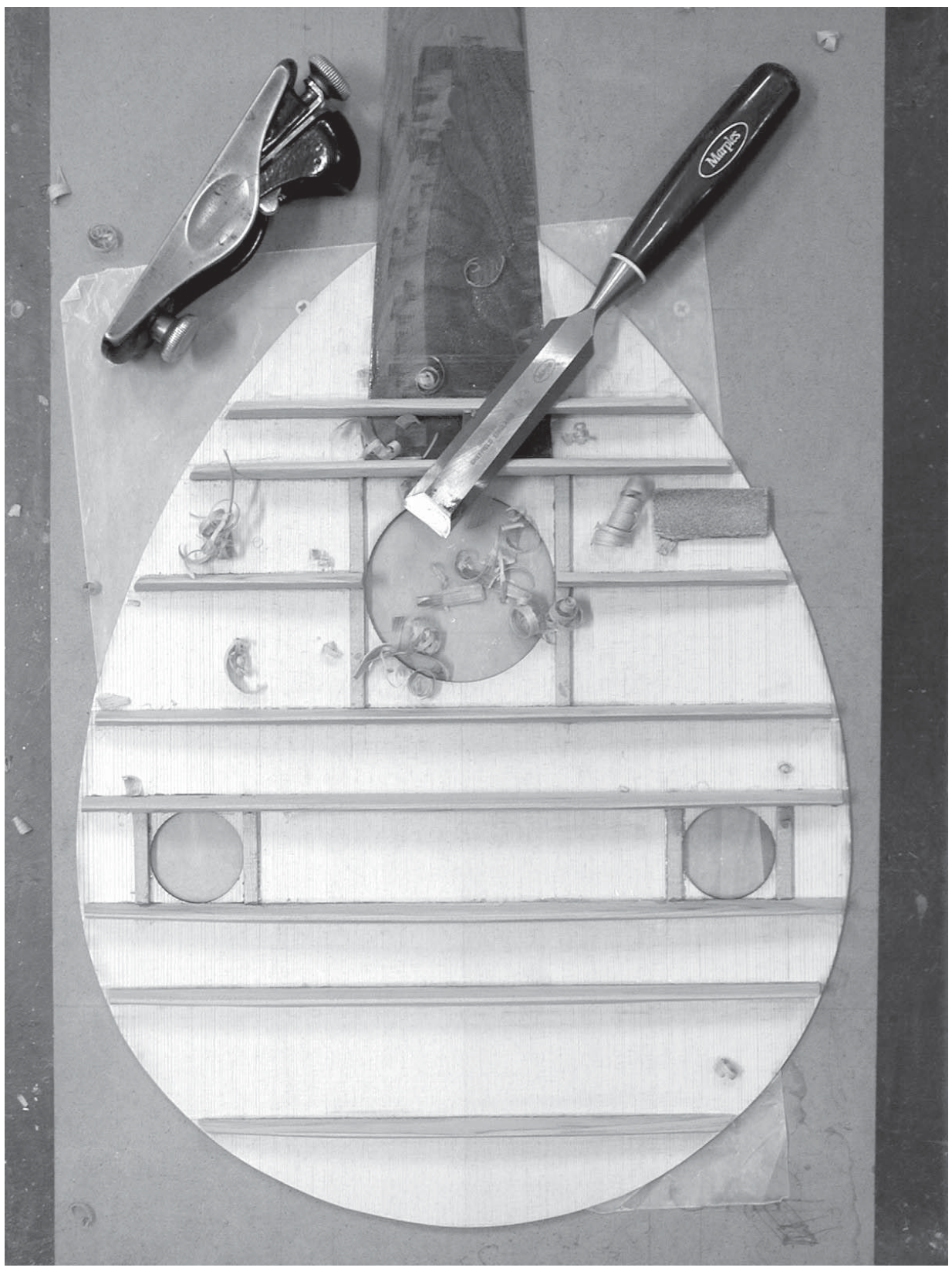
Surface resolution through a process of scraping and gradual sanding, combined with seamless joinery and the natural characteristics of hard maple (especially lightness of color, material density and grain pattern) serve to accentuate the elegance of form through geometric composition and reasoning.



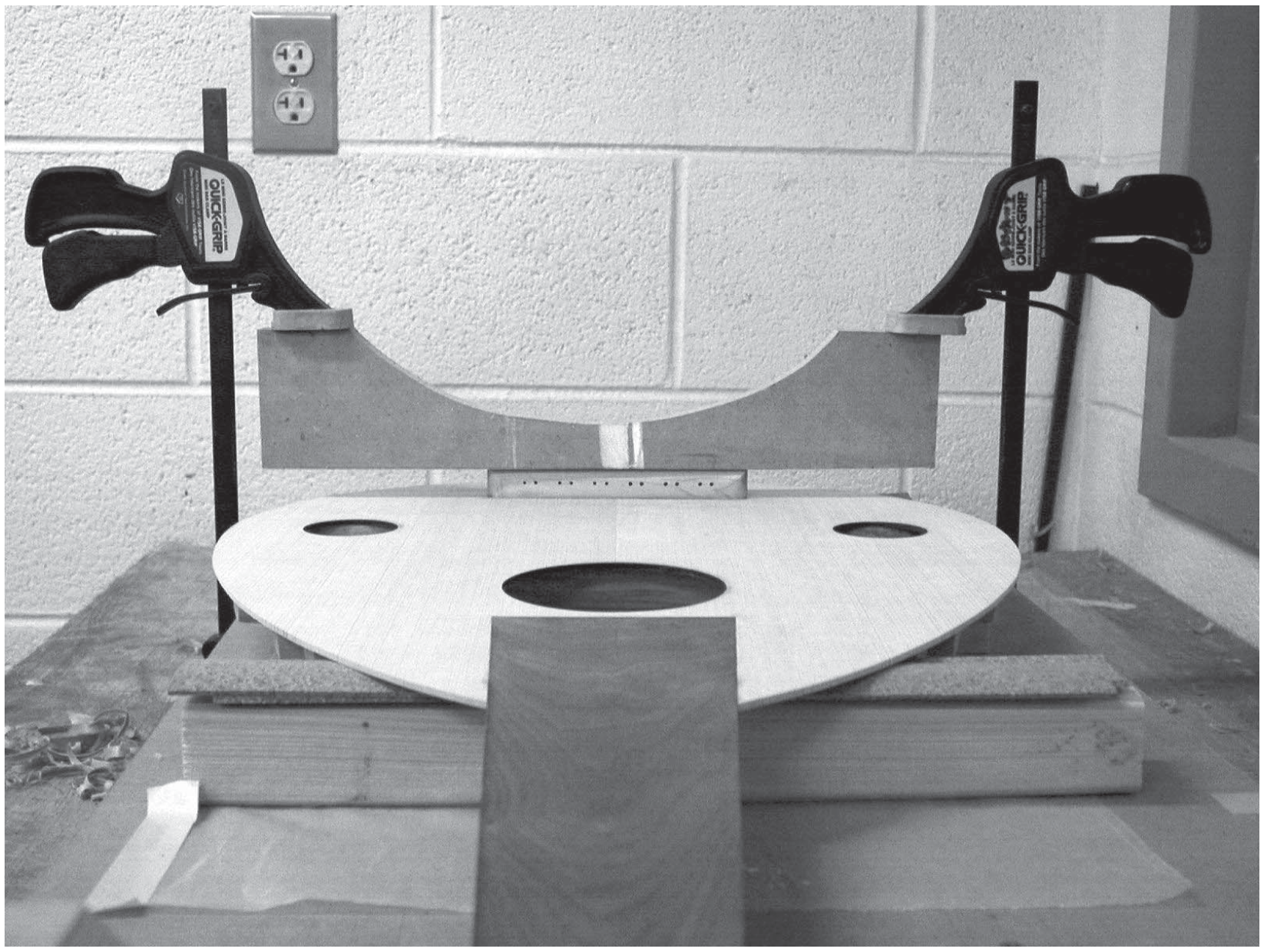
Bass is a light-weight wood with no noticeable expansion/contraction. Two blocks (neck and end) of this material serve as a beginning point over which the shell is built. The maple shell requires no other supporing structure.

(above) The definition of the pegholes using a tapered aluminum shaft and sand paper.

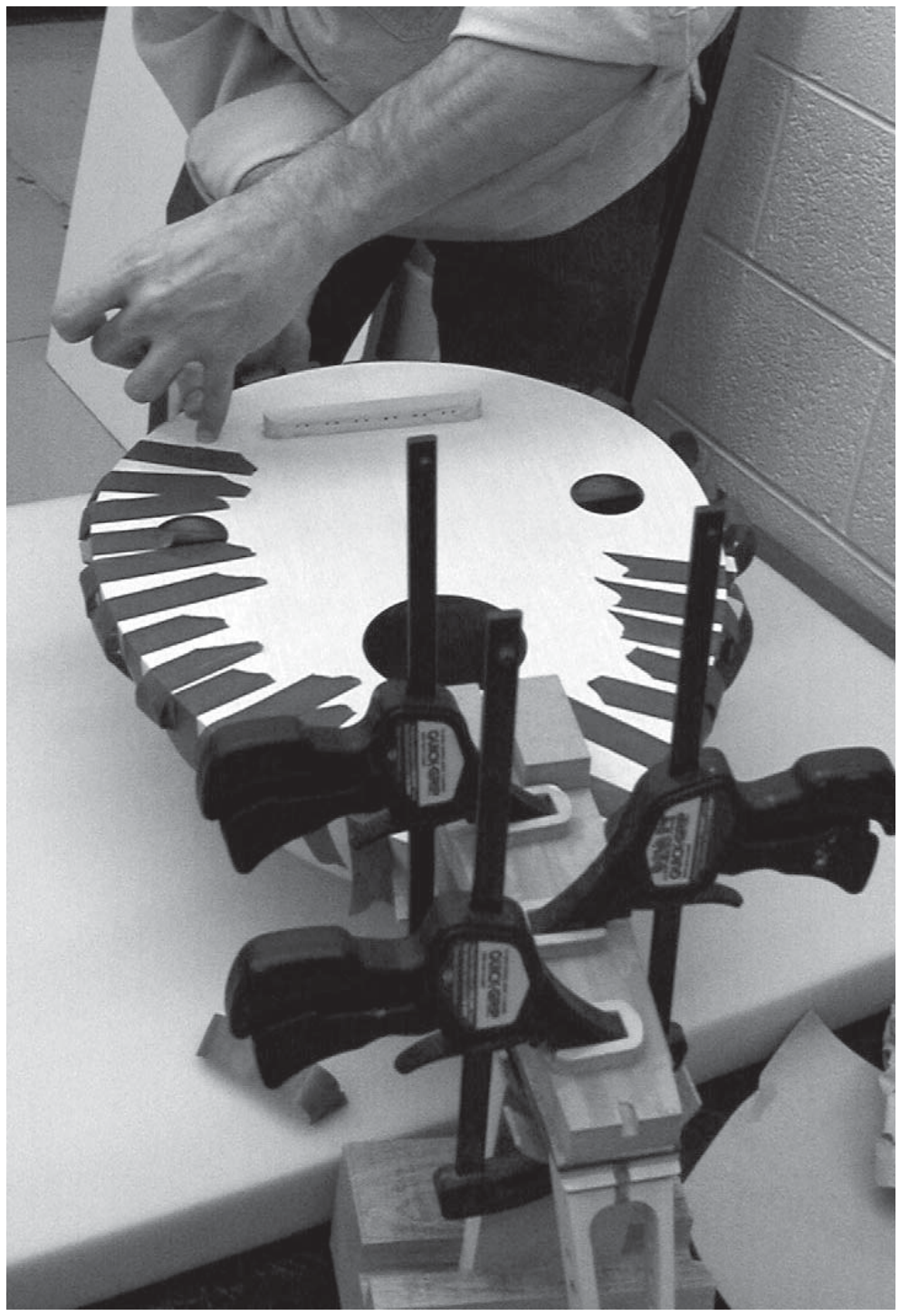
(previous page) The traditional geometry of a pegbox consists of a double curve, instead, a deliberate effort was made to suggest a relative point of beginning in Oud design. This was achieved through triangulations and a series of subtractions done on a single piece of maple. The pegs were left without refinement to consider ergonomics of their use in terms of the tuning action and how it relates to the weight and movement of the hand. (bottom-left): prototype neck and pegbox. A walnut stringer is enclosed within the neck to counteract the forces exerted on the instrument while the strings are in tension.



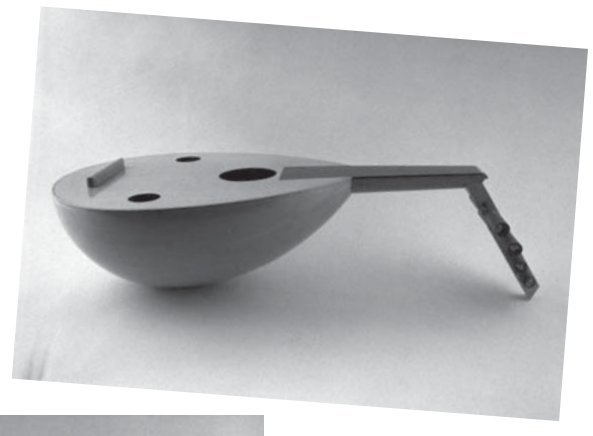
Cedar wood is used to brace the soundboard, braces are shaped by hand after being glued .

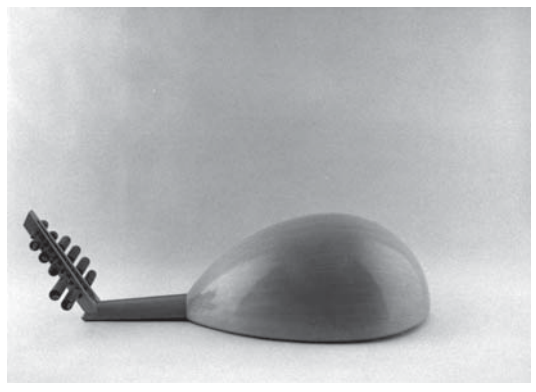


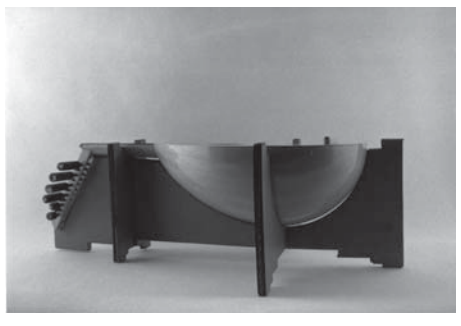
The bridge and braces are glued using the clamping technique shown in the picture above. A piece of 3/4" medium density fibreboard (MDF) with a slight convex curve along its underside spans between two clamps. The slight curvature is meant that the clamps distribute equal pressure along the length of the bridge (shown under pressure).

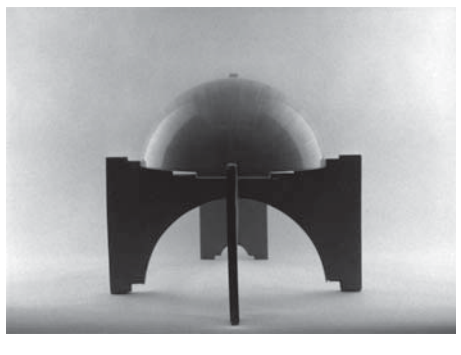


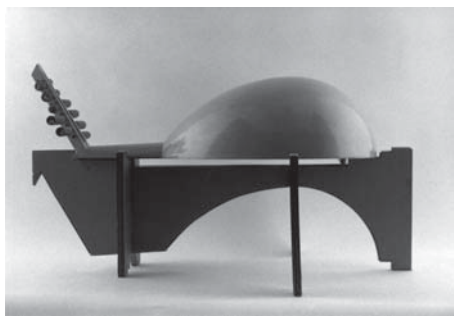
The front and back of the instrument are brought together, each as a complete entity. After some final trim work and fine sanding, the instrument is ready for "french polishing".











