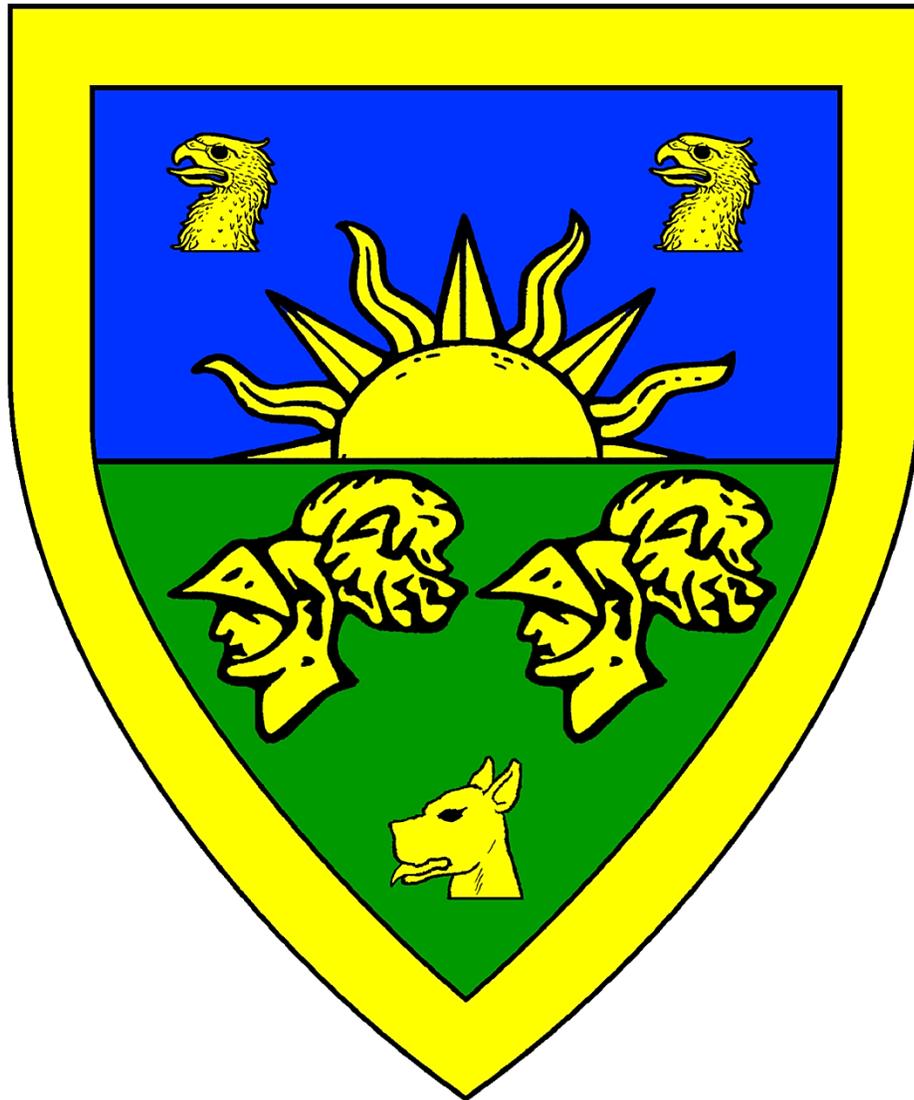


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Currents of Mechanical Thought:

The Clock of the Nations and its Antecedents, 800–1962

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DEDICATION.

This work is dedicated to my mother and father,
consiliatrix et magister,
and to my four grandparents.

Ora pro nobis, Sanctus Albertus Magnus, mea patronus.

ACKNOWLEDGMENTS.

I thank my patient readers, Drs. Carl Davila and Katherine Clark-Walter, and the staff at Drake Memorial Library. The College at Brockport, State University of New York's Department of History allowed me to pursue the research topic of my own choosing, and I am grateful for this intellectual latitude. I thank Dr. Anne Macpherson, chair of the department, for her coordination. I also thank Mr. Nabil al-Rashdi of the Library and Information Technology Department for his extemporaneous translation of the Arabic inscription visible in the illustration of al-Jazari's castle clock, the thirty-third plate in E.R. Truitt's *Medieval Robots: Mechanism, Magic, Nature, and Art*.

Since many automata I cataloged have no historical or contemporaneous pictorial depictions, I thank Mr. Matthew Simon Ryan Cavalletto, who permitted my use of a heraldic image repository he and his colleagues have assembled from pre-Modern, Early Modern, and contemporary sources. Recourse to this repository allowed the conventionalization of visual representations for automata in this document. Although Mr. Cavalletto's permissions obviated a need for images specific to every identified automaton or automaton-bearing device, I nevertheless thank Dr. E.R. Truitt; Mr. Mark Elling Rosheim; Dr. Thomas Ditzinger, a representative of Springer, Mr. Rosheim's publisher; and Dr. Philip Butterworth. Each graciously provided usage permissions for images in their respective publications and/or suggested external resources, such as the National Library of France. While the final realization of my work does not include these images, I will remember these permissions if I should ever host the contents of the thesis' largest appendix, which offers the sum of research undertaken for this project, on a website.

I thank Dr. Leandra Bedini of UNC Greensboro; Elizabeth King; Caitlin Wilson, Lead Associate Editor of the online journal *Blackbird* at Virginia Commonwealth University; and all others who have corresponded with me regarding this project. Everything I have done has necessarily been based upon information, and I appreciate all provisions of the same. If anyone has in some way supported this project and been omitted from these acknowledgements, they too receive my gratitude.

STATEMENT OF INTELLECTUAL INTEGRITY.

I, Christopher Patrick Pursel, MSIS, do hereby state that this work, “Currents of Mechanical Thought: The Clock of the Nations and its Antecedents, 800–1962,” is solely my own contribution. Any similarities to other scholarly works are coincidental, and all such works reviewed during the research underlying this master’s thesis have been duly referenced, when necessary and/or appropriate, pursuant to conventions of the Chicago Manual of Style. Further, I wish to state that I neither used artificial intelligence software of any kind, including generative artificial intelligences, nor any other computer automation software in the composition of this thesis document and its appendices. Accordingly, any errors or omissions are my exclusive responsibility.

ABSTRACT.

This master's thesis posits seven currents of thought applicable to pre-Modern and Early Modern automata. All currents of thought and evidentiary automata were conceived in the years 476–1650 CE per the thesis' contentions, research, and scheme of periodization. It regards "automata" as works of technology with figural, biological designs. The proposed currents are interpreted through identification and discussion of automata dating from the noted eras. This thesis includes a catalog of pre-Modern and Early Modern automata drawn from consulted resources, with each entry interpreted according to the thesis' argumentation. English-language scholarship comprised the work's research base.

KEYWORDS.

- 01.** History.
- 02.** Automata.
- 03.** Robots.
- 04.** Pre-Modern.
- 05.** Medieval.
- 06.** Early Modern.
- 07.** Renaissance.
- 08.** Technology.
- 09.** Culture.
- 10.** Ideas.

MAIN TEXT.

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“It’s against my programming to impersonate a deity.”

--- Anthony Daniels playing C-3PO, a brazen-colored android, in the film *Return of the Jedi*, as theatrically released in the year 1983.

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INTRODUCTION.

In 1962, *The Clock of the Nations* was installed at Midtown Plaza in Rochester, New York. This device continued to operate until 2008, when its shopping center was permanently closed, and it was then displayed at the Rochester International Airport before disassembly and placement in storage.¹ *The Clock of the Nations* contained numerous automata, moving figurines intended to represent the ethno-national identities of twelve immigrant groups who had settled in the city of Rochester. Every hour, these automata were revealed dancing and gamboling, in vignettes complete with painted backgrounds, when one of twelve protruding capsules housing each “nation” opened and then rotated with the others around a central column decorated with tilework, surmounted by four clock faces, and crowned by mobile, sculpted birds circling the top. This action continued throughout the hours of each day until every capsule displayed its automata at noon.

Some years later, in 1977, a revolving restaurant named The Changing Scene opened in the twenty-first and highest story of the First Federal Plaza building, also in Rochester, New York. Situated in a saucer-shaped extension atop the square skyscraper, this establishment would remain open for business until only 1988, with the twenty-first floor subsequently remodeled as offices. Patrons dined on a ten-foot ring that rotated past bays of windows, furnishing a commanding view of metropolitan Rochester and its surroundings.² Rochesterians who visited The Changing Scene may not have known in those years that they were participating in a conceptual tradition extending back to the Emperor Nero’s *Domus Aurea*, a building which likewise contained a rotating dining and observation deck.³ This architectural tradition survived into the European Middle Ages and beyond, at least conceptually, for The Changing Scene was not the only restaurant of its type to exist in the twentieth century.