Analogy of the String
Sound explorations: designing non-material things.

1. Monochord "harmony of the spheres"/numeric strings proportions and pitch. -Awakening to a thought of"what if?"

2. Translating the geometry unto string proportions.

3. Exploring corresponding pitch pattern.

4. Again translating the geometry into time pattern.

5. Distribution of pitch over time formations.

6. Geometric pattern as composition.

7. The use of several sound samples (piano, xylophone, sin-wave alone, sin-wave with an addition of overtones).

8. Explore designing a sound sample. Sin-wave, with both overtones and relevant amplitudes for each harmonic, using the geometry. This would be an imposition of sounds that are against the nature of "what is an overtone".

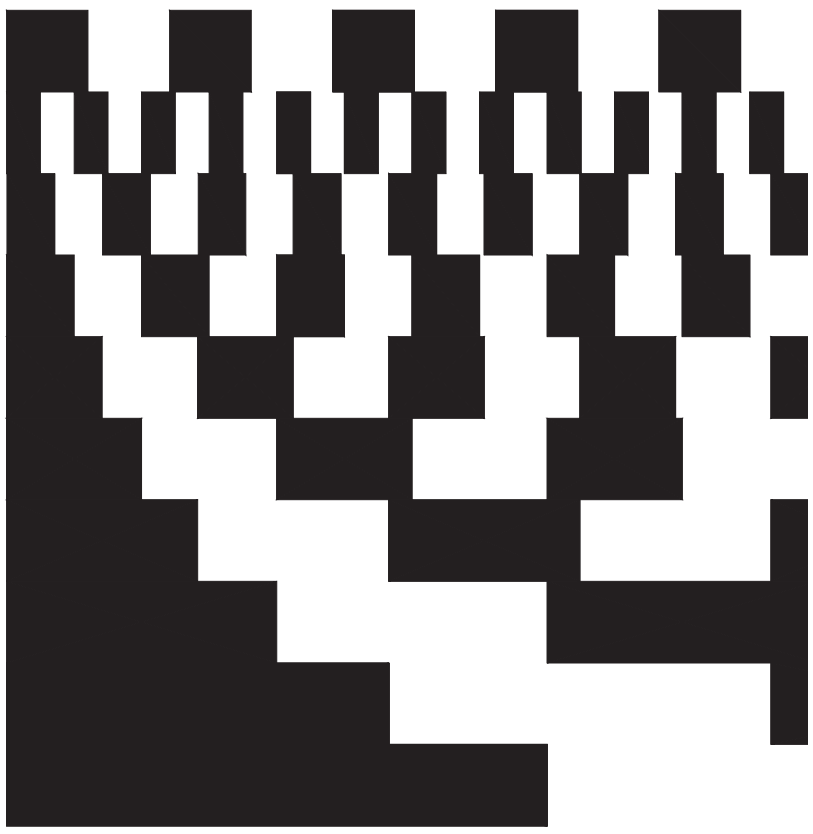
9. Numeric nature of overtone phenomena.

10. The possibility of evolution in the geometric composition, evolving into an autonomous visual art, not just visual/graphical interplay of audible and visual patterns and not representing linear time/pitch sequence.

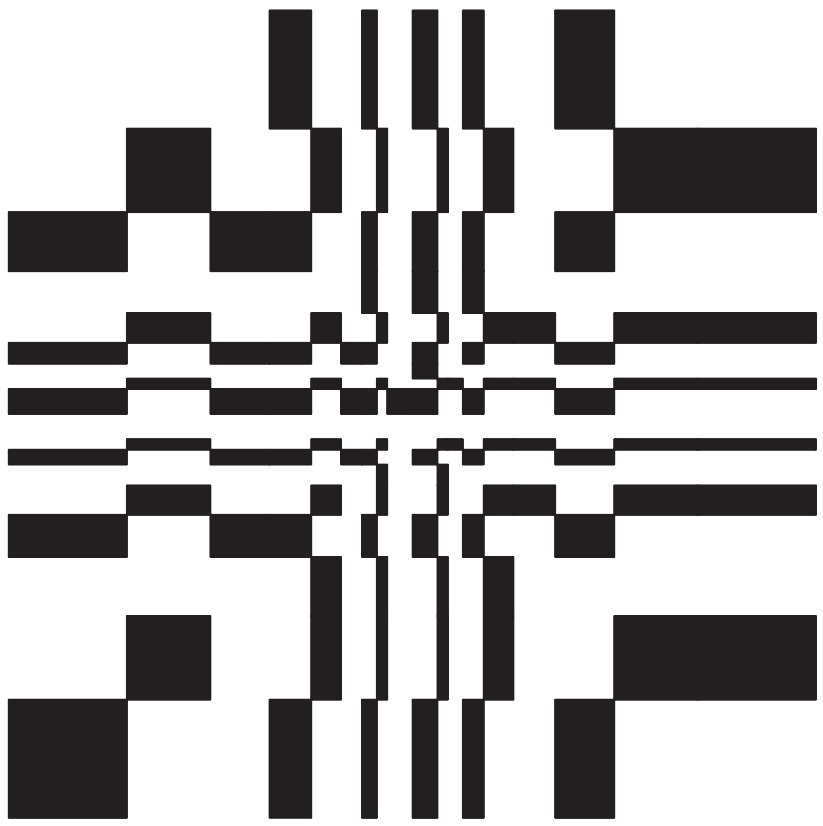
11. Realizing that the geometric pattern had other scale related applications (object, boat, house, town); surprise to find other ways to explore geometry within the same scale of studying the design of a musical instrument.

12. The necessity to translate geometry into number value for computing.
Proportion 1:1.414

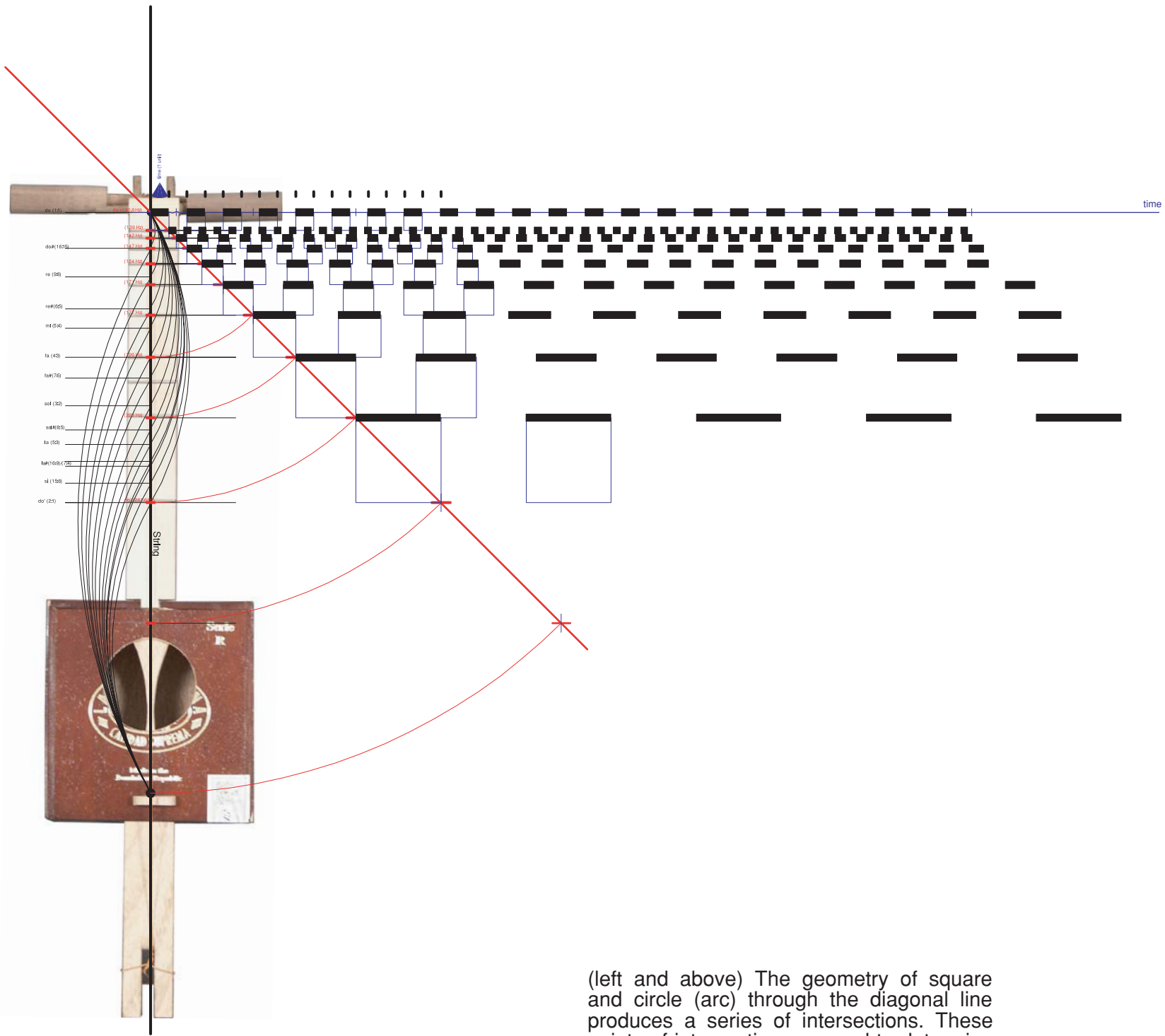
13. Further translations into color schemes prove inconclusive. These are points of intersection on a line that represents the color spectrum. The resulting colors represent points of intersection on a range of 256 points. The complexity of the question on color is one that again seems to be addressing itself through number logic. (revision; see "Color Harmony through Geometric Order")



Segment of sound pattern: (left to right) each pitch is distributed over equal amounts of sound (black) and silence (white space); (top to bottom) each distinct pitch is programmed within a specific time measure.



Translating the graphical function of geometric pattern, as representaion of audible phenomena, into a purely graphical art form. The example below is that of two measures of silence (white space) for one measure of sound (black). They are arranged in a clock-wise spiral going out from the center.



(left and above) The geometry of square and circle (arc) through the diagonal line produces a series of intersections. These points of intersection are used to determine time measures and pitch variations. A stringed monochord was constructed to study the relationship of the sounds to each other. Later, the above graphic pattern of sound, duration and timing was translated into computer-generated audio samples.

note: sound explorations on CD-ROM

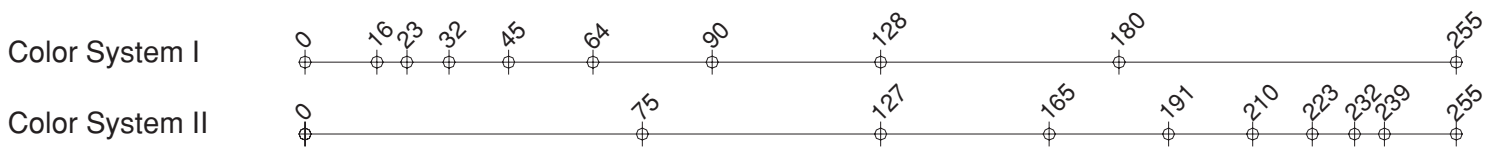
Color Harmony Through Geometric Order:

The following experiment into abstract color is a further translation of a geometric order into "scale". It presupposes a line - vibrating string representing not sound, but a specific color system. A computer monitor can produce 256 variants of color per red, green and blue. A line is drawn to represent a distance between two points; zero and 255. The idea is first to locate a series of points of intersection along a line, derived from thesis. The number of intersecting points, including both zero and 255 is equal to ten. Lines represent the range of possibilities within each color range per R-G-B.

The study thus shows one thousand color variants that are a product of "mixing" red, green and blue. The orientation of the geometry can produce a similar, reversed system, with that, an additional pattern is produced. To explain the color plates: a color plate is part in a color system, consisting of ten plates per system. A plate is comprised of 100 variants (products of the mixing process), and begins with assigning a value for the color red (utmost top-left square), which will be maintained throughout the individual plate. the addition of blue to the color mixture occurs as one's eye moves towards the right, increasing with each color square. The color green increases similarly from top to bottom. These observations may require a closer eye onto the plates, as specific measures of red, green and blue are used in the design of every individual color squares found within.

Abstract color is described as color devoid of a material association, as in a red brick, or blue violet. It restrains the focus to color itself, and the various measures of coloring/pigment. Within these represention/plates, a multitude of color relationships and associations are possible, of which color harmony is highly noticeable. This extension of ideas on proportion, geometrically and architecturally speaking, into color theory is both simple and complex, and further enriches the search for a design language, as well as unity of form.

note: for color studies see Appendix I & II



(above) subsequent color pallette using Autocad 2002.

sample color study

History of the Oud (Al-'Ud):

The Oud is a fretless short-necked lute. The earliest known forms of the musical instrument are the Berbat of Ancient Persia and Nefer of Ancient Egypt, where it had been carved out of a single wooden piece, covered with skin, and strung with gut. It was made popular by the Arabs, while its use flourished with the spread of Islam. The Arabic term "oud" denotes the modern form of the instrument since the 8th century, signifying the use of several thin flexible wooden staves in its construction. The modern form also substituted the natural skins for a wooden soundboard.

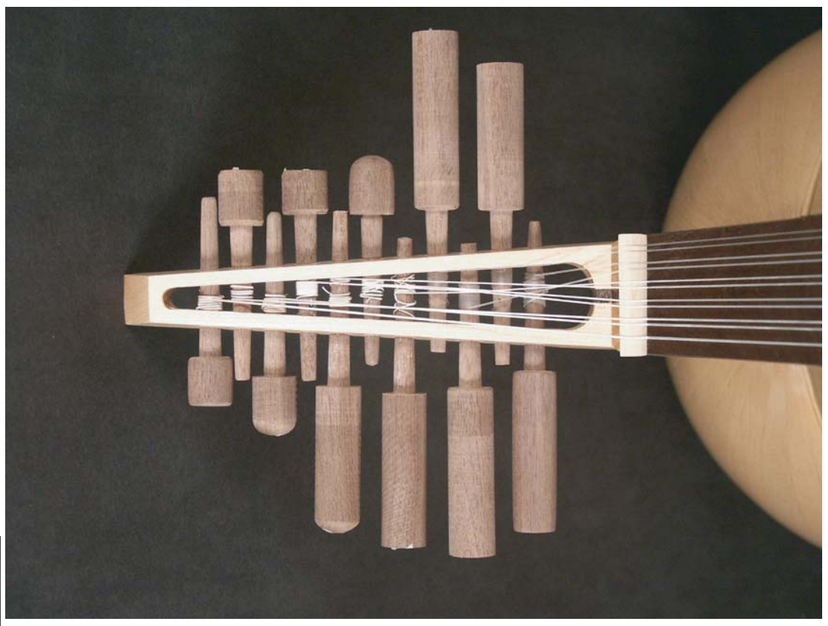
Arabic speaking civilizations had adopted some of the early Greek thought on music, its healing and medicinal powers. The strings of the Oud had traditionally been four strings, representing the four bodily humors. A fifth string had since then been added to represent the presence of the soul, while other strings have been added to increase the tonal range of the instrument. This chordophone is the ancestor of the European lute, by way of Andalusia and the Crusades.

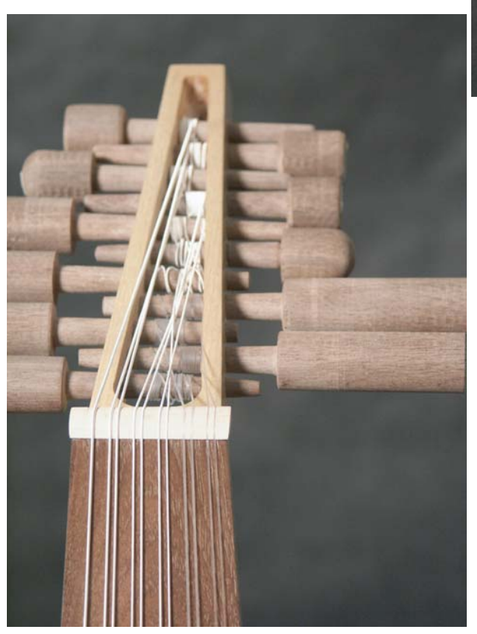
Modern Oud construction employs several woods such as mulberry and rosewood for the back, neck, and fingerboard, while quarter-sawn spruce or cedar is usually selected for the soundboard and bracing. Also, string-manufacturing technology has substituted gut strings with nylon wound with silver-plated copper. The instrument has not been standardized neither in terms of shape nor material; luthiers have come to apply various subtleties of design and have experimented with various wood types in search of a desired tonality and/or playability. Contemporary Oud makers have focused more on these factors and less on the decorative customs that have come to be associated with the Oud as an object. The tradition for decorative embellishment, using mother-of-pearl inlays and rosette motifs, stems from the Oud's long history, and its placement as the "sultan" of Arab musical instruments.

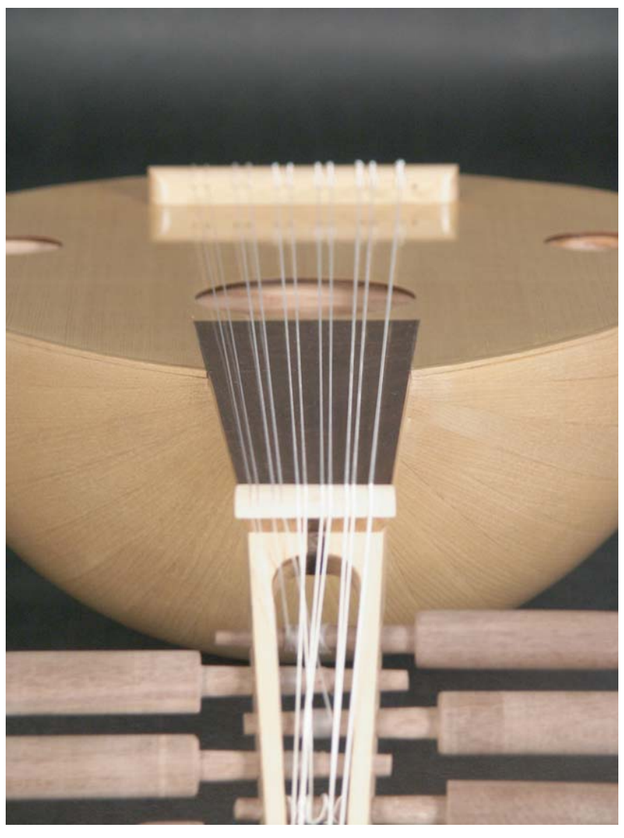
contemporary Ouds

clockwise from top-left: examples from the work of luthier Nazih Ghadban. Replica Nahat Oud by Jameel Abraham. Oud by Muhammad Faudel Hussain. Electric Oud by Vicken Najarian.

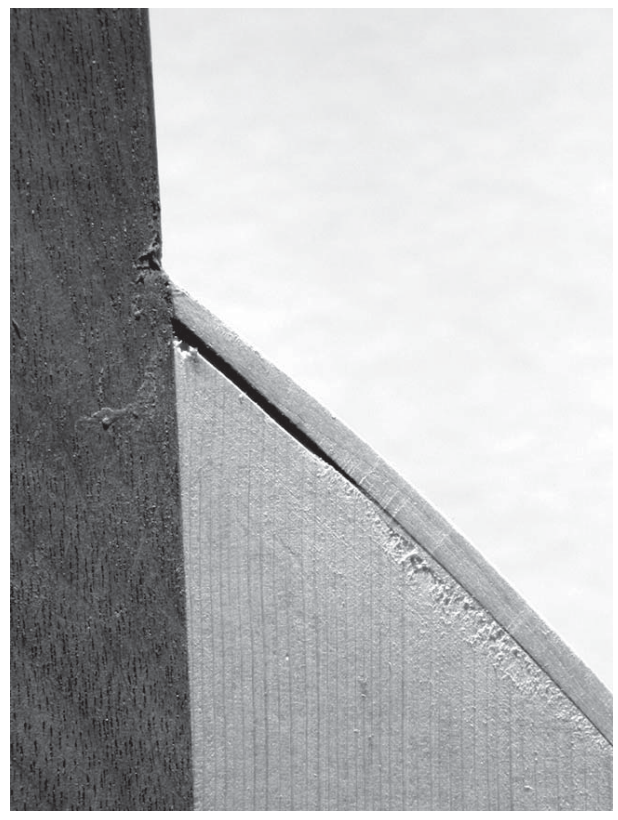
final model-back

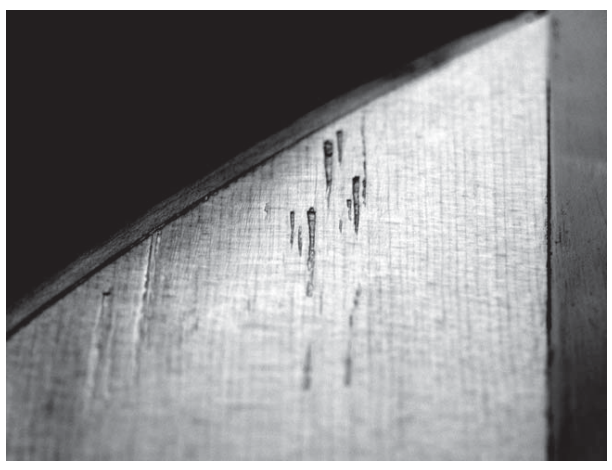


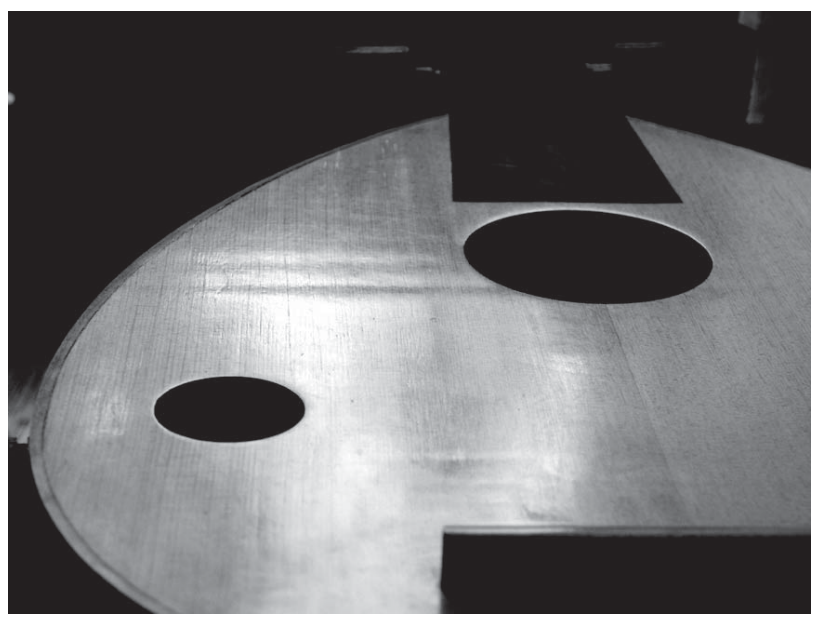




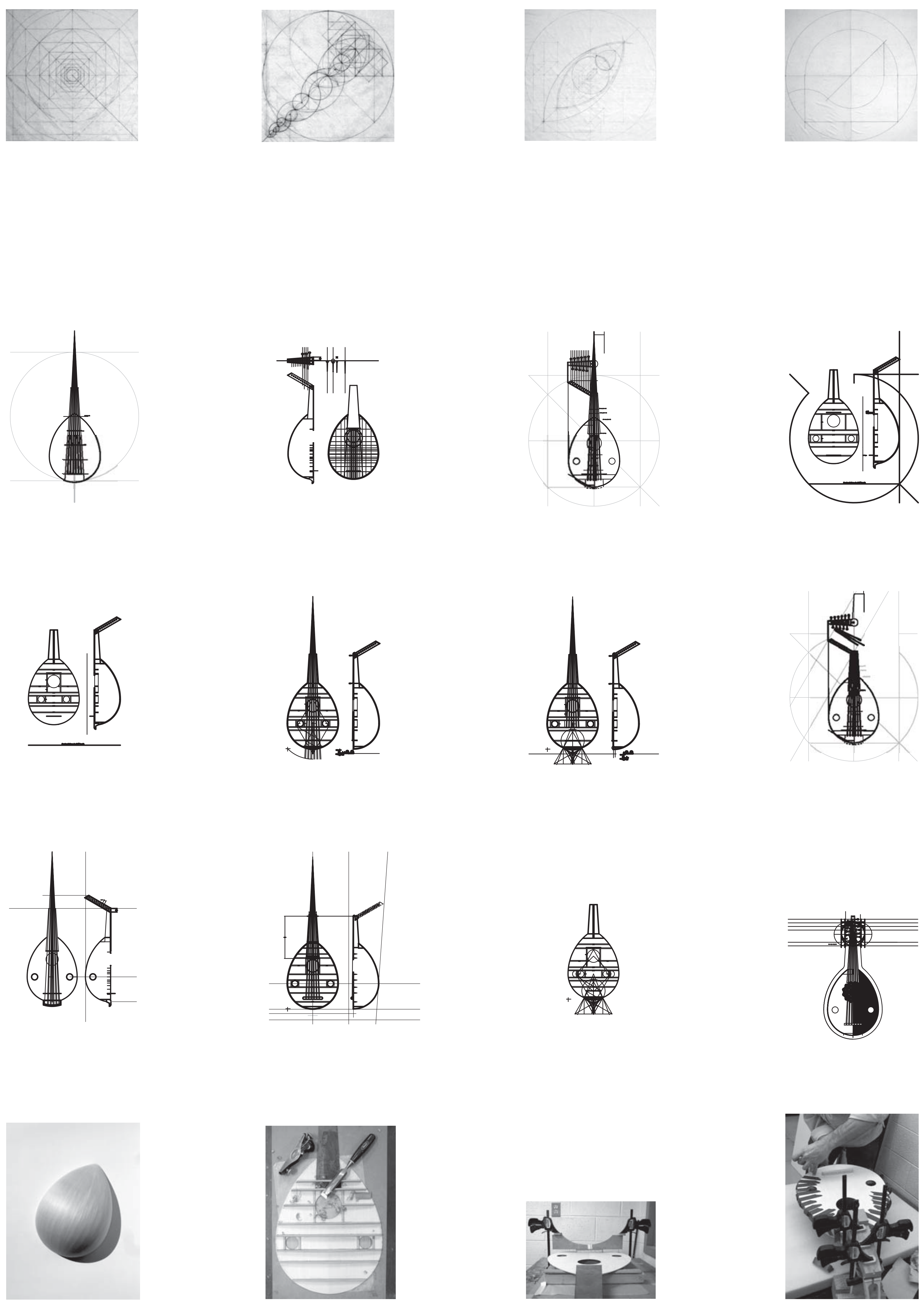
final model - collage

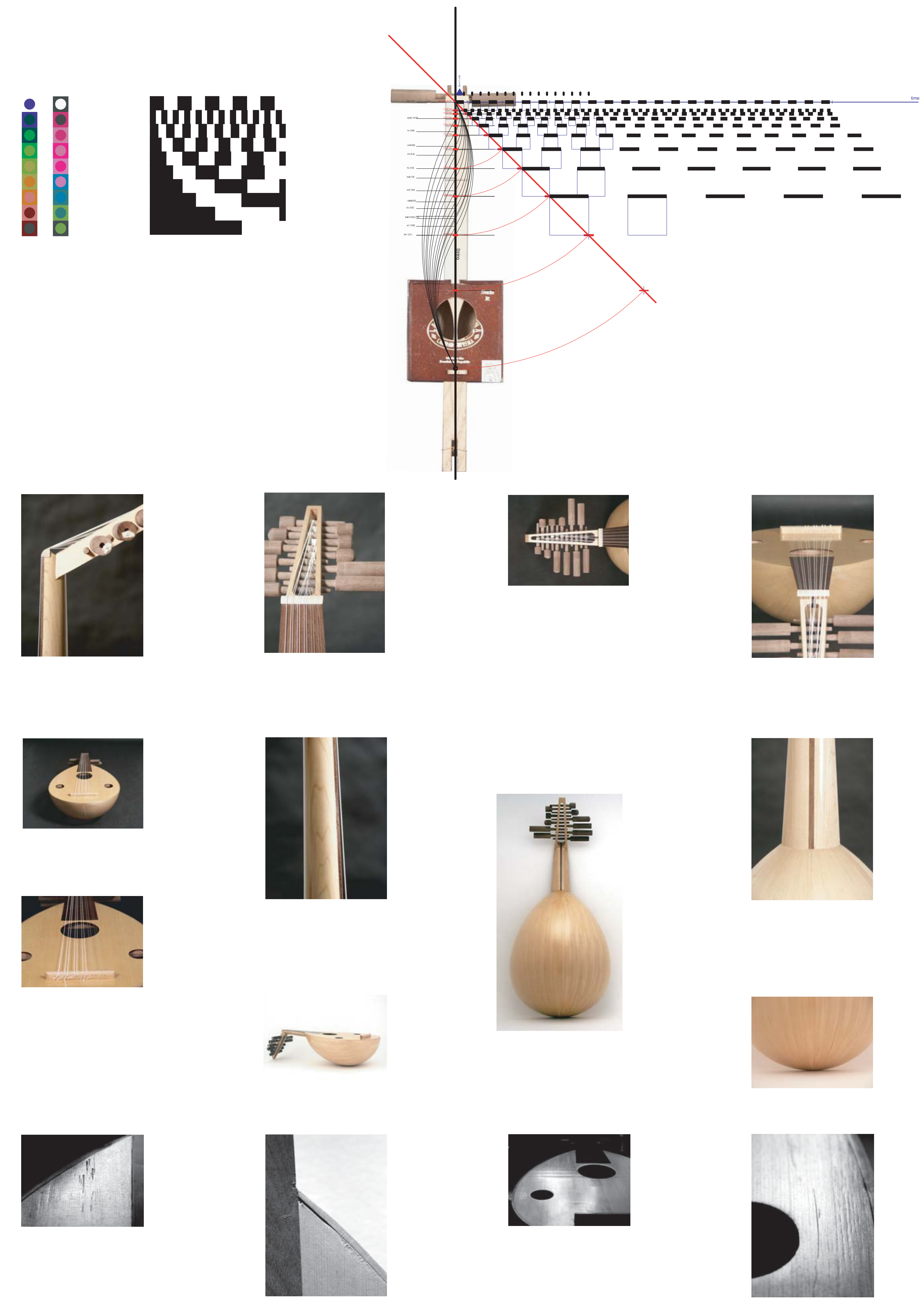






Sound preceded Light,
Silence preceded sound,
This silence, knew
LIGHT.