More recently, in 2015, E.R. Truitt published *Medieval Robots: Mechanism, Magic, Nature, and Art*, the first scholarly, book-length treatment in English of automata in the Middle Ages as a subject unto itself. This work made extensive use of *Le Pèlerinage de Charlemagne*, a medieval romance, to offer insights on cultural conceptions of technology which underlie the representations of artificial beings in works of medieval fiction. *Le Pèlerinage* contains many instances in which

¹ See reportage by Pat Taney, WHEC-TV, News 10, Rochester, New York, published online by that television station as a digital video file with accompanying text under the title “Good Question: What happened to the Clock of Nations?” on August 12, 2019: <https://www.whec.com/news/good-question-what-happened-to-the-clock-of-nations/5454478/>.

² See reportage by Alan Morrell, freelance contributor to the *Democrat and Chronicle*, newspaper of record for the Rochester, New York region, published online by that newspaper with accompanying archival photographs under the title “Whatever Happened to... The Changing Scene?” on November 22, 2013: <https://www.democratandchronicle.com/story/lifestyle/rocflavors/2013/11/22/whatever-happened-to-the-changing-scene-/3682233/>.

³ See reportage by Marta Falconi, Associated Press writer, published online by the Associated Press with an accompanying photograph under the title “Nero’s rotating banquet hall unveiled in Rome” on September 29, 2009: <https://phys.org/news/2009-09-nero-rotating-banquet-hall-unveiled.html>.

technology is described, but the two often discussed by Truitt are the fictive Emperor Hugo's rotating throne room in this *chanson de geste*'s fantastical Constantinople, and that chamber's figural automata.⁴ Authors who treated the topic of automata in medieval literature prior to Truitt likewise emphasized these two wonders when discussing *Le Pèlerinage*.⁵

While none may have been aware of these key commonalities, the inhabitants of Rochester, New York in the years 1977–1988 were living in a city that could be construed as a realization of *Le Pèlerinage de Charlemagne*'s Constantinople. The Changing Scene was a restaurant, not a throne room, but it was certainly a visual locus of power and prestige within the city; and while *The Clock of the Nations*, with its numerous automata, was not situated inside The Changing Scene at the First Federal Plaza, but in the indoor concourse of Midtown Plaza, these plazas' close proximity in the center of Rochester allows amalgamation of their urban spaces for argumentative purposes.

Further, and more importantly, a person of the Middle Ages or Renaissance could recognize The Changing Scene's mechanical revolution and *The Clock of the Nations*' mechanical automata as intelligible articles of technology. A mechanician of these eras would be impressed by *The Clock of the Nations*' twelve displays of automata, and automaton birds, when it was unveiled in 1962. This *Clock* was an article of midcentury modernity that partook of "currents of mechanical thought" first articulated in the Classical Roman period, as with the Emperor Nero's own "changing scene," re-articulated through the Middle Ages' intervening lens and given newfound articulations in those ages, and then articulated anew in the Renaissance. *The Clock of the Nations* modernized and presented these currents of mechanical thought to the twentieth-century inhabitants of Rochester, NY as a spectacular achievement. Thus, *The Clock of the Nations* had a distinctly pre-Modern and Early Modern lineage, and it existed as an outgrowth of medieval and Renaissance intellectual culture.

As in Truitt's work, the example of Emperor Hugo's palace is used as an entrance to the topic of pre-Modern and Early Modern automata, but different approaches to the consideration of such automata as a historical phenomenon in literary and material culture will apply. Among these distinctions will be the parameters which define an automaton. Neither the Emperor Hugo's palace nor The Changing Scene, two rotating buildings, are regarded as automata, though *The Clock of the Nations*' figurines, and their early antecedents, are so regarded. Now, let us travel through history, span the fall of Rome to the English Civil War, and return in time to see *The Clock of the Nations* at its end, much as we have seen it at its beginning.

⁴ As a building, the fictitious palace in Constantinople and its rotating throne room are not considered automata in this work because no living organisms are represented as three-dimensional figures, or as figures in relief, by the building itself. For the automata in Emperor Hugo's throne room, see data presented by entry "II-006" in the thesis' appendices.

⁵ See Secondary Sources 2–5 under entry "II-006" in the thesis' appendices.

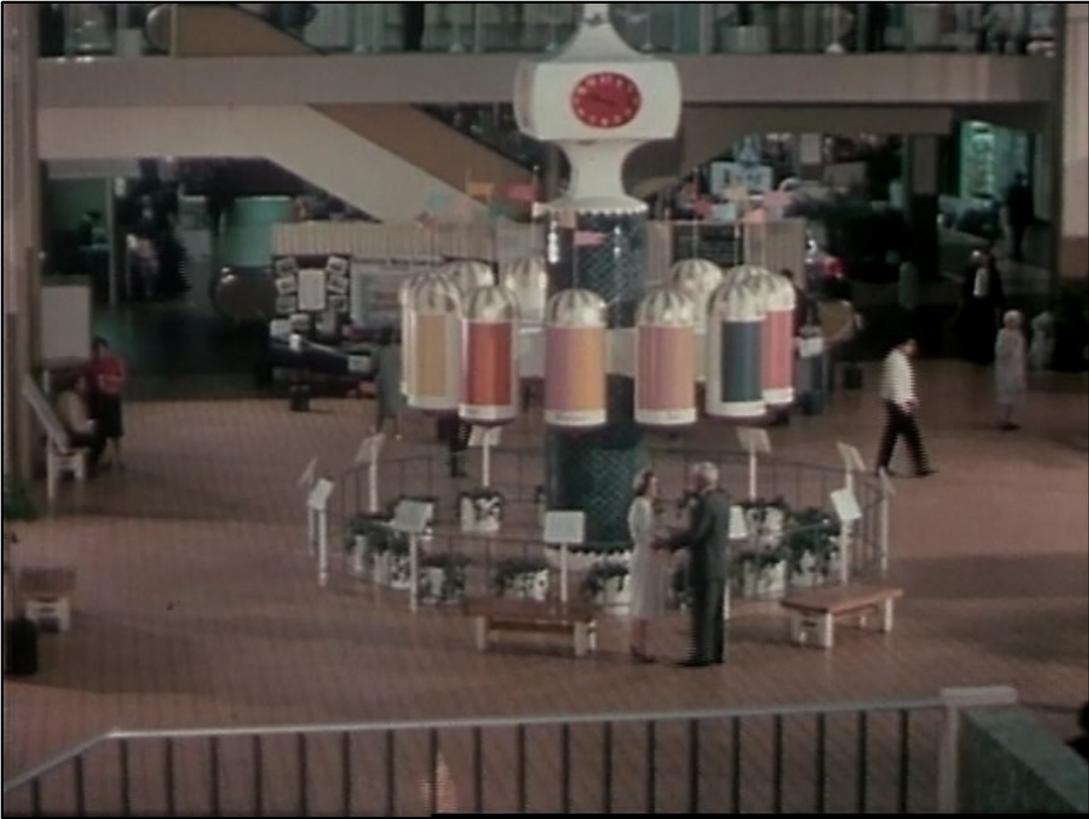


Figure I: *The Clock of the Nations* as it existed in 1963, shown with its capsules closed and with distant visual framing; 00:30/27:15.

The above image is a still frame captured from *Rochester: A City of Quality*, a short film produced by the Rochester Gas and Electric Corporation and released in 1963 to promote business investment in Rochester, New York. The actor and actress shown standing before *The Clock of the Nations* in Midtown Mall's lobby, who arrive separately, subsequently reappear as seated spectators bearing expressions of amused awe in a brief shot moments after this introductory scene. Note that the twelve capsules containing automata, which are termed "electronically-controlled marionettes" by the film's male narrator, are all closed, indicating that no chime is sounding. Also note that in this view from 1963, and only in this figure corresponding to that year, the automaton birds atop the clock are barely visible, including one seen moving over the peaked area of the white assembly which houses the clock's four faces. The copy of *Rochester: A City of Quality* used to produce the above image, and Figures II–IV, has been made available via the Internet Archive by the Prelinger Archives of San Francisco, California, which digitized this work as a standard-definition video file (VGA, 640 pixels by 480 pixels). During playback of this copy in the .MP4 file format on a high-definition computer monitor (1080p, 1920 pixels by 1080 pixels), the above image was captured with dimensions of 1440 pixels by 1080 pixels, downscaled to the native VGA resolution, and then reduced 15% in size to fit the effective page margins, as were the images for Figures II–IV. In the copy of *Rochester: A City of Quality* used to create Figures I–IV, which includes a five-second title card from the Prelinger Archive, Figure I is visible 30 seconds into the short film, which has a total duration of 27 minutes and 15 seconds. Note that all images from *Rochester: A City of Quality* are in the public domain.

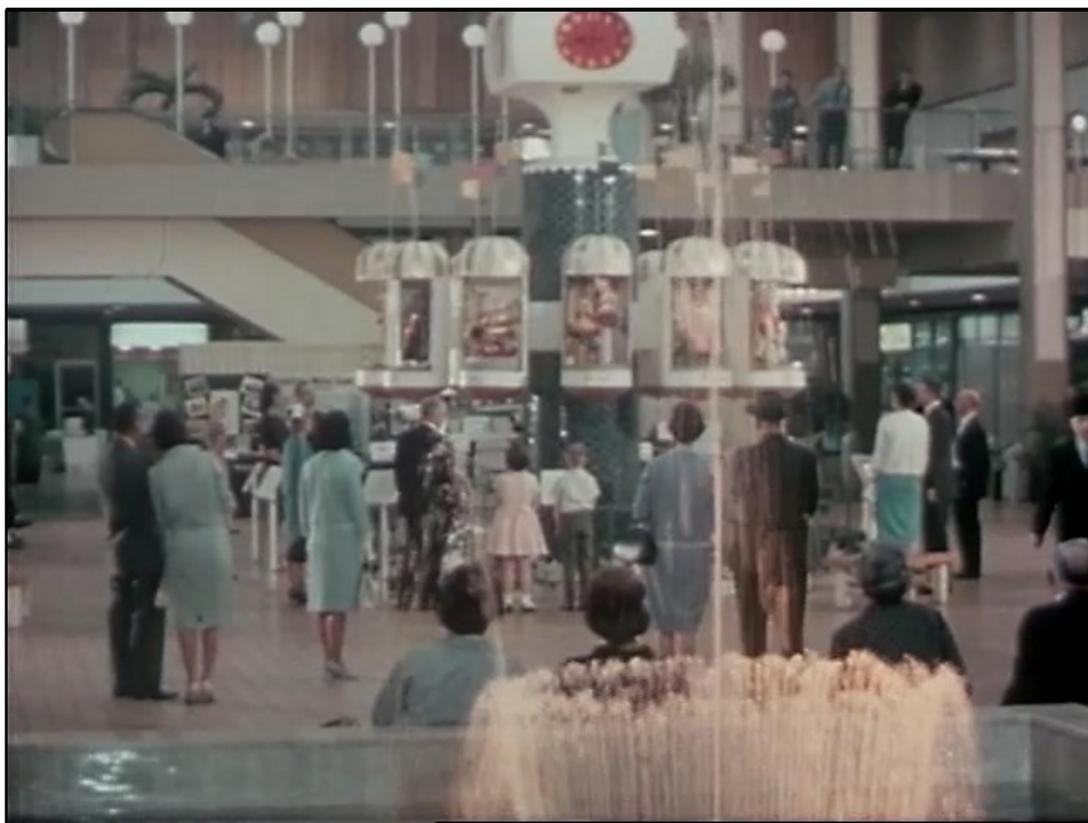


Figure II: *The Clock of the Nations* as it existed in 1963, shown with its capsules opened and with distant visual framing; 00:45/27:15.

Here, a view is afforded at sufficient distance to show *The Clock* in operation, providing an impression of its spectacle for visitors to Midtown Mall. Note that in the above image, unlike Figure I, automaton birds above the clock faces are not visible, as the full device extends beyond the field of view to a greater degree than in that figure. The presence of a fountain near *The Clock*, despite the ubiquity of this feature in late-twentieth century shopping mall architecture, is of interest, as fountains typically accompanied automaton-bearing devices installed in the courts, palaces, and estates of high nobles in Western Europe (e.g., the Kingdom of France) and in the Near East (e.g., the Byzantine Empire and the 'Abbasid Caliphate). What unites the pre-Modern/Early Modern and Modern/Postmodern tendencies to position automata and fountains in close proximity is the associations both have historically held with luxury as expensive species of material culture, with leisure as technologies typically requiring refined technical knowledge and craftsmanship, and therefore patrons at liberty to expend time appreciating and enjoying the fruits of costly, lengthy, labor-intensive projects, and ultimately, with the suggestion of mastery over forces of the natural world. In making these contentions, the work of al-Jazari is relevant, as he specifically instructs that certain automaton-bearing devices be emplaced near pools and fountains in his work, *The Book of Knowledge of Ingenious Mechanical Devices*, which also contains a distinct chapter on building fountains and structures related to the operation of hydraulic displays. Sharon Farmer's work on the medieval aristocratic estate at Hesdin is also relevant to this point, as she discusses how the artificiality of the landscape carefully maintained at that site can be construed as an expression of the noble occupants' prerogatives, or in a word, their power.

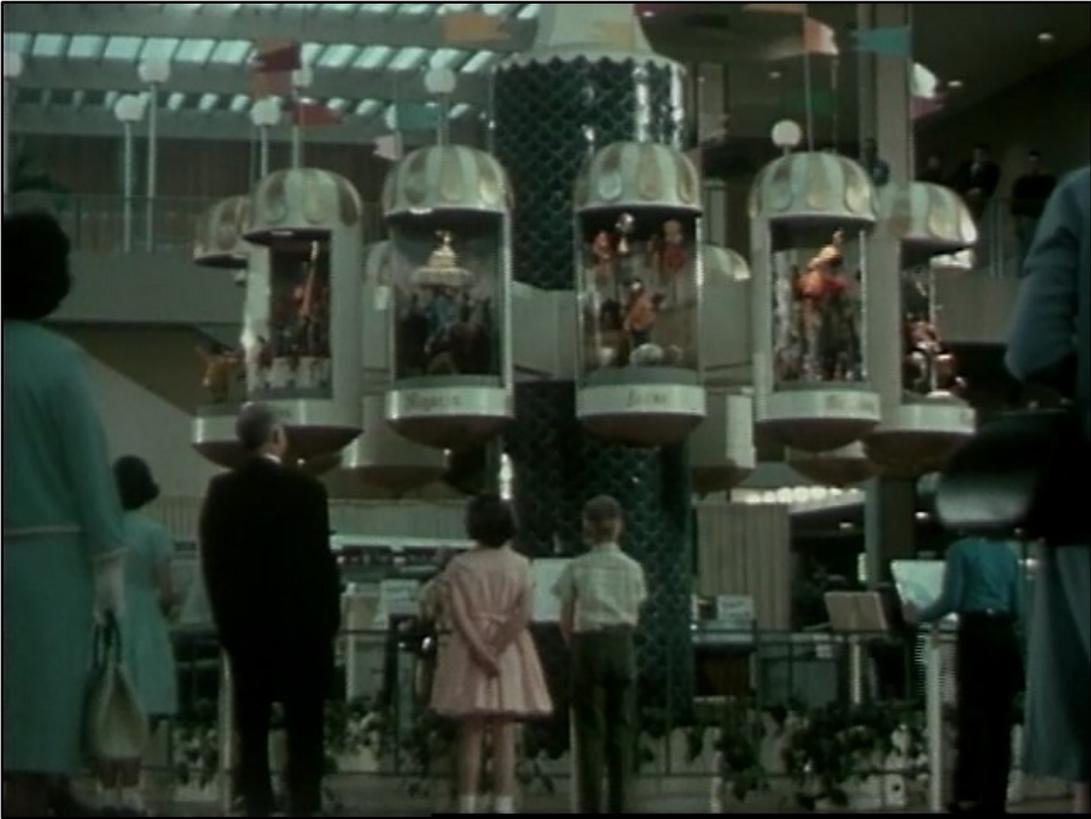


Figure III: *The Clock of the Nations* as it existed in 1963, shown with its capsules opened and with moderate visual framing; 1:00/27:15.

Following from remarks for Figure II, it should be established that Midtown Mall was one of the first examples of an enclosed, indoor commercial space, or “mall” as the term is popularly understood, to exist in the United States, and that its fountains, which were emulated by many later malls, must thus have been intended to evoke still earlier spaces which, as the thesis contends, were those of the pre-Modern/Early Modern worlds. While fountains became a clichéd mainstay of mall corridors, automaton-bearing devices like *The Clock of the Nations* did not attain this same commonality, and this divergence is attributable to the monumentality of every public automaton-bearing device, now, in the twentieth century, and in the distant pre-Modern and Early Modern past, as every such device is an installation which demands skillful preparation for complete accomplishment. In the above image, a better sense of scale is suggested, for rather than a view from one of Midtown Mall’s stairwells, or from within the recess of a fountain, this shot appears to have been filmed from a sedentary position on one of the public lobby benches. As is evident, *The Clock* is rather large, with the bases of the automata capsules higher than the heights of the adults to the left and right sides of the foregrounded pair of children, who symbolize a future “of quality.” The capsules, too, appear taller than the average adult height, although the figural automata they contain are scaled with sizes smaller than the living organisms each depicts. Further, the automata are not very naturalistic and/or realistic, having the bright colors, abstraction, and minimalistic conventionalization which are hallmarks of the self-assured Mid-Century Modern aesthetic. Yet taken as a whole, *The Clock* has an element of fantasy, of romance, for pennants fly from each domed capsule, and the central column is in *zellij* tile.



Figure IV: *The Clock of the Nations* as it existed in 1963, shown with its capsules opened and with close visual framing; 1:00/27:15.