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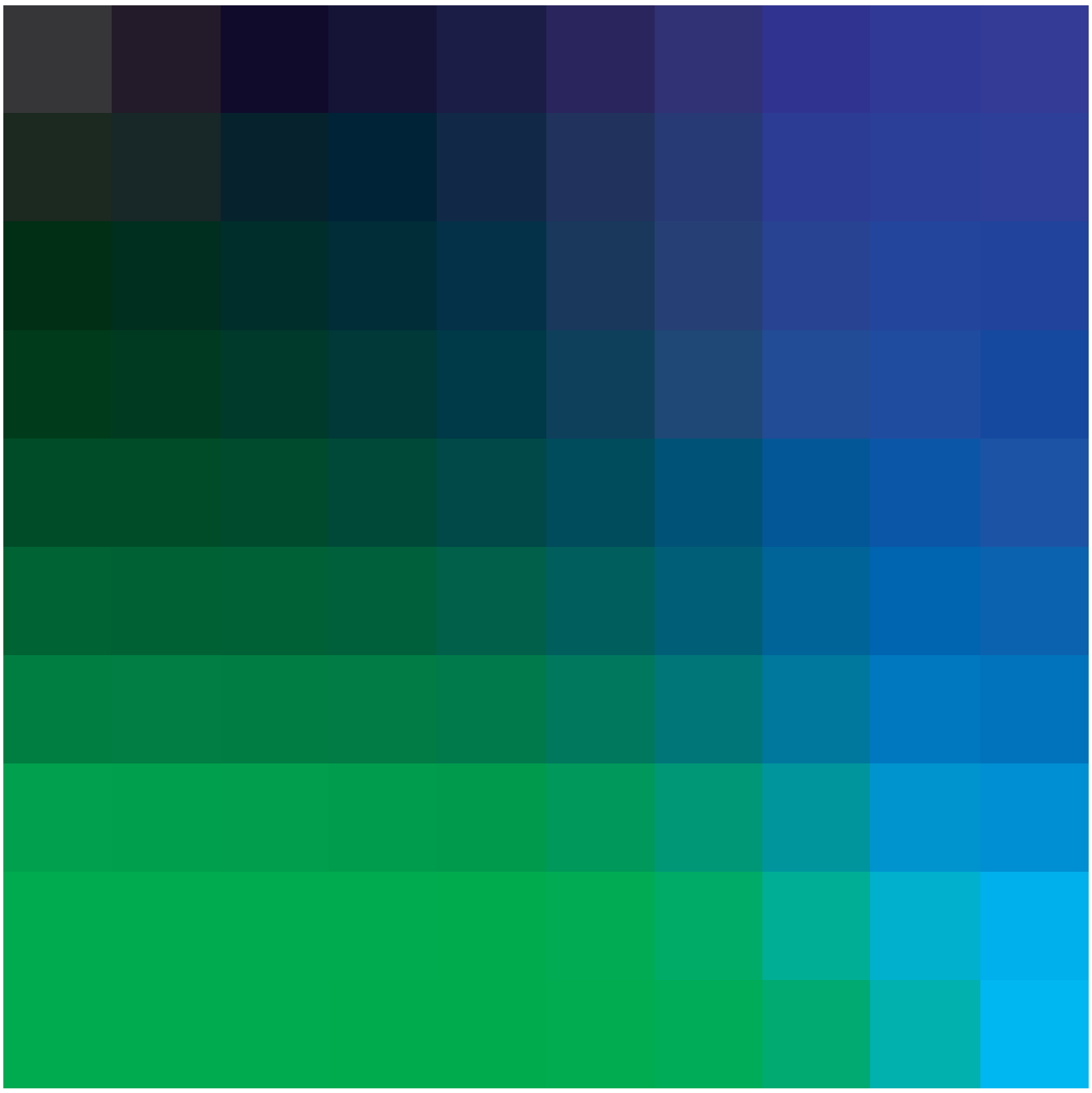
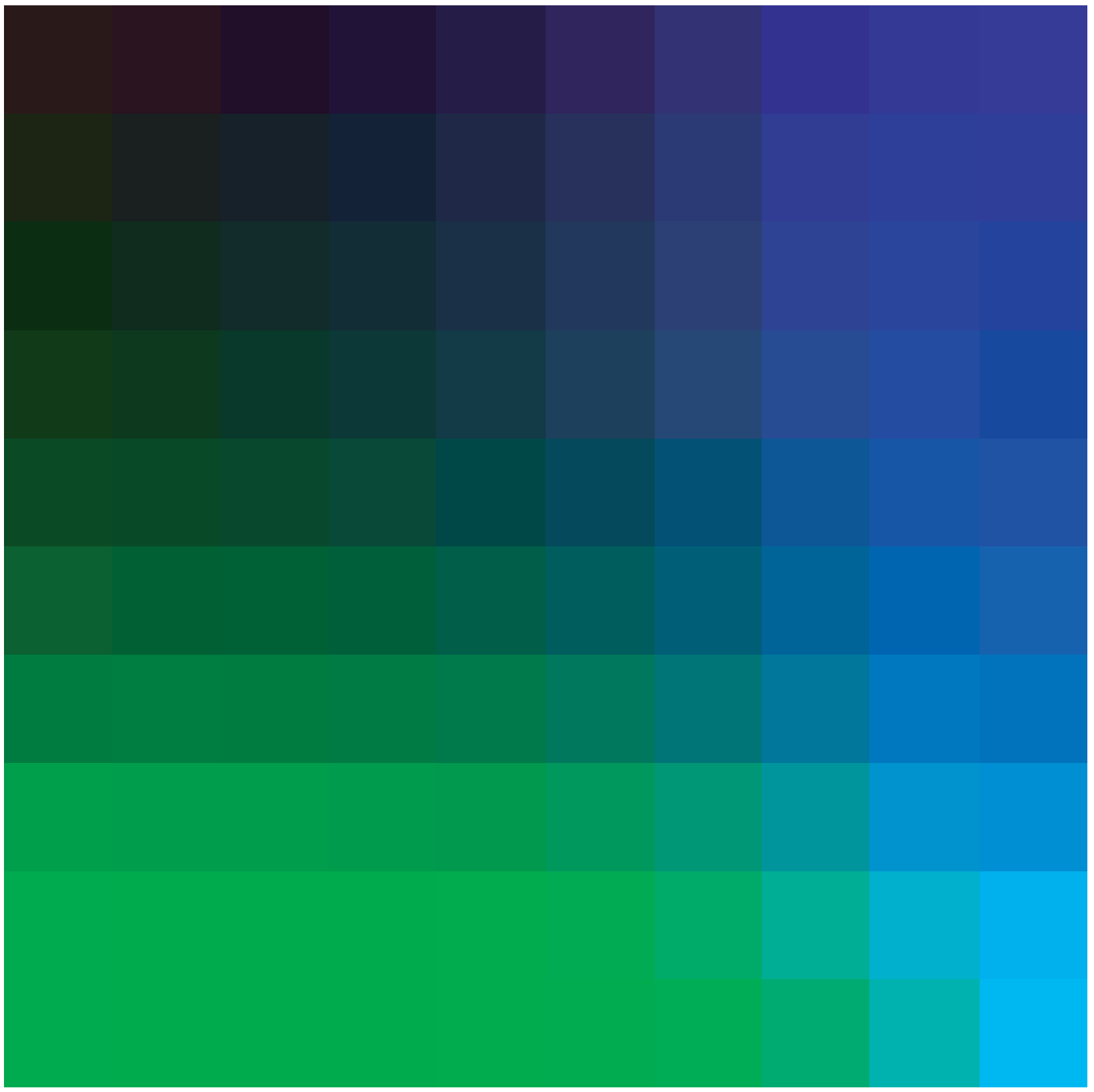
Note: All work produced by author except where mentioned.
All computer-generated sound studies were programmed using MatLab, Courtesy of Mr. Barbar Akle.
Oud sample, first sound, recorded using a mini-voice recorder.

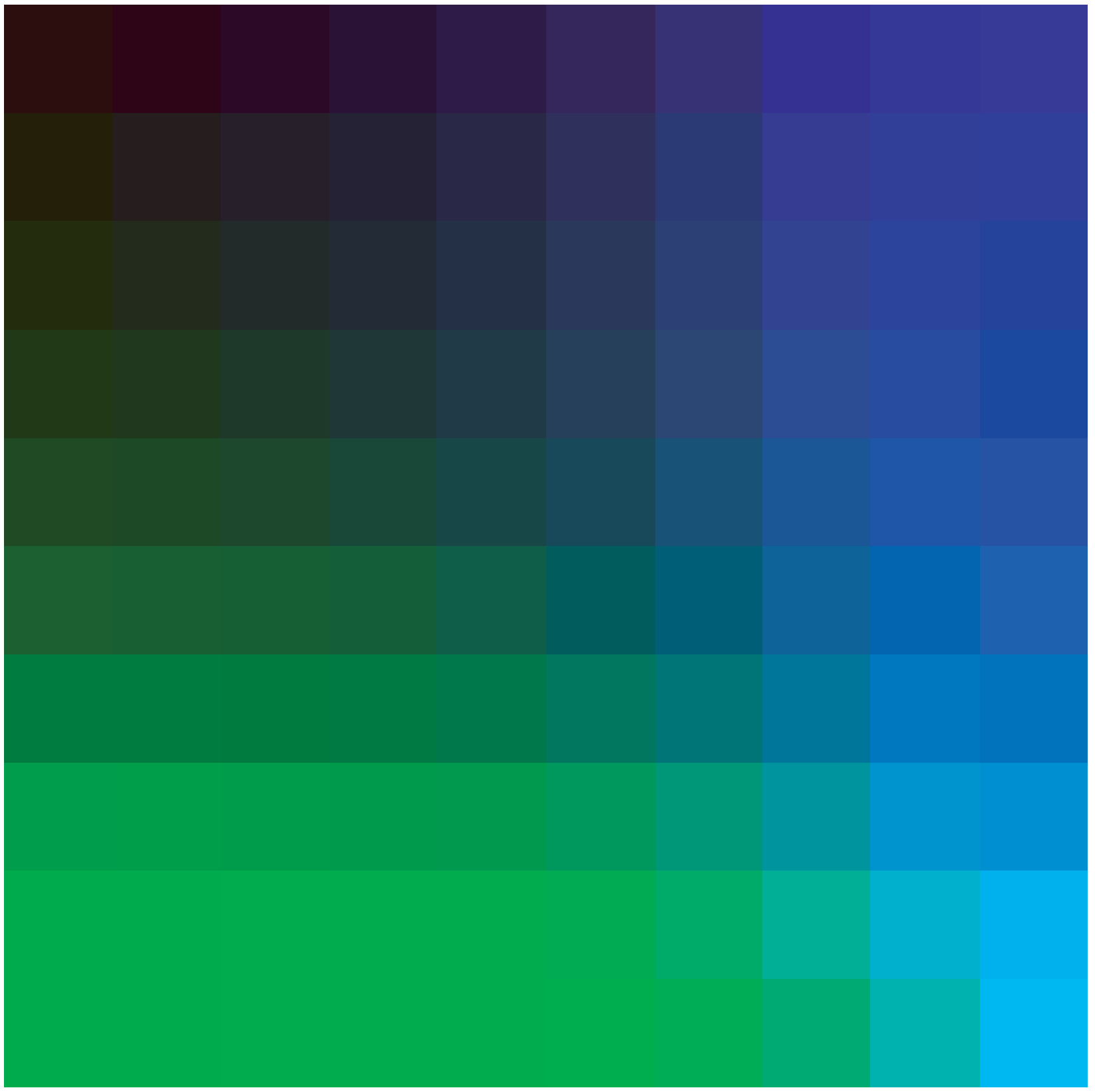
Sari B. Khoury

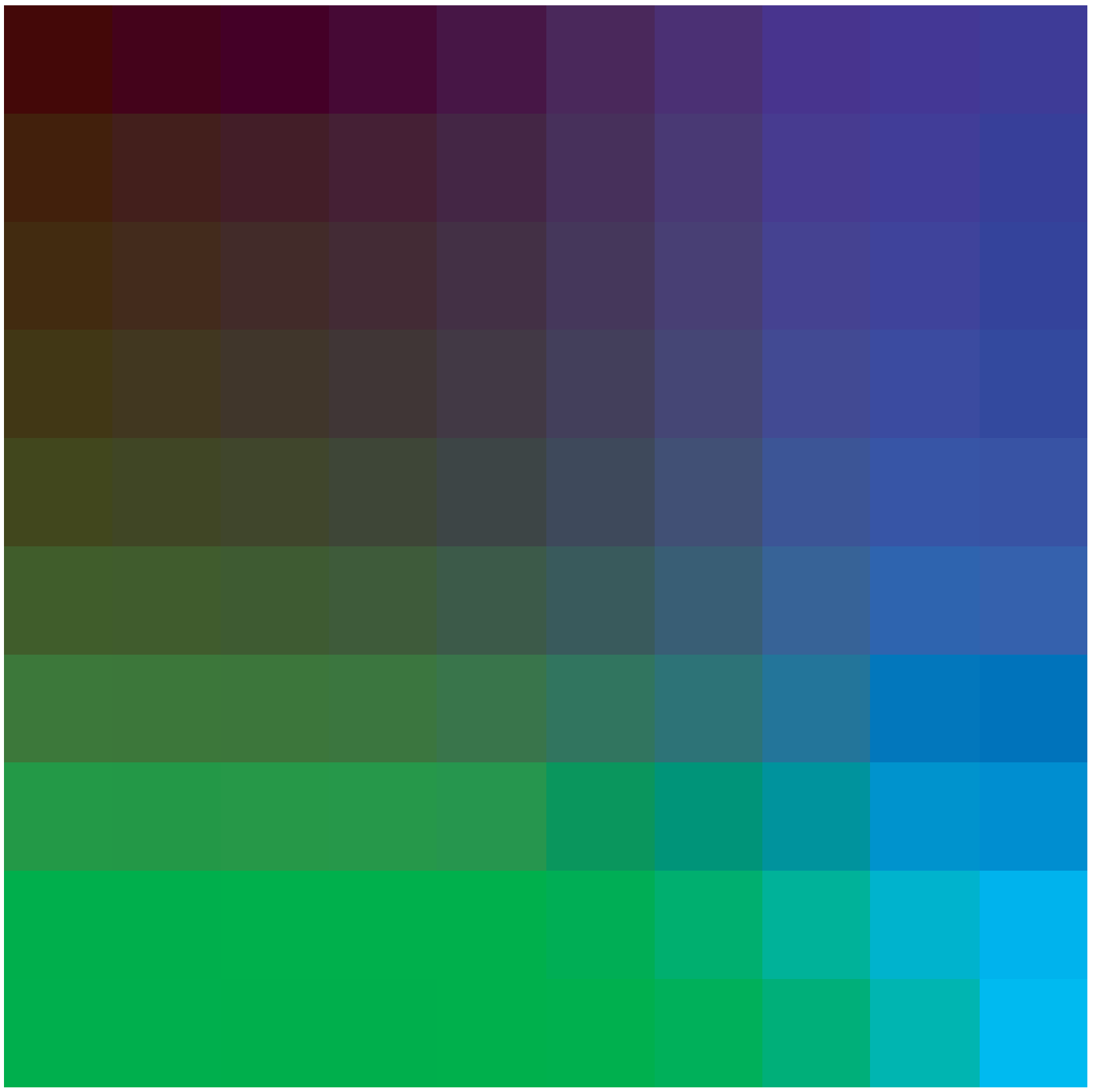
Master of Architecture	Sept. 2004	VPI & SU
Bachelor of Architecture	Dec. 2003	VPI & SU