In the above image, the child actor and actress featured in the opening scene of *Rochester: A City of Quality*, and who are contrasted in that work with the mature man and woman seen in Figure I as a means to emphasize the appeal of Rochester, New York, Midtown Mall, and *The Clock of the Nations* to both young and old, marvel at the capsule corresponding to The Hour of the Nation of Japan, one of the twelve capsules which rotated about the central column. Note that “Japan” is written in gold calligraphic script beneath the capsule’s opened door, unambiguously identifying the represented nation. A swaying automaton figure of what is ostensibly a Kabuki performer in traditional *oshiroi* makeup moves within the capsule, “encapsulating,” for *The Clock’s* audience, the cultural achievements of the Japanese people. The reduction of each “nation” to a single display not necessarily endorsed or authorized by any respective representatives thereof, even granted that a “nation,” as conceived in *The Clock’s* design, could possibly appoint a cultural spokesperson, is the primary reason this “fabled timepiece,” to use the male narrator’s phrase from *Rochester: A City of Quality*, may now be considered insensitive, and even offensive in its naïve simplicity. It is now something of another time, but in the thesis’ opinion, it remains an artifact of tremendous significance to the local history of metropolitan Rochester, New York, and indeed, to general horological history. As such, it is fully deserving of professional curation and conservation work by trained specialists in a museum environment, a sentiment shared by the municipal government of Rochester, New York at the present time. Finally, note that the tessellating *zellij* tilework of the central column, in a blue suggestive of antique lapis lazuli, is clear in the above image; it obliquely represents the Islamic contribution to horological science.

STATEMENT OF SCHOLARLY CONTRIBUTION.

As an exercise in the application of a new typological system proposed by this thesis, a catalog of pre-Modern and Early Modern automata has been prepared. All cataloged automata were originally conceived by their describers, designers, and builders in the interval dating from Saturday, January 1, 477 CE to Tuesday, December 31, 1650 CE. To organize this catalog, the scholarship of Minsoo Kang was consulted. In his book *Sublime Dreams of Living Machines: The Automaton in the European Imagination*, Kang proposes four types of medieval automata: the first, “fictional and of otherworldly origin;” the second, “fictional and of human manufacture but involving some form of magic;” the third, “of actual human construction or design;” and the fourth, “speculative.”⁶

Using Kang’s existing typology, discrete automata have been systematically identified. This project represents the first known attempt to catalog pre-Modern and Early Modern automata using methodological practices in data science, and as a novel development, it cannot be characterized as a simple recapitulation of others’ scholarship. Bibliographic information for the cataloged automata is included in this document, and a controlled vocabulary for various attributes of these devices has been implemented.

No other author known to this thesis has used Kang’s existing typology in a survey of pre-Modern and Early Modern automata, nor undertaken such a survey to elaborate a new typological level hierarchically subordinate to Kang’s system, nor produced standardized documentations for historical automata in such an elaboration. The thesis’ proposed typological level furthers the organization of information concerning species of material culture, namely pre-Modern and Early Modern automata, which are or ought to be of equal interest and value to studies of medieval history as any exemplars of historical objects in the fictional or non-fictional primary sources of the given periods.

Within these historical pre-Modern and Early Modern contexts, automata were works of high technology; achievements comparable to the realizations of complex musical instruments, such as organs and hurdy-gurdies; and were often elements of spectacular displays, like the public fountains mentioned in Figure II’s commentary.⁷ In fact, automata accompanied or were included in the designs of

⁶ See Minsoo Kang, *Sublime Dreams of Living Machines: The Automaton in the European Imagination* (Cambridge, MA: Harvard University Press, 2011), 61.

⁷ For a fictitious automaton which plays the hurdy-gurdy, and which is thus a sentient mechanical being playing a non-sentient mechanical instrument, in addition to eleven other instruments, see pre-Modern/Early Modern automaton “II-010” in the thesis’ appendix. For automata built into or in conjunction with the operation of organs, many examples exist. Three of the more spectacular are the famed automaton-laden organ sent to Sultan Mehmed III of the Ottoman Empire under the patronage of Queen Elizabeth I of England in 1599, which is no longer extant, the organ dated 1557 at the Abbaye de Saint-Savin-en-Lavedan, featuring three mask-like faces here considered demi-humanoid automata and extant in the Hautes-Pyrénées, and the automaton figures connected to the organ of Strasbourg Cathedral, including the notorious Pretzel-Man, which are, of course, extant. The fictitious musician and two real-world organs mentioned in this footnote will be discussed, together with the

organs and fountains, especially when the act of “making special” was intensified by association with the gifts or courts of monarchal authorities.⁸ Since the pre-Modern and Early Modern periods have few popular associations with STEM topics, studying automata derived from the scientific and technological knowledge of those periods allows historians to pose research questions typically advanced for later historical eras. Opportunities are also so afforded to apply STEM research methods to objects from the distant past, as have Mark Elling Rosheim and Nadia Ambrosetti.⁹

Study of the pre-Modern and Early Modern automaton demonstrates the interrelatedness of intellectual, artistic, and craft histories within these periods of interest. The scientific and technological achievements of the pre-Modern and Early Modern worlds may be emphasized by presenting a specific material-cultural category which includes both both fictive extrapolations from real objects and the bases of these representations, the real objects themselves. In the case of automata, extant examples do exist, and the comparative study of both actual and fictive instances is therefore possible, although fictitious examples remain independently valuable as source evidence.

Awareness of the pre-Modern and Early Modern automaton reframes medievalism as a pursuit complementary to the STEM disciplines by situating familiar STEM elements, such as the technologies of robotics and animatronics, within unexpected historical settings. The resultant confluence of historical, historically scientific, and contemporaneously scientific thought affords a space in which STEM enthusiasts may cultivate an appreciation of history, and in which historians may reconsider the prevalence of robotic and animatronic technologies in the pre-Modern and Early Modern worlds.

other three hundred and sixteen identified automata or automaton-bearing devices, and including those named in footnotes eight and nine, under subsequent sections.

⁸ See Ellen Dissanayake, *What is Art For?* (Seattle, WA: University of Washington Press, 1988), 92–101, to learn the meaning of the phrase “making special.” An instance of an automaton-bearing device given as a gift from one reigning monarch to another is named in the prior footnote. Even when not used as diplomatic gestures, fictitious and non-fictitious pre-Modern and Early Modern automata usually appeared within the courtly culture of the nobility, including nobles in holy orders, or even at the direct behest of a specific aristocrat; but then, so did most known expressions of meaningful intellectual, literary, and visual culture during these periods. This inescapable fact does not negate the worth of pre-Modern and Early Modern automata as a topic of scholarly inquiry, and it cannot itself diminish the qualities of automata or automata-bearing devices of these eras. Each was and is a precocious imagining in the history of ideas in literature, or instead a precious achievement wrought by strenuous effort in material culture. An example of an automaton-bearing device built near a fountain is al-Jazari’s *Water-Clock of the Peacocks*, described in the sixth chapter of *The Book of Knowledge of Ingenious Devices*’ first category.

⁹ See Nadia Ambrosetti, “Cultural Roots of Technology: An Interdisciplinary Study of Automated Systems from the Antiquity to the Renaissance” (PhD diss., University of Milan, 2010) for applications of Universal Modeling Diagrams to pre-Modern and Early Modern automata. Also see Mark Elling Rosheim, *Leonardo’s Lost Robots* (Berlin, DE: Springer, 2006); Rosheim, a roboticist, engineer, and later-day fountaineer, applies his technical expertise to elucidate plans for specific automata sketched in several of Leonardo da Vinci’s preserved notebooks.

LITERATURE REVIEW.

This review mostly presents textual sources containing the automata which comprise the body of evidence underlying its typological elaboration. These are categorized as either general or specific, and rationales for each categorical placement are provided. Certain other sources have been noted argumentatively, and each is appropriately cited.

Sherwood's 1947 article "Magic and Mechanics in Medieval Fiction," Bowie's 1959 translated edition of *The Sketchbook of Villard de Honnecourt*, Reid's 1958 translation of Chapuis and Droz's monumental volume *Automata: A Historical and Technological Study*, and de Solla Price's 1959 article "On the Origin of Clockwork, Perpetual Motion Devices and the Compass" are all grouped as general works.¹⁰ Two articles from the Winter 1964 issue of *Technology and Culture* specifically concerned with automata, Bedini's "The Role of Automata in the History of Technology" and de Solla Price's "Automata and the Origins of Mechanism and Mechanistic Philosophy," are likewise considered general, with Bedini's output an early attempt to catalog automata.¹¹ A later cataloging effort is made by Riskin in her article "Machines in the Garden," which improves upon Bedini's work.¹²

Hill's 1974 translation of Ibn al-Razzaz al-Jazari's *Book of Knowledge of Ingenious Mechanical Devices* is considered general in that its automata are presented for manifold purposes in a broader assemblage of technological apparatuses, much as in de Honnecourt's album.¹³ Olivé's brief article on al-Muradi's *Manuscript of Clocks* is similarly general because al-Muradi's treatise also documents, in chapters 21–26, how to construct "war machines and water pumps," besides timekeeping devices without figural automata in chapters 8, 9, 29, and 31; the thirty-first and final chapter describes sundials.¹⁴ The two treatises by al-Jazari and al-Muradi are not the only primary sources with automata which remain extant from the medieval Islamic world

¹⁰ See Merriam Sherwood, "Magic and Mechanics in Medieval Fiction," *Studies in Philology* 44, no. 4 (October 1947): 567–592; Villard de Honnecourt, *The Sketchbook of Villard de Honnecourt*, ed. and trans. Theodore Bowie (Bloomington, IN: Indiana University Press, 1959); Alfred Chapuis and Edmond Droz, *Automata: A Historical and Technological Study*, trans. Alec Reid (Neuchâtel, CH: Éditions du Griffon, 1958); Derek J. de Solla Price, "On the Origin of Clockwork, Perpetual Motion Devices and the Compass," *Bulletin of the United States National Museum* 218 (1959): 81–112.

¹¹ See Silvio A. Bedini, "The Role of Automata in the History of Technology," *Technology and Culture* 5, no. 1 (Winter 1964): 24–42; Derek J. de Solla Price, "Automata and the Origins of Mechanism and Mechanistic Philosophy," *Technology and Culture* 5, no. 1 (Winter 1964): 9–23.

¹² See Jessica Riskin, "Machines in the Garden," *Republics of Letters: A Journal for the Study of Knowledge, Politics, and the Arts* 1, no. 2 (April 30, 2010): 16–43.

¹³ See Ibn al-Razzaz al-Jazari, *The Book of Knowledge of Ingenious Mechanical Devices*, ed. and trans. Donald R. Hill (Dordrecht, NL: D. Reidel Publishing Company, 1974); *The Sketchbook of Villard de Honnecourt* is documented in footnote ten.

¹⁴ See Eduard Farré Olivé, "The Clepsydra of the Gazelles, from *The Manuscript of Clocks*, by al-Muradi," *Arte y Hora* n. 128H11 (March–April 1998): 10–18.

in whole or part. The Banu Musa's treatise was read in this thesis' research, and it is another important source for pre-Modern automata and general technological works.¹⁵

Kang's 2011 book *Sublime Dreams of Living Machines: The Automaton in the European Imagination*, which introduced an organizational system with four types, and Truitt's 2015 book *Medieval Robots: Mechanism, Magic, Nature, and Art*, which does not use Kang's typology, are also general, as both discuss automata by situating these devices within broader culture and do not focus on the devices themselves.¹⁶ Pickover's 2019 coffee-table book *Artificial Intelligence: An Illustrated History: From Medieval Robots to Neural Networks* instead presents automata on an instance-by-instance basis, although it spans all recorded history, presenting not only pre-Modern and Early Modern automata, but many other developments in the cultural and technological histories of computer science, mathematics, formal logic, etc. with the brevity and superficiality necessitated by this genre.¹⁷

Works written to discuss automata and other topics in the histories of science and ideas from specific primary sources include Flowers Braswell's 1985 article "The Magic of Machinery: A Context for Chaucer's 'Franklin's Tale,'" Sullivan's 1985 article "Medieval Automata: The 'Chambre De Beautés' in Benoît's Roman de Troie," and O'Brien's 1990 article "'Ars-Metrik:' Science, Satire, and Chaucer's Summoner."¹⁸ Tally Lionarons' 1993 article "Magic, Machines, and Deception: Technology in the 'Canterbury Tales,'" like Flowers Braswell and O'Brien's articles, specifically discusses automata which either relate to *The Canterbury Tales* or are present in that canonical work.¹⁹ Although its primary subject is not considered an automaton by this thesis, Fliegel's 2002 article "The Cleveland Table Fountain and

¹⁵ See the Banu Musa (Muhammad, Ahmad, and al-Hasan, the sons of Musa bin Shakir), *The Book of Ingenious Devices*, translated and annotated by Donald R. Hill (Boston, MA: D. Reidel Publishing Company, 1979).

¹⁶ See Minsoo Kang, *Sublime Dreams of Living Machines: The Automaton in the European Imagination* (Cambridge, MA: Harvard University Press, 2011), esp. Chapter 2, "Between Magic and Mechanics: The Automaton in the Middle Ages and the Renaissance," 55–102, with endnotes on 318–328; E.R. Truitt, *Medieval Robots: Mechanism, Magic, Nature, and Art* (Philadelphia, PA: University of Pennsylvania Press, 2015).

¹⁷ See Clifford A. Pickover, *Artificial Intelligence: An Illustrated History: From Medieval Robots to Neural Networks* (New York, NY: Sterling, 2019), esp. 12–25; note that Pickover's work contains some factual and interpretative errors, such as misstating the date "1574" as "1547" on page 21 (see, among other things, the frontispiece of this thesis), but in fairness to Pickover, Silvio A. Bedini was prone to this same misstep, as the latter author mangled "1598" as "1698" on page 27 of "The Role of Automata in the History of Technology."

¹⁸ See Mary Flowers Braswell, "The Magic of Machinery: A Context for Chaucer's 'Franklin's Tale,'" *Mosaic: An Interdisciplinary Critical Journal* 18, no. 2 (Spring 1985): 101–110; Penny Sullivan, "Medieval Automata: The 'Chambre de Beautés' in Benoît's *Roman de Troie*," *Romance Studies* 3, no. 2 (1985): 1–20; Timothy D. O'Brien, "'Ars-Metrik:' Science, Satire and Chaucer's Summoner," *Mosaic: An Interdisciplinary Critical Journal* 23, no. 4 (Fall 1990): 1–22.

¹⁹ See Joyce Tally Lionarons, "Magic, Machines, and Deception: Technology in the 'Canterbury Tales,'" *The Chaucer Review* 27, no. 4 (1993): 377–386.

Gothic Automata" nevertheless contains valuable presentations of automata, including a well-executed technical rendering of de Honnecourt's chantepleur.²⁰

On balance, specific treatments of automata outnumber general surveys. Other works drawn from specific primary sources include Rosheim's 2006 book *Leonardo's Lost Robots*; a brief presentation of one automaton described by Rosheim in Moran's 2006 article "The da Vinci Robot;" and King's 2002 article "Clockwork Prayer: A Sixteenth-Century Mechanical Monk."²¹ Much as a relationship exists between Rosheim's book and Moran's discussion of da Vinci, a similar relationship exists between Truitt's 2012 article "Celestial Divination and Arabic Science in Twelfth-Century England: The History of Gerbert of Aurillac's Talking Head" and *Medieval Robots*, Truitt's 2015 book, in that Truitt's elucidation of the intellectual history underlying the legend of Gerbert's brazen head likely influenced her later composition of *Medieval Robots*.²² Swift's 2015 article "Robot Saints" invites general application of its eponymous term, but it is mainly concerned with presentation of a specific automaton, *La Virgen de Los Reyes*, while Grafton's "The Devil as Automaton: Giovanni Fontana and the Meanings of a Fifteenth-Century Machine" specifically analyzes automata built by Fontana, a fifteenth-century engineer.²³

In some cases, discussions of automata as defined by this paper occur in works concerned with other historical subjects or with spatial sites tangential to this material-cultural category. Two articles in the 2017 volume *Medieval Theater Performance: Actors, Dancers, Automata and their Audiences*, Groeneveld's "'lyke unto a lyvelye thyng:' The Boxley Rood of Grace and Medieval Performance," and Butterworth and Williamson's "The Mechanycalle 'Ymage off Seynt Iorge' at St. Botolph's, Billingsgate, 1474," exemplify such discussions, as does Farmer's authoritative "Aristocratic Power and the 'Natural' Landscape: The Garden Park at Hesdin, ca. 1291–1302."²⁴ The entirety of *Medieval Theatre Performance* was

²⁰ See Stephen N. Fliegel, "The Cleveland Table Fountain and Gothic Automata," *Cleveland Studies in the History of Art* 7 (2002): 6–49.

²¹ See Mark Elling Rosheim, *Leonardo's Lost Robots* (Berlin, DE: Springer, 2006); Michael E. Moran, M.D., "Epochs in Endourology: The da Vinci Robot," *Journal of Endourology* 20, no. 12 (December 2006): 986–990; Elizabeth King, "Clockwork Prayer: A Sixteenth-Century Mechanical Monk," *Blackbird: An Online Journal of Literature and the Arts* 1, no. 1 (Spring 2002): https://blackbird.vcu.edu/v1n1/nonfiction/king_e/prayer_toc.htm.