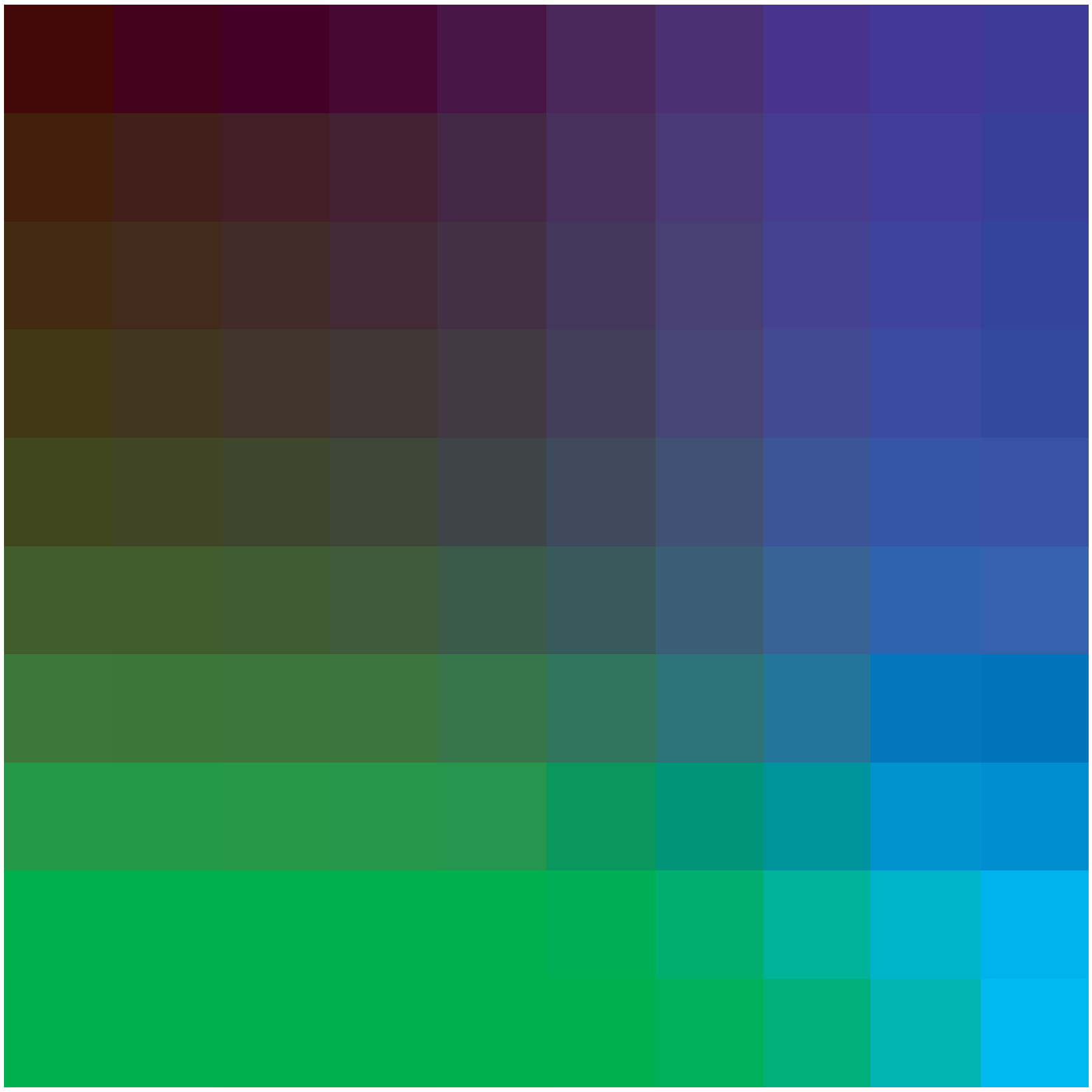
Appendix I

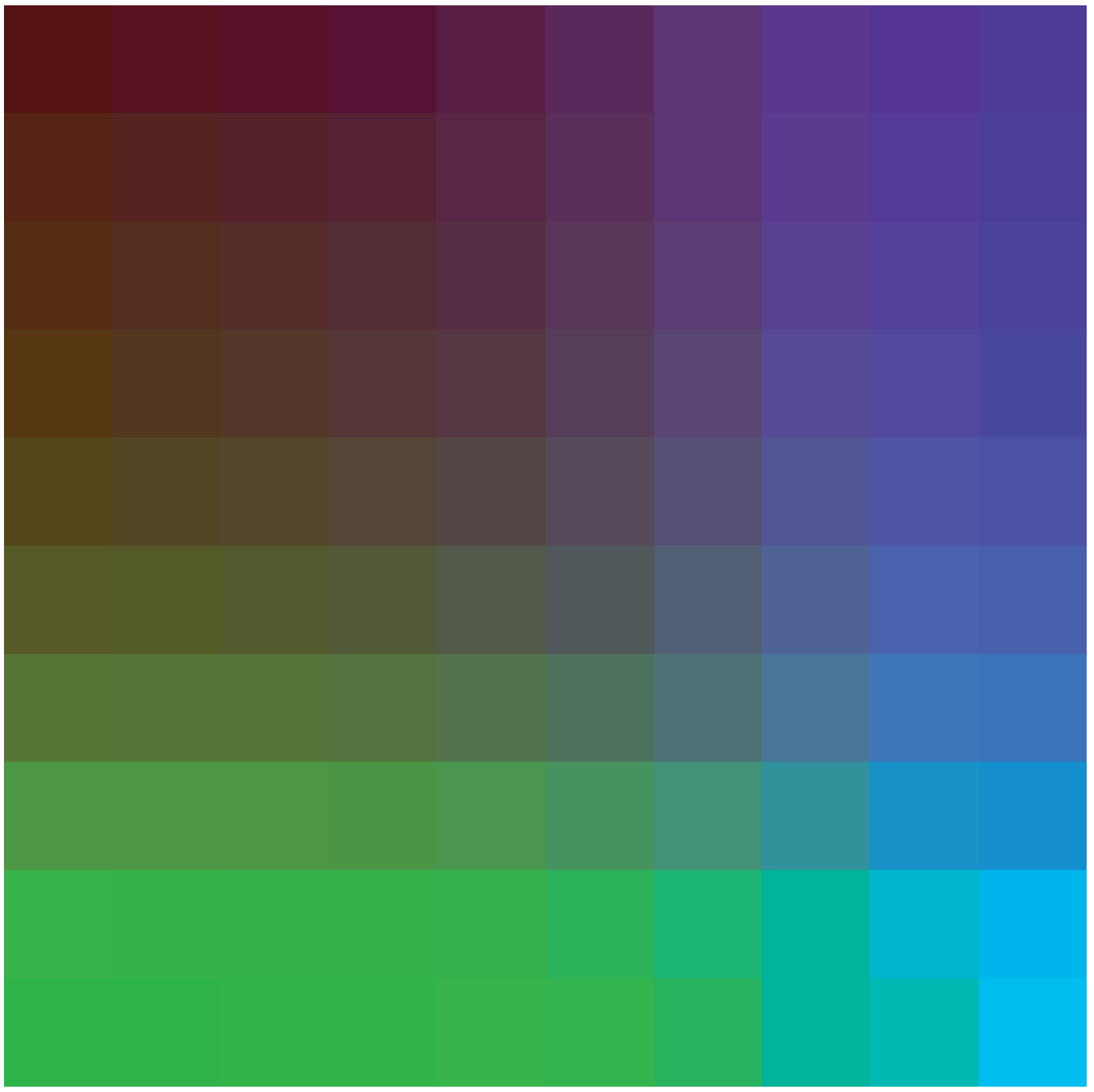


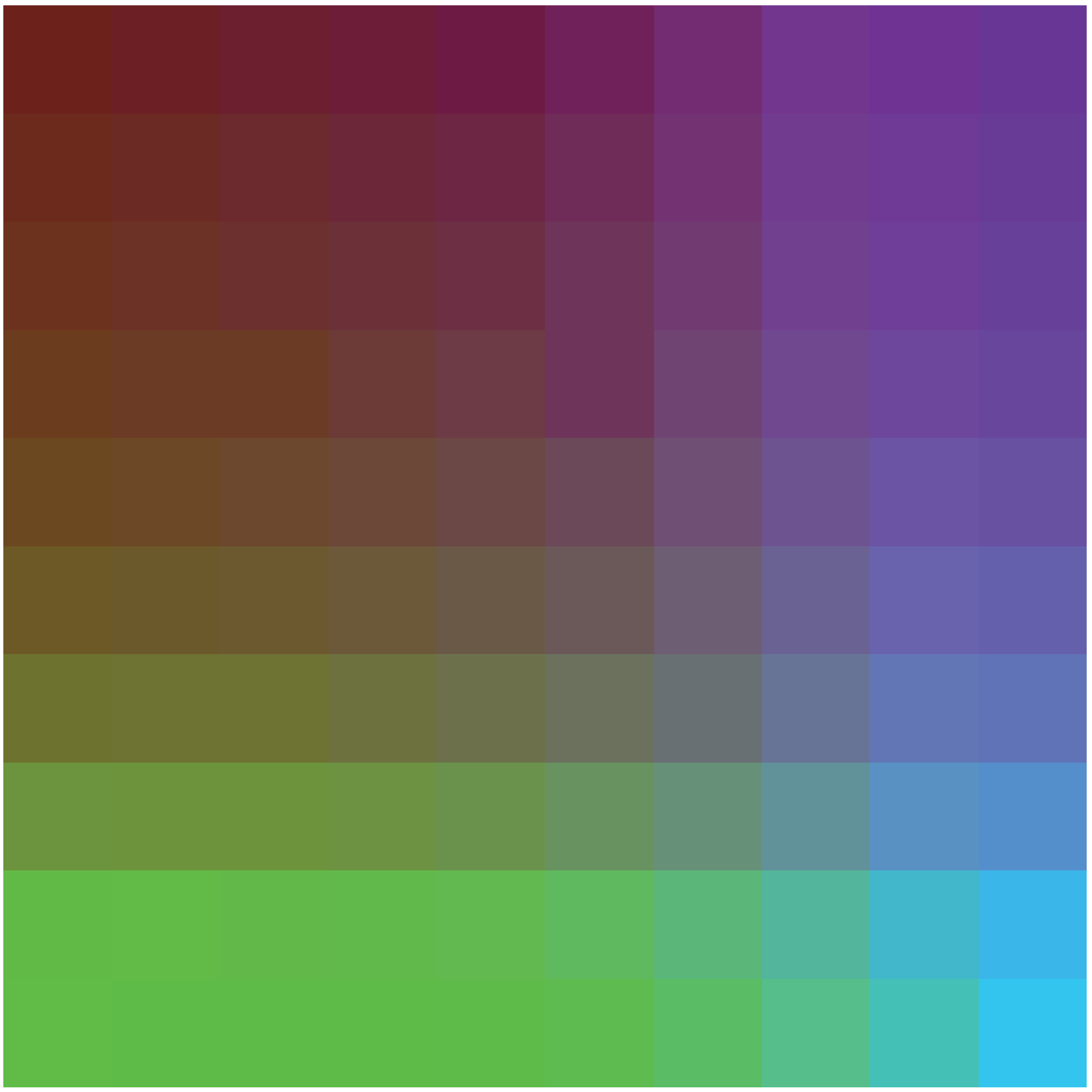


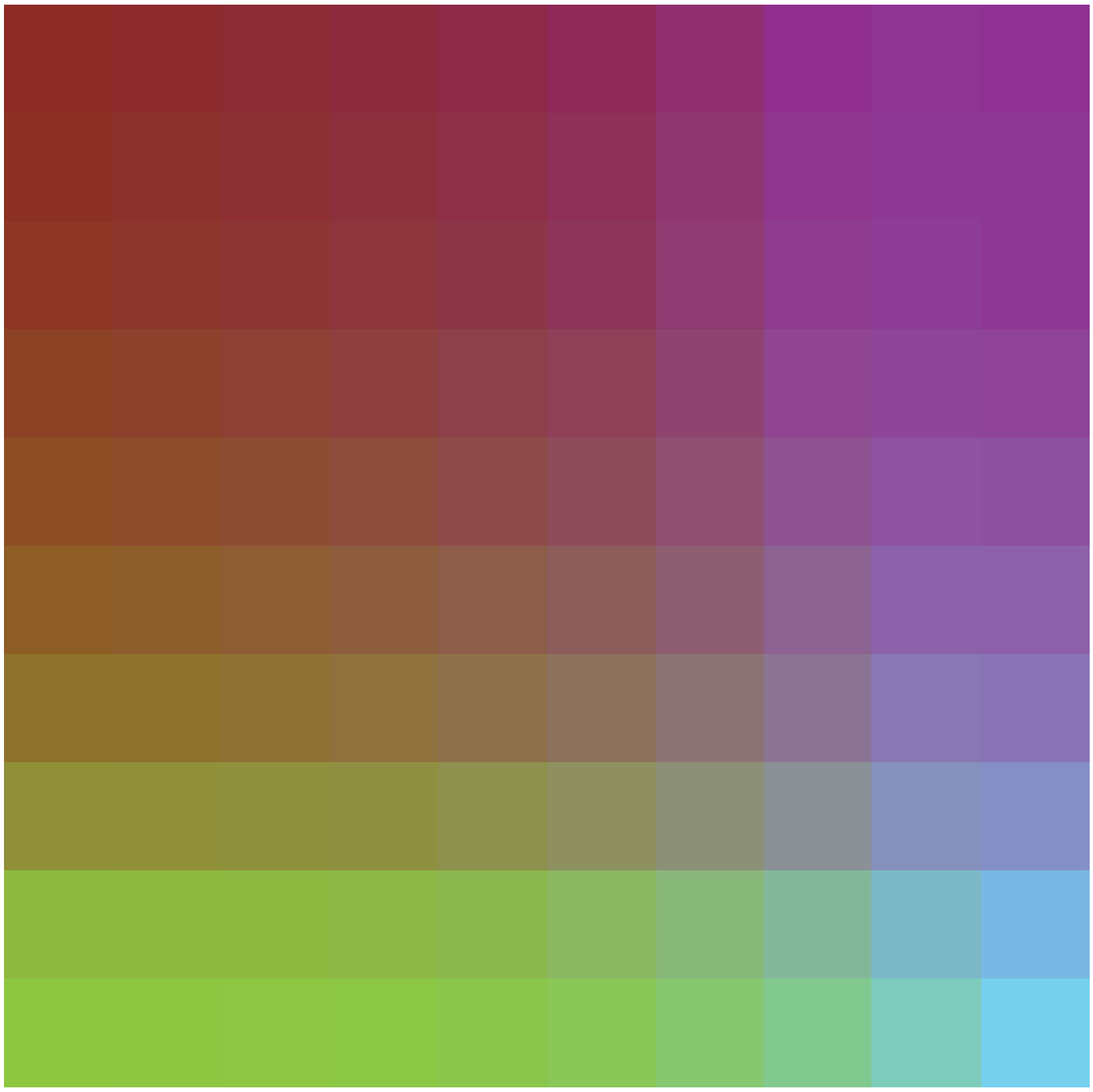


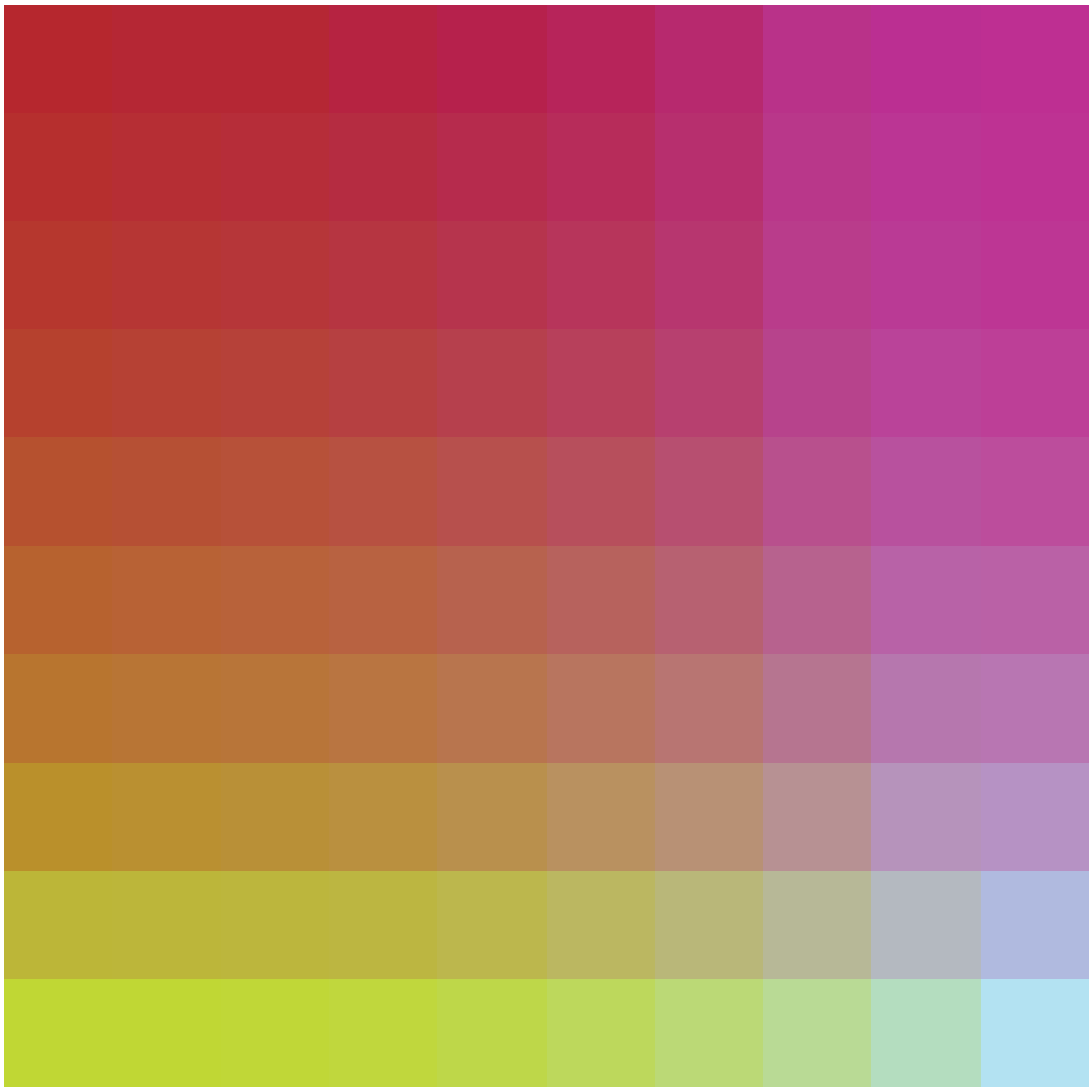