²² See E.R. Truitt, "Celestial Divination and Arabic Science in Twelfth-Century England: The History of Gerbert of Aurillac's Talking Head," *Journal of the History of Ideas* 73, no. 2 (April 2012): 201–222; *Medieval Robots* is documented in footnote fifteen.

²³ See Christopher Swift, "Robot Saints," *Preternature: Critical and Historical Studies on the Preternatural* 4, no. 1, Special Issue: Animating Medieval Art (2015): 52–77; Anthony Grafton, "The Devil as Automaton: Giovanni Fontana and the Meanings of a Fifteenth-Century Machine," in *Genesis Redux: Essays in the History and Philosophy of Artificial Life*, ed. Jessica Riskin (Chicago, IL: University of Chicago Press, 2007), 46–62.

²⁴ See Leanne Groeneveld, "'lyke unto a lyvelye thyng:' The Boxley Rood of Grace and Medieval Performance," and Philip Butterworth and Eric Williamson, "The Mechanycalle 'Ymage off Seynt Iorge' at St. Botolph's, Billingsgate, 1474," in *Medieval Theater Performance: Actors, Dancers, Automata and their Audiences*, eds. Philip Butterworth and Katie Normington (Cambridge, UK: D.S.

consulted, and certain of its other articles present automata. Another treatment of a space that included automata is Schlauch's 1932 article "The Palace of Hugon de Constantinople."²⁵

Online materials were mainly consulted by the thesis to gain added information for instances of automata which had already been cataloged, including material from various webpages created to document individual automata and automaton-bearing devices for the Metropolitan Museum of Art's recent exhibition *Making Marvels: Science and Splendor at the Courts of Europe*.²⁶ A webpage which advertises Mole's edition of Dallam, *The Sultan's Organ*, was accessed because it contains a diagram of the titular organ with more information on that device's automata than Bedini's "The Role of Automata in the History of Technology."²⁷ In another instance where more information was needed to accurately catalog an automaton-bearing device, the figures and characters of Immser's astronomical table clock were established by *Under Time's Spell*, Van Dyck's 2017 museum exhibition guide, which was solely accessed to obtain this information.²⁸ Online materials thus differ from consulted texts in that they were not used to identify automata *per se*, although a few new automata were found while reviewing *Making Marvels'* exhibition webpages.

Sources named in the foregoing paragraphs, in addition to many other works available online and through the Internet Archive, were considered to identify and establish points of detail for fictitious automata in the partial catalog supplementally included as an appendix, and for factual and legendary automata named in the thesis' text. Especially with respect to the catalog, but also the thesis' text, general reference works which establish common knowledge have been named when consulted, but reviewing these works is considered impractical and unnecessary, as no automata were sourced from the same. Accordingly, readers are advised to mount their own

Brewer, 2017), 197–214 and 215–238; Sharon Farmer, "Aristocratic Power and the 'Natural' Landscape: The Garden Park at Hesdin, ca. 1291–1302," *Speculum* 88, no. 3 (July 2013): 644–680.

²⁵ See Margaret Schlauch, "The Palace of Hugon de Constantinople," *Speculum* 7, no. 4 (October 1932): 500–514.

²⁶ Individual web pages accessible from the Metropolitan Museum of Art's web presence will be cited when referenced in the remaining text of the thesis. Although these webpages were exclusively consulted, their contents are reflected in a published exhibition guide and catalog; see Wolfram Koeppel, ed., *Making Marvels: Science and Splendor at the Courts of Europe* (New Haven, CT: Yale University Press, 2019).

²⁷ See Thomas Dallam, *The Sultan's Organ: London to Constantinople in 1599 and adventures on the way: the diary of Thomas Dallam put into modern English by John Mole*, ed. and trans. John Mole (United Kingdom: Fortune Books, 2012), 5; the diagram on page 5, which originates with Mole, not Dallam or the latter's contemporaries, is available, without an image of Sultan Mehmet III for scale, on <https://johnmole.com/TheSultansOrgan.html> as of this writing. "The Role of Automata in the History of Technology" is referenced in footnote eleven.

²⁸ See Maarten Van Dyck, *Under Time's Spell*, trans. Gregory Ball (Ghent, BE: Binders Media/Manual.to and the Boekentoren/Book Tower, 2017), 75–76. The above work is also available online as of this writing under the URL <https://indebanvandetijd.manual.to/browse>, and the information used by this thesis from pages 75–76 is under the section "Object 2 – The Mechanical Clock: The imitation of time 1300–1700" in both hard and soft copies.

investigations of any general reference work or old edition made available online and mentioned by the thesis or its appendices.

CHRONOLOGICAL, SPATIAL, AND SEMANTIC BOUNDS.

“Pre- Modern” and “Early Modern” establish consecutive periods of interest, which are namely the postclassical period, Early, High, and Late Middle Ages, Renaissance, and English Jacobean and Caroline reigns. The thesis is concerned with Old World mechanical figures described in fictional and nonfictional works authored between the fall of the Western Roman Empire and years of the English Civil War, or which were built in that interval. Most specifically, the thesis treats automata which originated throughout Europe, and in the medieval Islamic world south and east of Europe. Some other automaton-building traditions in the historical polities of China and India were uncovered during research, but because consulted authors presented these traditions briefly and incidentally, this thesis must do likewise.

The years of research interest begin on Saturday, January 1, 476 CE, the beginning of the year in which the Roman Emperor Romulus Augustulus was deposed on Saturday, September 4, 476 CE, and end on Tuesday, December 31, 1650 CE, approximately two years after King Charles I of England’s deposition on Tuesday, January 30, 1649 CE. Padding the opening bound by approximately nine months and the closing bound by approximately twenty-three months allows for the subjectivity of artificial periodization schemes. The selected bounds are considered a good fit for the first and last dates germane to the named periods. In consideration of the differing transitions to modernity in disparate regions of Europe, and in those of Asia and India, a long view of Early Modernity is justified.

Semantically, “automata” is the plural form of “automaton,” which is derived from Greek terms for “self” and “mover.”²⁹ This paper will use the modern definition of “automaton,” which signifies a constructed object which is figural and biological, that is, built with the recognizable appearance of a living organism, and which demonstrates the semblance of animation by its artificial motion. Note that this definition is distinct from that used by computer scientists. In using this “modern”

²⁹ Normington and Butterworth’s “Introduction” to *Medieval Theatre Performance: Actors, Dancers, Automata and their Audiences* presents definitions for “puppet” and “automata” from the sixteenth century onward, citing one of the *Oxford English Dictionary*’s definitions for “puppet” as synonymous with that for “poppet,” an earlier spelling, as of the 1530s. This definition for “puppet,” “An idolatrous object or image, an idol (hence) any material object which is worshipped,” is consistent with the first current of thought proposed by this thesis, as will be shown; see Normington and Butterworth’s “Introduction,” page 4. Also see page 2 of this same “Introduction,” where the editors write “It is clear that the disciplines of theatre and dance and the operation of puppets and automata share a number of common characteristics in their respective capacities to engage with their audiences.” Five English-language definitions for “automata,” not “puppet,” which appeared prior to December 31, 1650 are also presented by Normington and Butterworth on pages 7–8 of the “Introduction,” and include those of Thomas Elyot (1538, “Automata, thynges without lyfe, wych seme to moue by them selves; as it may appere in old horologes, and ymages, whiche by vices do moue”); Thomas Cooper (1565, “Automatus, a, um. That goeth by a vice, that seemeth to moue of it selfe. Euery thyng that happeneth, without a manifest cause”); Thomas Thomas (1587, a partial repetition of Cooper’s definition per Butterworth and Normington); Randle Cotgrave (1611, “Any thing that goes by a vice, or peise [piece], yet seemes to moue of it selfe”); and an *Oxford English Dictionary* usage not provided verbatim by the editors, but which dates from 1616.

definition for “automata,” this thesis follows the prior work of Silvio Bedini.³⁰ The medieval paradigm for works of high technology, including automata, was looser, potentially encompassing anything with moving parts. However, this paradigm is not useful when discussing automata in a manner which accords with contemporary understandings of robotics and animatronics. Truitt, in naming her book *Medieval Robots*, preempted the disjoint between the vocabularies of medieval and modern science by substituting “robot” for “automaton,” and this thesis will also follow Truitt’s work in its placement of greater weight on the familial resemblance of the term “automaton” to the term “robot” than to other possible terms.

For purposes of this thesis, automata are three-dimensional and typically sculptural. Note that high reliefs satisfy this criterion, as well-executed figures protruding from a flat surface produce the same semblance of biological life as freestanding figures. If not sculptural, and instead a simple cutout, figures must move in negative space, as do mobiles, before being considered automata; cut-out figural representations with components that move parallel to flat surfaces, as in automated paintings of the late seventeenth and eighteenth centuries, postdate the thesis’ period of interest, and they are not regarded as automata.³¹ Similarly, flat images moved in any direction by technological means, such as the moon-phase complication seen on antique long-case clocks and modern wristwatches, are not considered automata.

Given this definition, a hypothetical fountain would not be considered an automaton, as fountains never historically existed as organisms and did not fantastically appear as such in fictional primary sources. In making this distinction, the general referent for “fountain,” and the imagery this word evokes, is applicable. If the hypothetical fountain contained static, silent, three-dimensional biological figures, it would still not be an automaton-bearing device, even if these sculptures or reliefs passively supported moving pieces that were themselves non-figural, such as musical bells, provided that the movement of these bells was perceptibly unrelated to the figures. “Passively” denotes an absence of perceived agency on the part of the hypothesized figures, which is attributable to motionlessness and the unrelated motive source of the hypothesized bells. In turn, the presumptive lack of artificial means to achieve movement in such static figures would preclude their identification as automata. The case of the hypothetical bells, moving, three-dimensional components that are non-figural, is likewise precluded from identification as an instance of automata, for despite their motion, the referent of “bell” is no more a biological organism than a fountain. This arrangement could possibly be an automaton if so

³⁰ Bedini uses the term “biological automata” in the third paragraph of “The Role of Automata in the History of Technology” after first noting that “They [automata] constituted the first step in the realization of his [“man’s,” humankind’s] dream to fly through the air like a bird, swim the sea like a fish, and to become ruler of all nature” in the introductory paragraphs on page 24 of that article.

³¹ Chapuis and Droz devote an entire chapter of *Automata: A Historical and Technological Study* (Chapter VII, “Mechanical Pictures and Picture-Clocks”) to this species of animated technological object, which could be considered automata beyond the bounds of thesis and were so considered by these authors, great authorities on this subject. However, all examples presented in Chapuis and Droz’s named chapter postdate December 31, 1650, and therefore remain irrelevant to this thesis regardless of any semantic criterion.

constructed as to suggest that the bells were rung by the figural supporters, but once it is evident that a force external to these figures produces the bells' action, the illusion of agentive motion on the parts of the figures is lost.

Accordingly, the Cleveland Table Fountain, usually mentioned in existing literature on medieval automata, is neither itself an automaton nor a fountain containing automata, at least per the modern definition presented above.³² While this extant article of medieval material culture is certainly a valuable and significant object, and should by no means be overlooked by historians, it cannot be included in investigations of medieval automata which apply a modern conceptual definition, as has this thesis.

Hydraulic installations which jet water, whether singly or in groups, are not automata, as they lack a figural dimension. However, a biological figure may be considered an automaton if it emits fluids to simulate bodily actions such as spitting, the forceful discharge of saliva. This example is suggestive of a musculature, biological processes involved in salivation, and intentionality on the part of the figure. Birds, a popular figural subject, may accordingly be classed as automata if fashioned to "spit" by ejecting water at an audience, even if otherwise motionless. Spraying water or ejecting objects from inanimate figures' mouths are popular conceits in pre-Modern and Early Modern automata.³³ Further, any conceit whereby the clever appearance of water produces the illusion of agentive action in a three-dimensional figure constructed with the appearance of a biological lifeform must render that figure an automaton; the impression that the figure is knowingly responsible for a given discharge of water (as, for example, when pouring a libation), is key. Heron of Alexandria, a key designer and builder of automata in the classical world, understood this point well.

³² The Cleveland Table Fountain is discussed in commendable detail by Fliegel in "The Cleveland Table Fountain and Gothic Automata." The figural components are shown in detail by Figures 6, 7, and 8 in that work on pages 10–11. Note that figures such as those in Figure 8, which emit liquids as spouts or "nozzles," to use Fliegel's term, are also not considered automata, as statues such as gargoyles, and indeed, ornamented spouts or "nozzles," do not necessarily satisfy the mechanicalness, mobility, and non-consubstantiality required by the thesis' definition, even when a spouting figure is present in conjunction with separate moving components, as, for example, in the pitcher described by al-Jazari per the fifth chapter of his second category in *The Book of Knowledge of Ingenious Mechanical Devices* (see pages 110 – 114 in Hill's cited edition). A distinction exists between the passive flow of a liquid from a conduit worked to resemble a figure's orifice and the discernible semblance of that same liquid being actively cast from that same orifice by the figure. While none were memorably encountered by the thesis in research, *puer mingēns* sculptures such as the *Manneken Pis* are not considered automata, although they were contemporaneously popular, as the passage of water from these statues' penises is not considered active; it does not have the semblance of responsiveness to stimuli, or specific duration, and clearly exists in the mode of a fountain jet, much as does the passage of water through the breast of the *Fountain Figure of Abundance* shown in Fliegel's 14th figure on page 20 of "The Cleveland Table Fountain and Gothic Automata," which is then described on page 21.

³³ See the thesis' later presentation of automata in its delineation of the seven currents of thought for specific examples of automata that spray liquid or drop objects (usually balls) from the mouth.

Figural and biological constructs which are static, but carry sound from an internal source, may also be considered automata, as transmission of sound is apparently indicative of motive action; some source and conduit are established for soundwaves. A conduit does not necessarily require moving components, but invites and could be accompanied by the same. The important consideration is the semblance of life created by aural stimuli emerging from an automaton. This criterion can be understood with reference to the biological organisms categorically represented by all automata as facsimiles per the thesis' definitions. A human bugler, for instance, still moves an embouchure and breathes circularly. An otherwise unmoving figure of this same human playing its own bugle, stationary and cast in brass, communicates motion by sounding a succession of musical notes, thereby impressing the semblance of life without relying upon other conceits.

Automata, artificial and technological constructions representing biological organisms, are distinct from artificial constructions which represent these organisms without recourse to technology. The latter sort of representation differs from that of the technological automata of the pre-Modern and Early Modern worlds, and from the fictive combinations of "magic" and technology that characterize automata in medieval romances; these representations are instead grounded solely in mythology or the occult. This is the distinction which separates "living statues" from automata. Per Truitt and other authors, automata have some basis in various combinations of natural forces, natural science, machinery, craft, and the fabrication, assembly, and activation of various non-biological materials, even when some or all these bases are combined with "magic" in fiction or in the minds of an ignorant audience.³⁴ Absent any other technological component, the use of brass figures, gold-colored figures suggestive of brass, or rendered waxes preserves the technological element of true automata, as these are not naturally-occurring raw materials. Thus, *Der Golem*, a mythic statue sculpted from clay and endowed with life by Judaism's hermetic tradition, is not an automaton by this thesis' semantic definition, as it is composed of a single substance, not fabricated components or crafted materials. *Der Golem* is produced by operation of Judaism's occult articulation and, lacking scientific predicates, is closer to Pygmalion's beloved in Ovid's *Metamorphoses* than to automata, a "living statue" instantaneously animated once completely formed from elemental earth.³⁵

³⁴ This is a central premise of Truitt's work in *Medieval Robots: Mechanism, Magic, Nature and Art*, and is so pervasive throughout that book as to obviate extrication of specific passages.

³⁵ For a brief presentation of the golem, see page 25 in Pickover's *Artificial Intelligence: An Illustrated History: From Medieval Robots to Neural Networks*. In her 34th endnote to "Clockwork Prayer: A Sixteenth-Century Mechanical Monk," King compares a legendary automaton "puppet" described by Sir William Stirling-Maxwell (see Butterworth and Normington's discussion of "puppet" as regards automata and the conflation of "automaton" and "puppet" as terms) supposedly constructed by the engineer Gianello Torriano, a known builder of extant automata, to "the Jewish Golem." This comparison is inapt, as Torriano's actual automata, and by extension his legendary "wooden man" automaton, were mechanical, whereas golems, as has been discussed, have no moving components and are shambling, hulking men of mud.

Homunculi, in their pre-Modern and Early Modern sense, are also excluded from consideration as automata. King, in a footnote to *Clockwork Prayer: A Sixteenth-Century Mechanical Monk*, concisely describes how a homunculus, a tiny man, could supposedly be created by occult means. This process, which involved inseminating the concavity of a glass alchemical vessel to incubate a miniature human by harnessing the thermal energy of horse manure, could arguably be considered “scientific” in the said eras.³⁶ However, this practical methodology corresponds to bioengineering and cloning, not robotics and cybernetics, in contemporary scientific specializations. King nevertheless uses the term “homunculus” interchangeably with “automaton” to describe a particular “Robot Saint,” to use Swift’s term, which she persuasively argues was deliberately built in the image of San Diego de Alcalá.³⁷ Any automata presented by this thesis are unlike homunculi in that they are devoid of living tissue; further, many identified automata existed, and some still exist, while occult homunculi never existed and can never exist. This opinion is maintained for other occult creations of material or immaterial entities with biological figures, whether with or without sentience, including the Tibetan Buddhist *tulpa*.