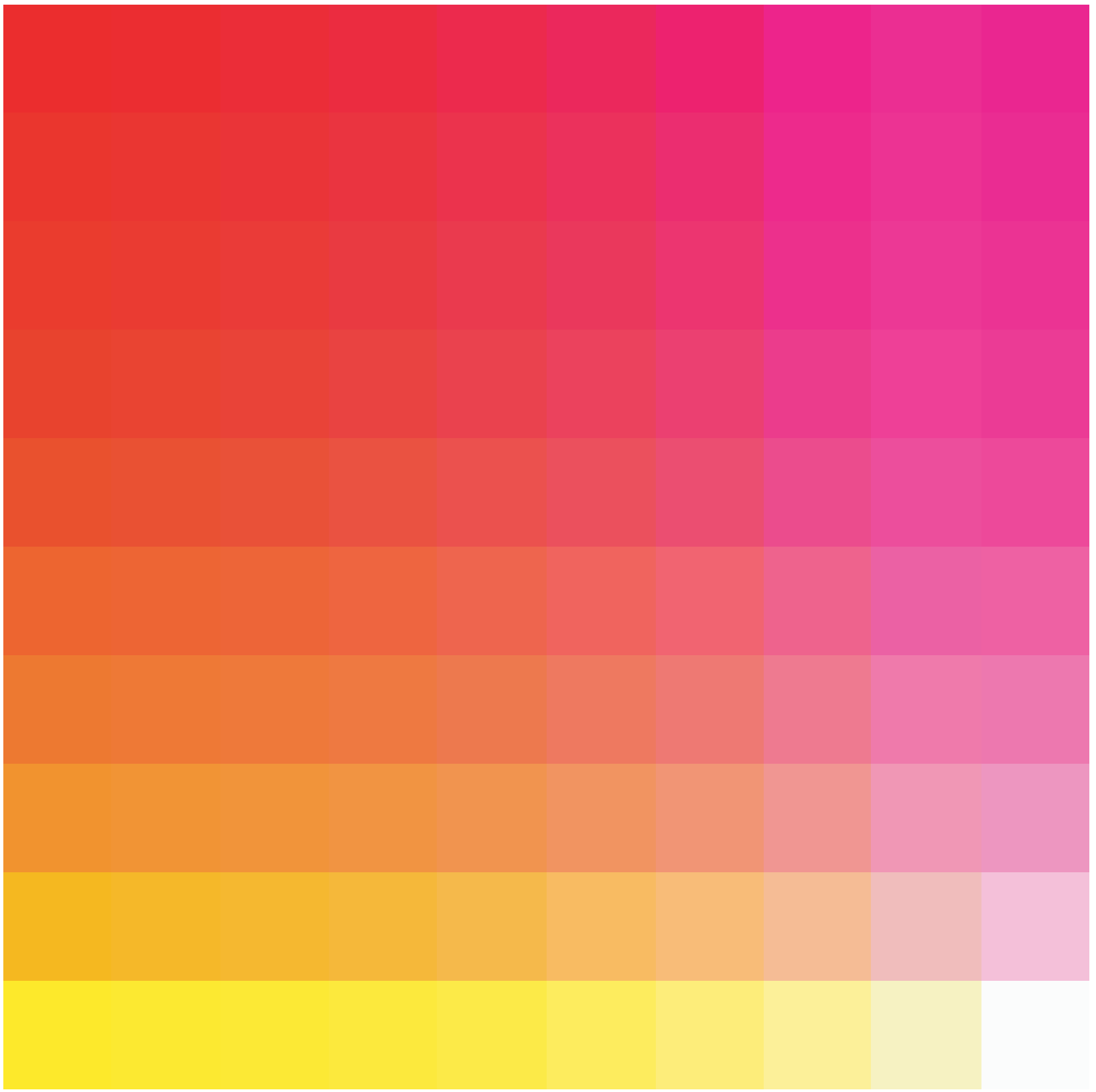












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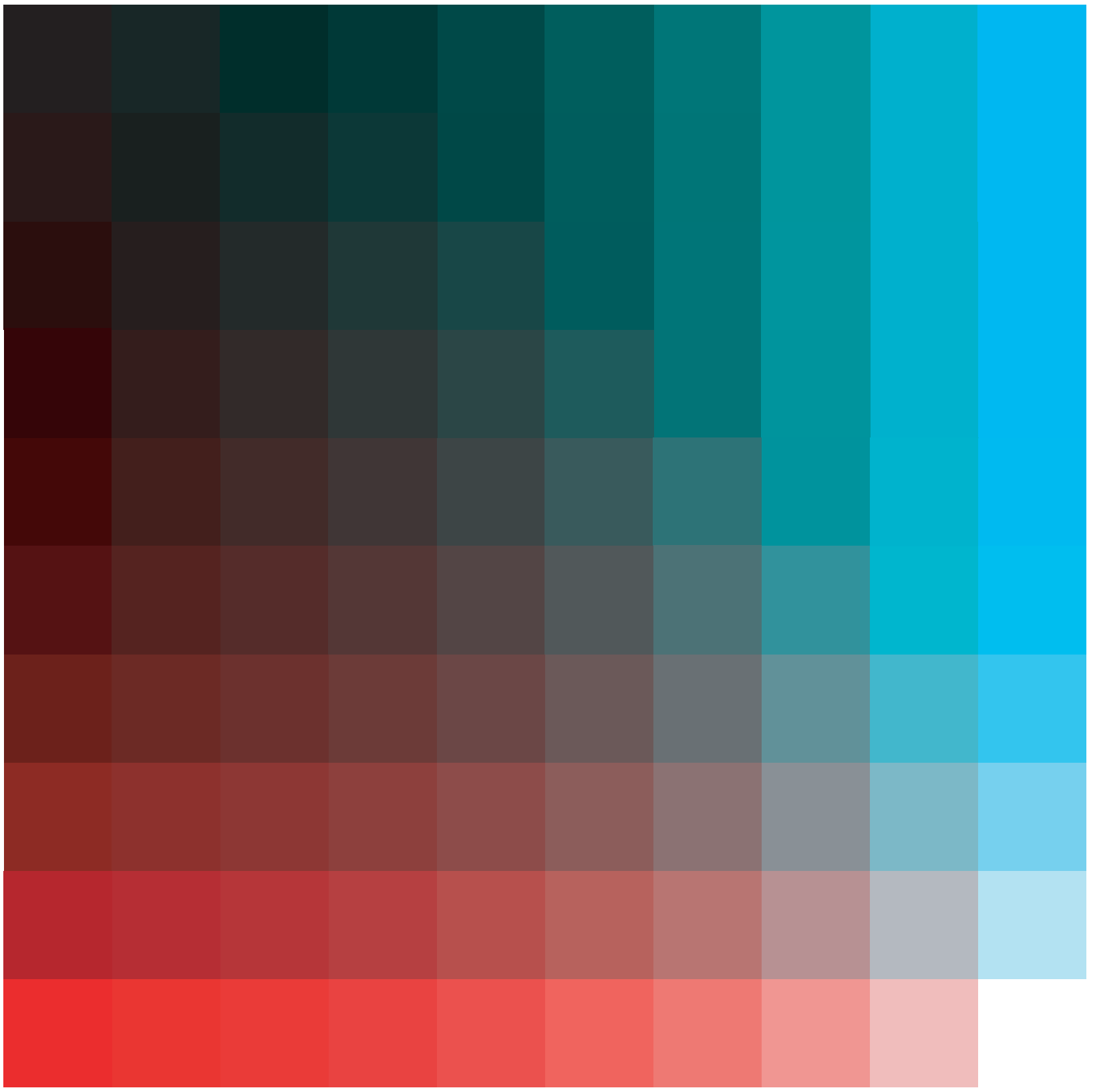
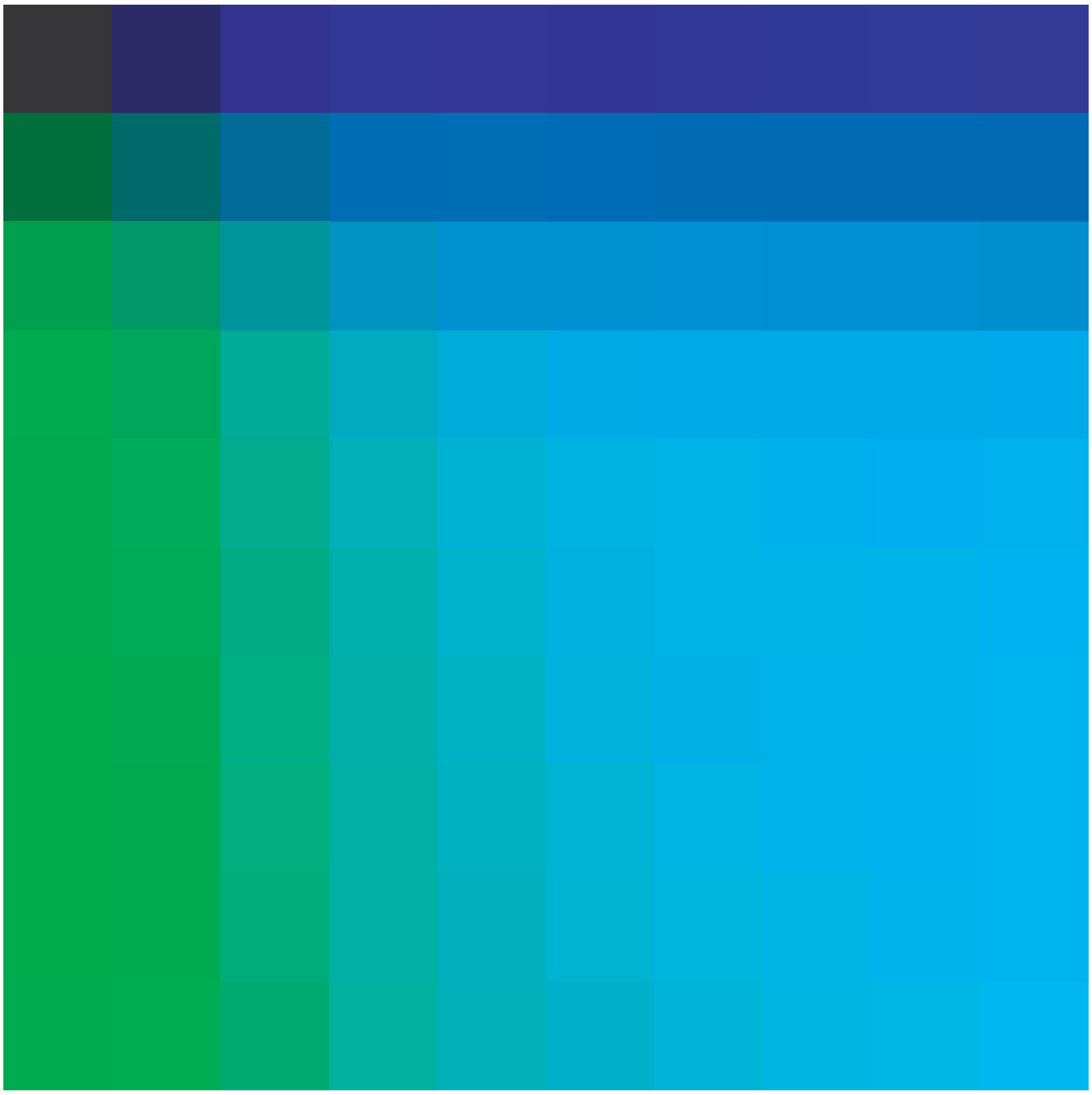
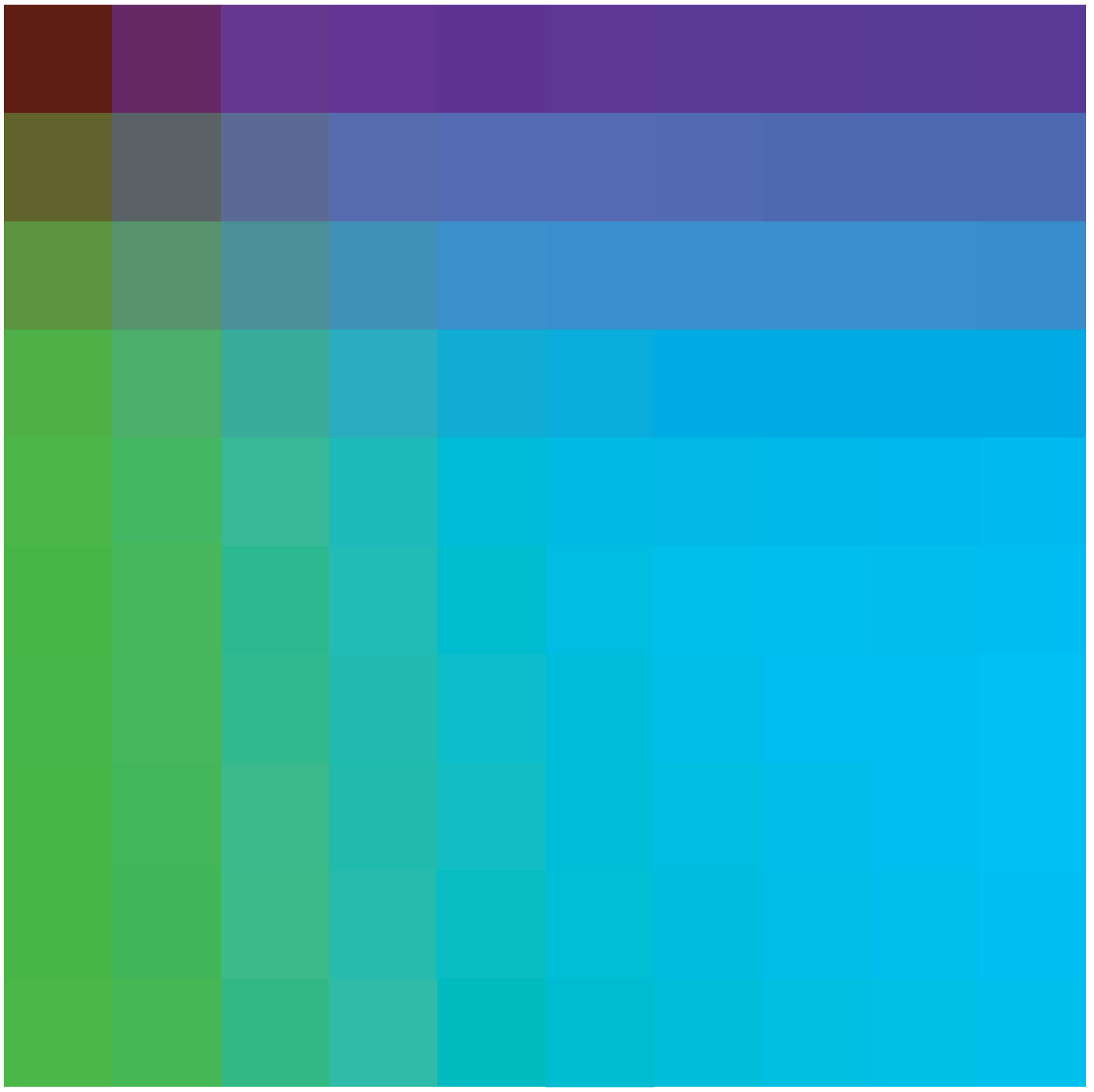
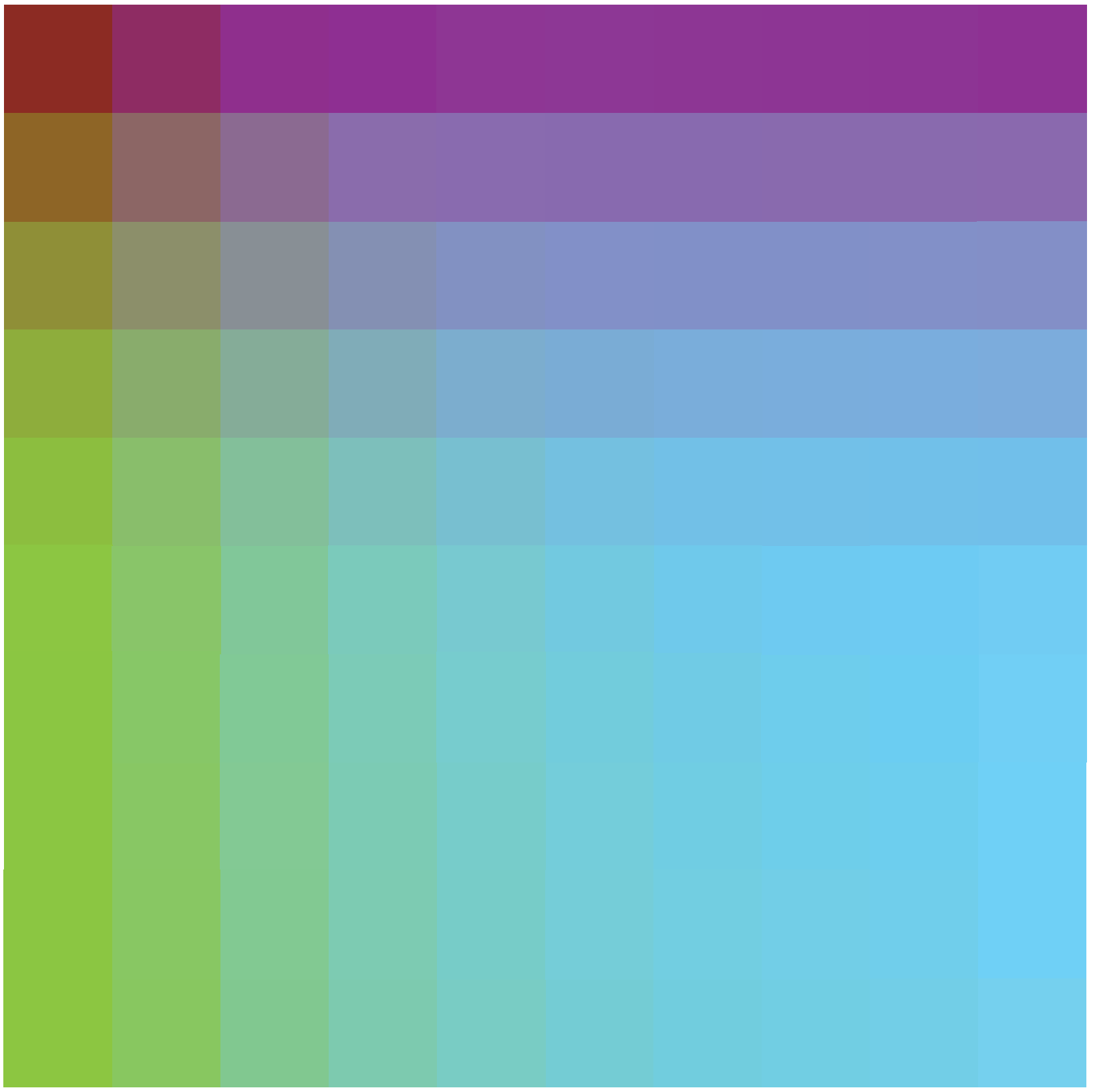


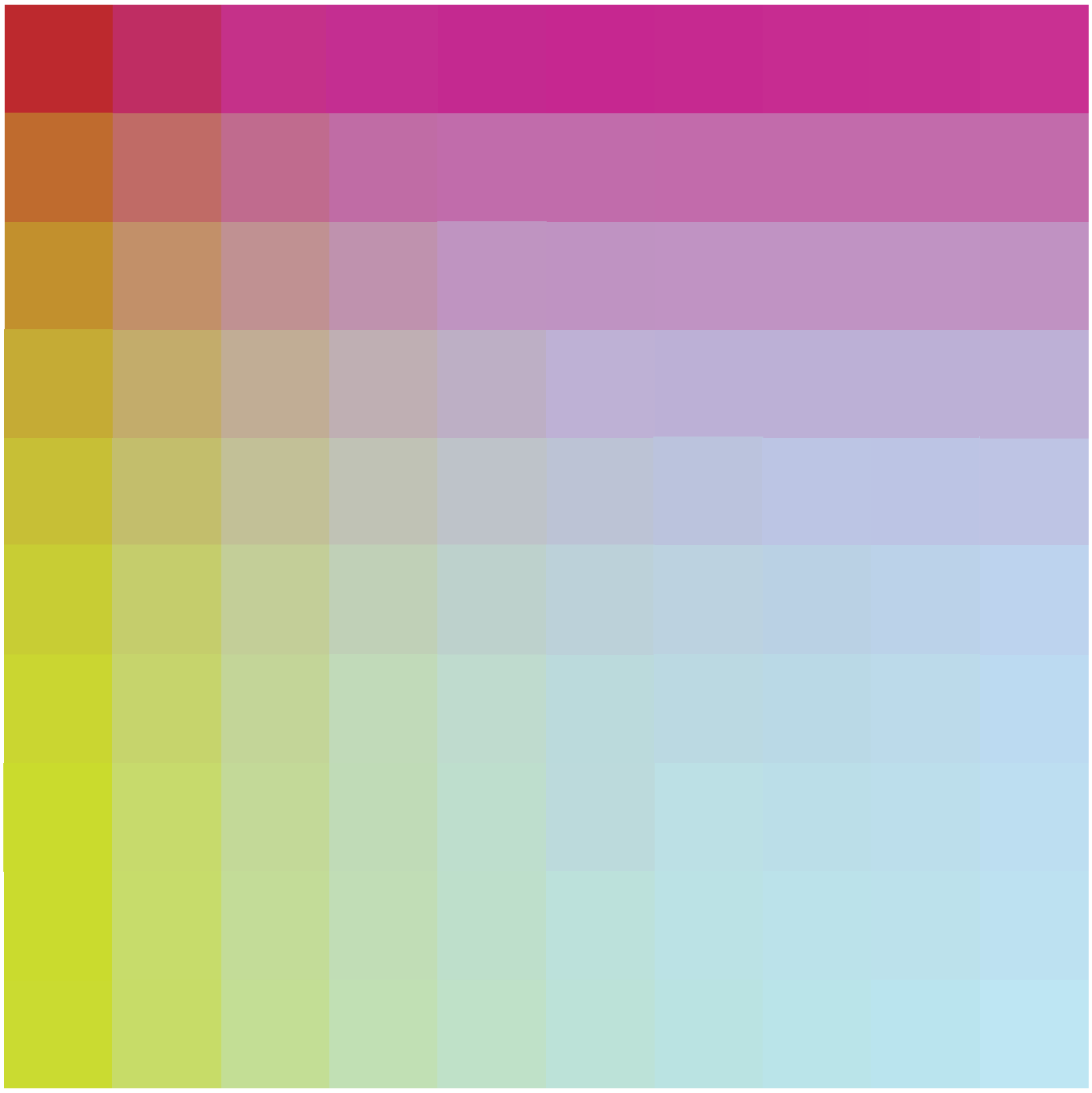
mid tones
system I

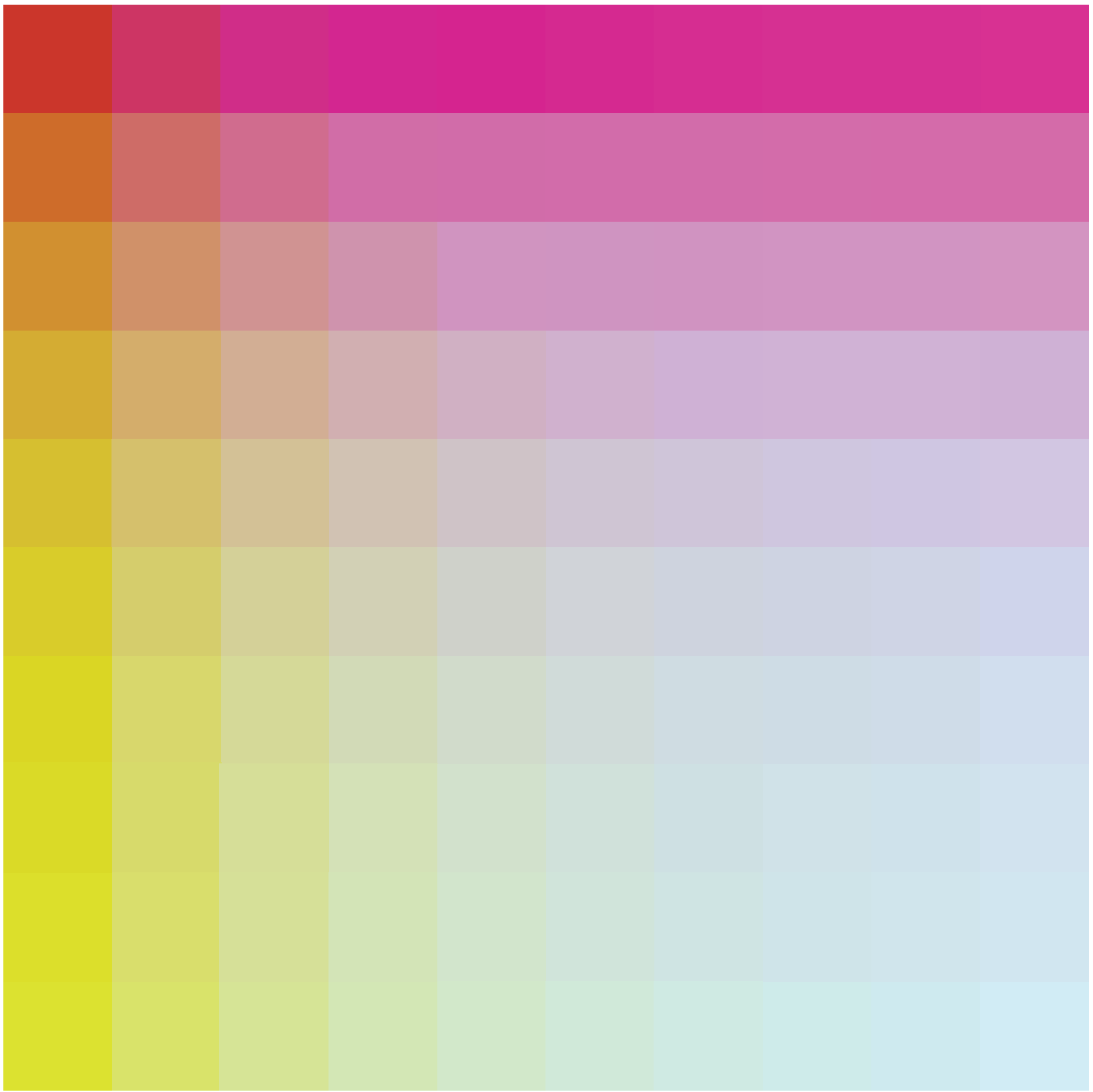
Appendix II

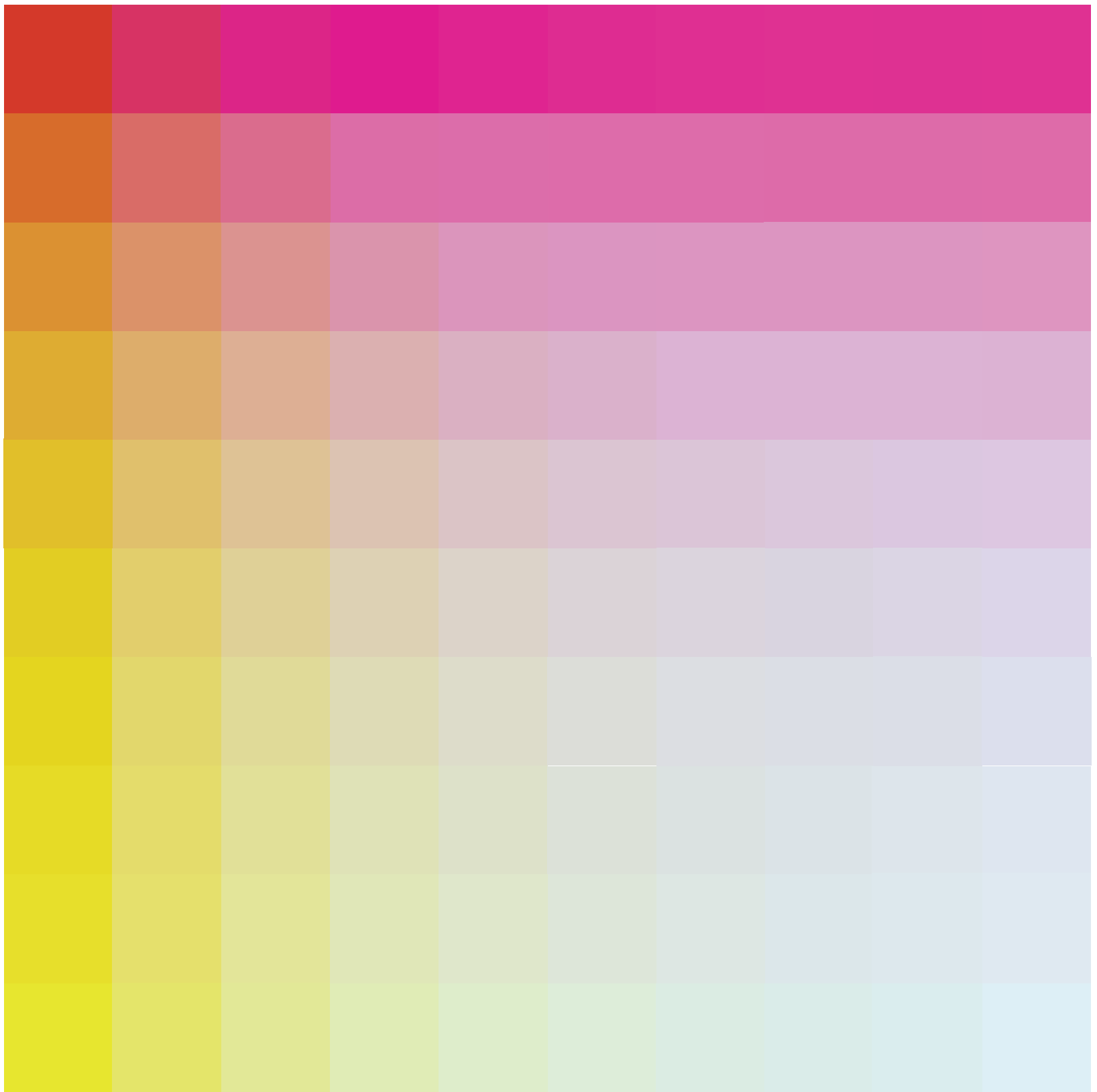


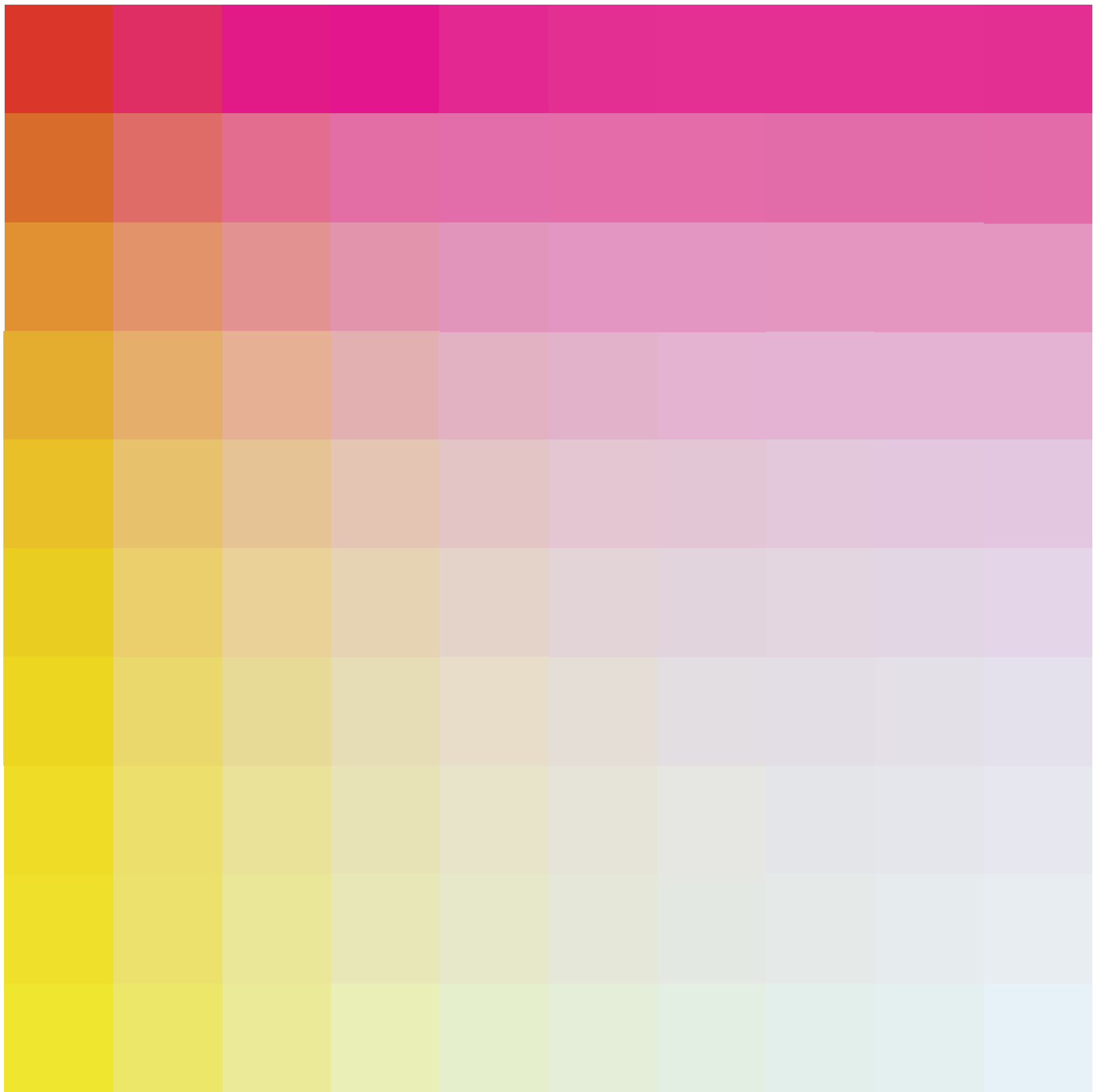


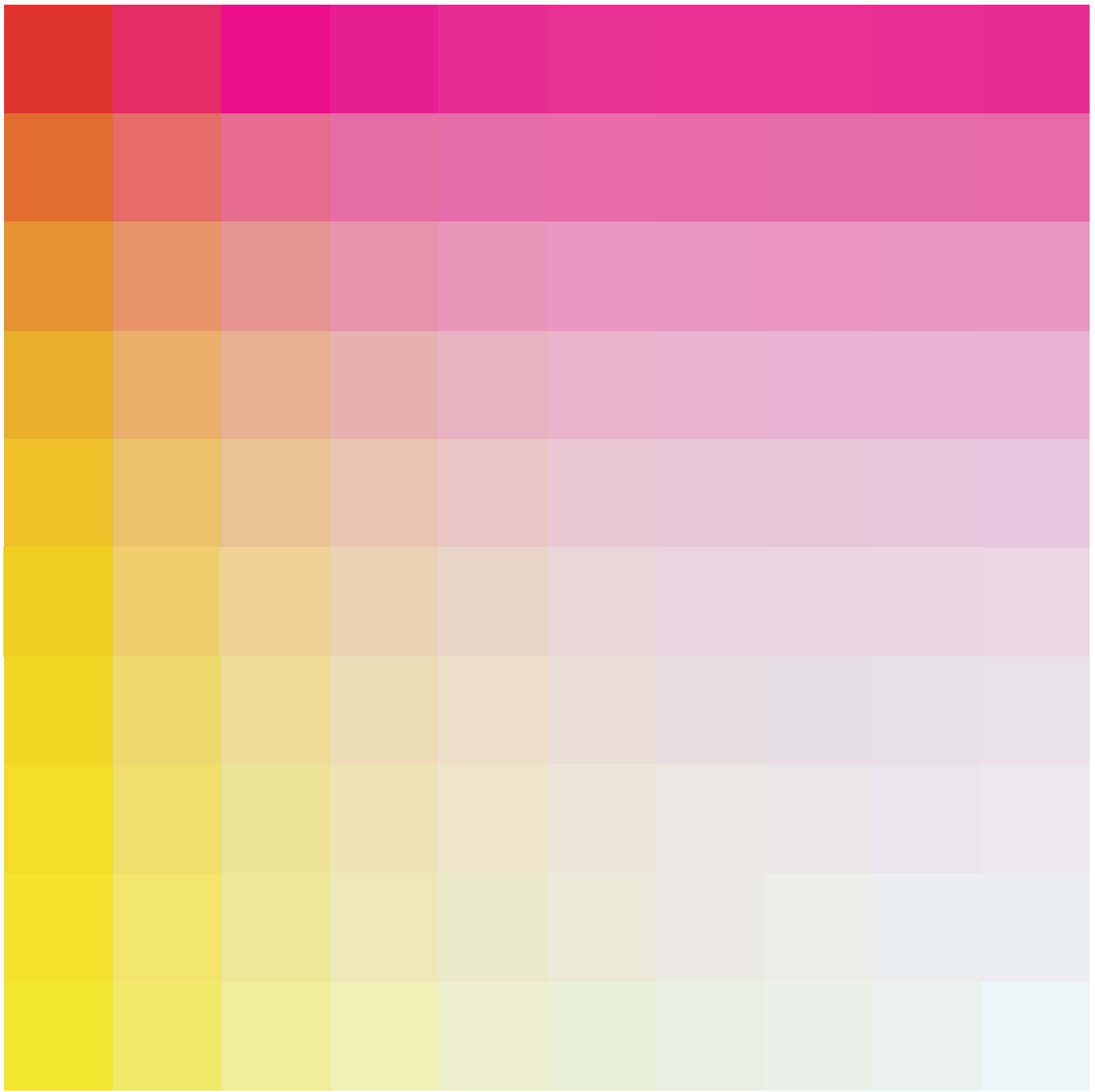


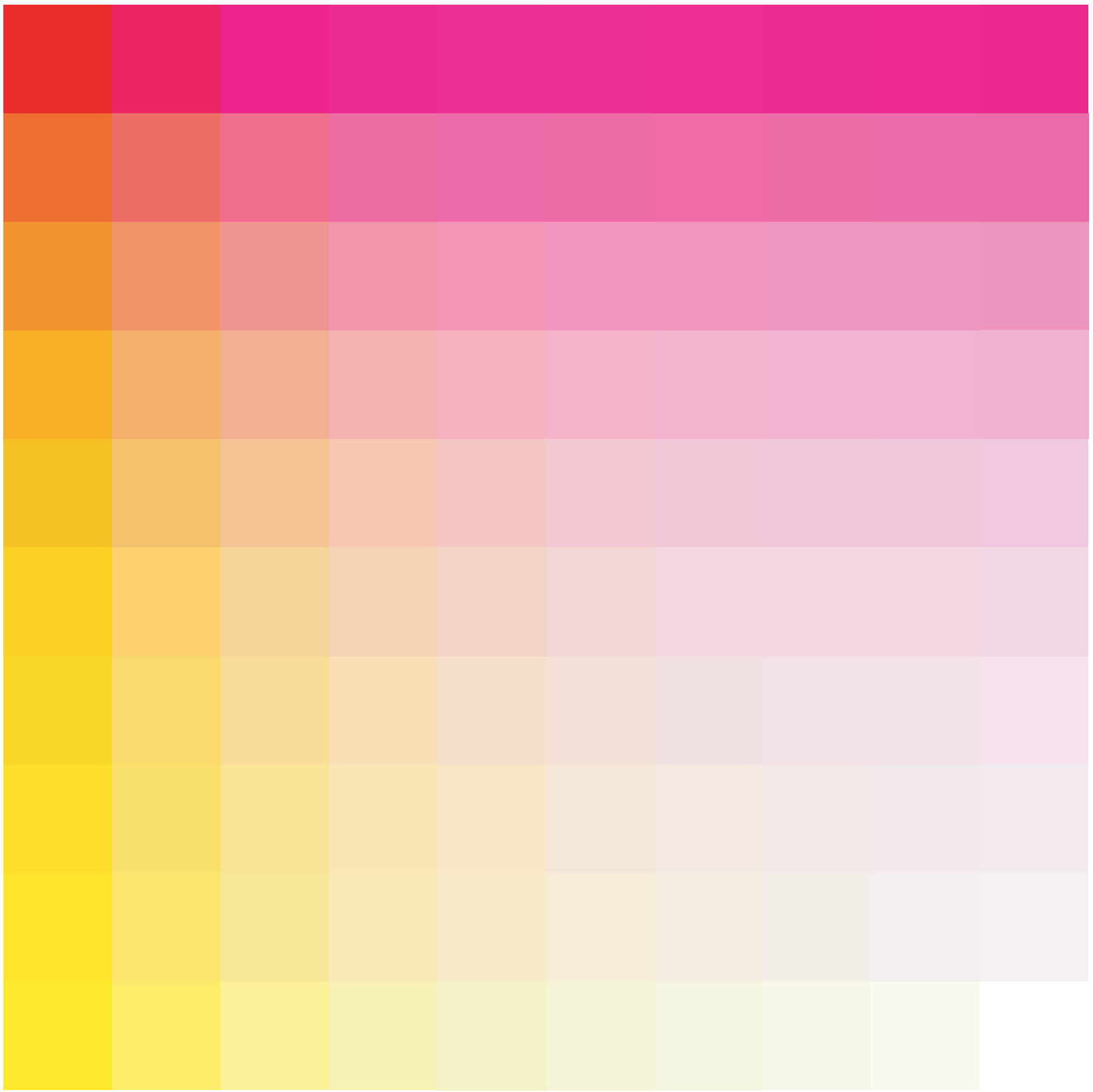


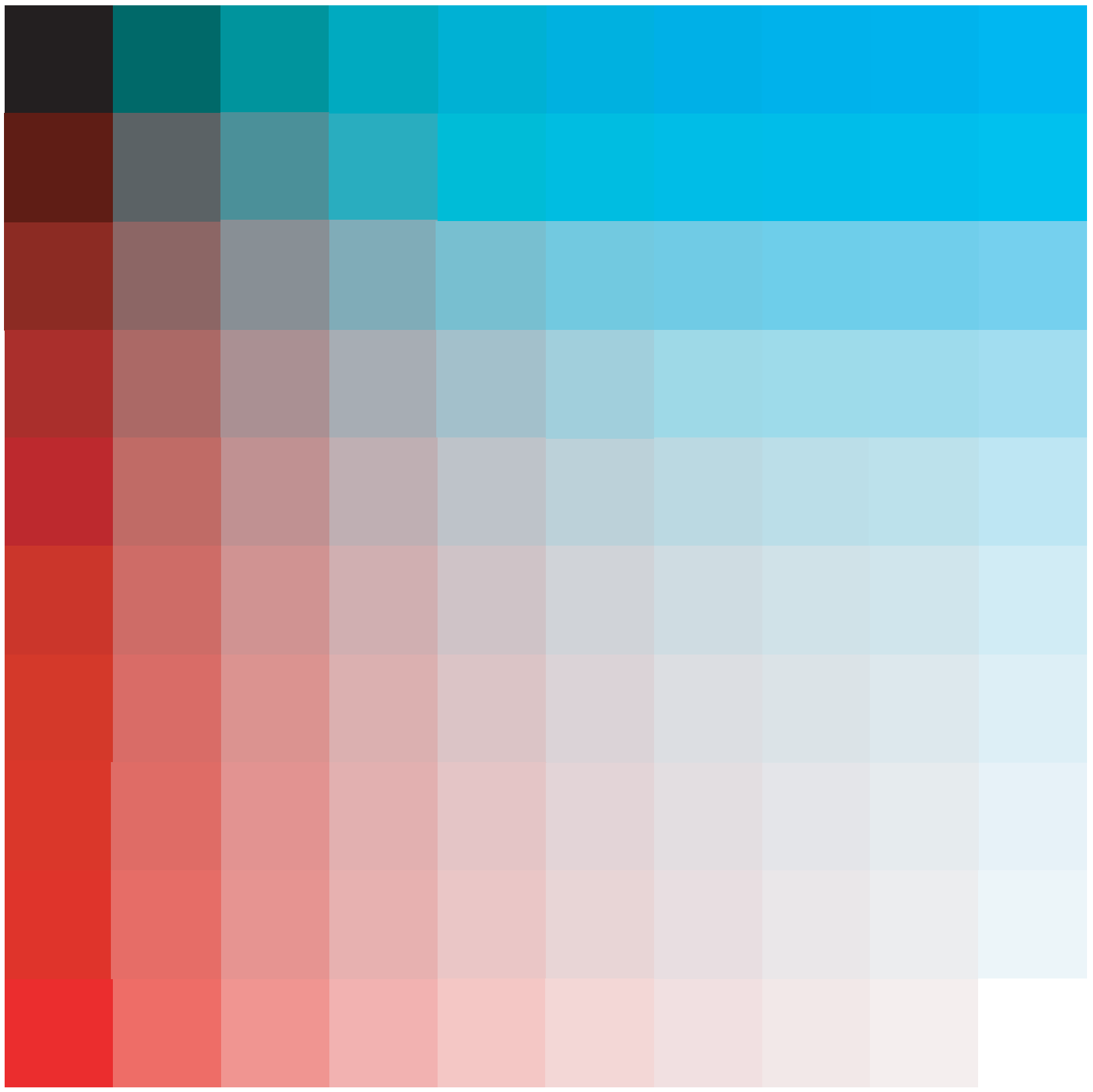












mid tones
system II