In using these terms, continuity is acknowledged with the prior scholarship of Silvio Bedini, who identified automata as figures synonymous with the endorsed sense of “biology” in his 1964 article “The Role of Automata in the History of Technology.” The *topos* of the pre-Modern and Early Modern automaton is enjoying a revival partly attributable to Truitt’s publication of *Medieval Robots*, and awareness of Bedini’s contribution has recently resurfaced in works such as Clifford Pickover’s publication on artificial intelligence. Pickover adapts Truitt’s phrase “medieval robot” to identify one of many phases in the history of robotics, and his book mentions Silvio A. Bedini by name.³⁸

In establishing these definitions, the thesis is consciously following a prior model for automata classification which was not devised by Ambrosetti, but which was described in her cited work. Thus, the thesis’ modeling, which will subsequently be delineated, is hierarchically subordinate to Kang’s classification model, which is itself subordinate to and operative upon one branch of the classification scheme

³⁶ King calls the procedure a “recipe;” relates how it is ascribed to the alchemist Paracelsus; and presents it as a long quote from *De Natura Rerum* under the sixty-sixth endnote in “Clockwork Prayer: A Sixteenth-Century Mechanical Monk.”

³⁷ See King’s introduction: “And when the child did indeed recover, Philip kept his bargain by having Turriano construct a miniature penitent homunculus.” Automata are constructed, but homunculi are grown. Under Part V, “Looking at the Monk Now:” “How much does he weigh, I suddenly wonder, this 15 inch tall homunculus?” In arguing that the monk automaton represents Saint Didacus (Diego) of Alcalá, King follows the analysis of Father Servus Gieben, whose correspondence is reprinted in King’s Part IV, “For Whose Sake?”

³⁸ See Pickover, *Artificial Intelligence: An Illustrated History: From Medieval Robots to Neural Networks*, 17. Pickover recycles Bedini’s concluding paragraph from “The Role of Automata in the History of Technology,” less one word and one phrase (“therefore,” “for whatever purpose”), in his entry for the “Hesdin Mechanical Park.” Bedini is cited in Pickover’s “Notes and References” section.

named by Ambrosetti. A chart is included in the appendices to provide a graphical representation of these classificational relationships.

THEORETICAL EXPOSITION.

Automata seldom figure in the prevailing understanding of pre-Modernity and Early Modernity because they are frequently equated with medieval legends. By contrast, medieval bestiaries are acknowledged as a source for European pre-Modernity's imaginative flights, yet automata have not enjoyed the benefits of this association. The medieval and Renaissance automaton has largely and wrongly been popularly perceived as a rumor, a by-product of pre-Enlightenment intellectual torpor, or a mere toy, if perceived at all.

Yet these misapprehensions should be redressed. Automata are an exemplar of scientific and technological activity throughout recorded history, and were as much a part of pre-Modern and Early Modern intellectual and popular culture as more often-studied phenomena. In Carlo Ginzburg's classic oeuvre, as in that of Emmanuel Le Roy Ladurie, inquisitorial registers are plumbed to locate folk innovations in spirituality and religion, recovering the lived experiences and worldview of the Middle Ages' non-aristocratic majority.³⁹ As has been discussed, automata were usually connected to societal elites in the pre-Modern and Early Modern periods as works of high technology, and many automata existed in the courts of monarchs and emperors. Nevertheless, study of these devices can yield insight into the perceptions of all societal ranks. Every automaton had a designer and a builder, who were often, but not necessarily, the same person, and not all automata had aristocratic patrons, especially when destined for display and use in churches or other public settings. Of course, all automata had audiences, and in the cases of prominent municipal locations' public automata, besides those seen by congregants in churches and cathedrals, these audiences surely comprised a cross-section of society.

An example of a popular perception in pre-Modern and Early Modern popular culture is the material associated with automata. In medieval fiction, and in physical realizations under its influence, automata are very often presented as having a golden color. Sometimes this color is ascribed to the creation of automata in the brass or gold mediums, and in other cases, extant automata or extrapolations from their historical uses indicate coatings with golden paint. For the thesis' purposes, automata with this characteristic color have been termed "Things of Brass." For purposes of this thesis, the use of golden-colored materials or treatments is considered evocative of brass, even when authors (who may have written descriptions in general terms) specify other materials; thus, a "golden" automaton is never considered to simply be constituted of elemental gold, as such would be contrary to the thesis' definitions. It is interesting to note that brass, an alloy, carried technological connotations in the domains of metallurgy, applied metalwork, and alchemy. As an unnatural material, brass could be construed as a signifier of artificiality. However, from approximately the turn of the fourteenth century onward, the reviewed French sources suggest

³⁹ See Carlo Ginzburg, *The Cheese and the Worms: The Cosmos of a Sixteenth-Century Miller*, trans. John and Anne C. Tedeschi (Baltimore, MD: The Johns Hopkins University Press, 2013), and Emmanuel Le Roy Ladurie, *Montaillou: The Promised Land of Error*, trans. Barbara Bray (New York, NY: Vintage Books, 1979).

automata were not called “Things of Brass” when historically built by craftspeople; on the contrary, they were said to be “person[s] of wood.”

An excellent source for pre-Modern automata are the administrative records from the French estate at Hesdin, and these, when translated, refer to “personage[s] of wood.”⁴⁰ An unrelated automaton preserved in legend, unlike those of Hesdin, but which was associated with Gianello Torriano, a builder of extant automata, caused a Spanish thoroughfare to be called “The Street of the Wooden Man,” and this name persists to the present.⁴¹ In another case, a personal agenda maintained by a participant in the Italian Renaissance casually reminds its writer to build a “wooden man” which, in the opinion of Mark Elling Rosheim and his adviser, Carlo Pedretti, was not unlike Leonardo da Vinci’s automaton knight.⁴² These examples indicate that the notional sense conveyed by the phrases “wooden man” or “person of wood” existed in the pre-Modern and Early Modern worlds, across languages and centuries, in much the same way as the more recent term “robot.”

What is needed after identification of such a semantic trend is a model to recover its context. This model should show the interplay of causative factors in intellectual history, for the differing senses of the brazen automaton and the wooden automaton are reducible to specific and distinct cultural contexts, and to their emergent ways of thought. The distinctiveness of brazen automata, representing one such way of thought, can be attributed to the role of medieval European fiction, where these automata are usually expressions of magical power, as Kang’s existing model has correctly noted. Yet these gold-colored magical automata persisted in medieval fiction, even as automata constructed using a variety of materials, including wood and, indeed, brass, began to materialize in reality.

Sherwood, writing in 1947, contended that golden automata appeared in *romans antiques*, a staple of medieval European fiction, because real and actual automata were contemporaneously common in Western Europe.⁴³ This claim asserts

⁴⁰ The primary source for the automata “of wood” at Hesdin, an accounting document, is given by Truitt on pages 131–132 of *Medieval Robots* and by Sherwood on pages 587–589 of “Magic and Mechanics in Medieval Fiction.” As will be seen in the subsequent sections, many other cited authors refer to individual automaton figures from this source in passing, but only Sherwood and Truitt provide slightly different translations of the source at length.

⁴¹ See King’s concluding paragraph and block quotation in the “Clockwork Prayer” section titled “Juanelo Turriano,” and the corresponding thirty-fourth endnote of that article, which establishes that the description of the wooden automaton presented and cited by King originates with the fourth edition (1891) of Sir William Sterling-Maxwell’s *The Cloister Life of the Emperor Charles V*.

⁴² See Rosheim, *Leonardo’s Lost Robots*, 69, 110. As with all pre-Modern/Early Modern automata named in this and the preceding sections, identified currents of thought which apply to this instance will subsequently be specified by the thesis’ argumentation.

⁴³ See Sherwood, 573–574, 575, 591–592: “In the first place, sufficient attention has not, it seems to me, been paid to the extent to which real automata and the mechanical principles on which they worked were familiar to Western Europeans in the Middle Ages. . . . Western Europe in the Middle Ages was not ignorant of the principles of mechanics known to the East; in fact, it made new discoveries in that field. It had, besides, mechanical toys of its own. . . . It is not surprising, therefore, that statues that moved, images that spoke or sang, and goblets from which the wine mysteriously

the prevalence of the pre-Modern and Early Modern automaton, which was a more frequent sight in the centuries after the fall of the Western Roman Empire and before the era of the English Civil War, the mid-seventeenth century, than is generally assumed. Yet Sherwood's work replaced a consensus view on the intellectual-historical transmission of ideas from the Arab world and into Europe during the Middle Ages with a celebration of medieval European ingenuity.⁴⁴ While Europeans of this period were certainly capable, and indeed ingenious, to a greater degree than is stereotypically apprehended, their constructions of automata, both conceptual and physical, can be understood in a wide trajectory that passed from antiquity to modernity by way of the Arab world, as is reaffirmed by Farmer in her cited article.⁴⁵ This route certainly holds for many staples of medieval intellectual culture other than automata, and it is perhaps most famously exemplified by the contribution of Averroes, "Commentator" on the Aristotelian corpus. In this trajectory, medieval Europe participates in ideas about automata and delivers its novel interpretations and innovations for this topic within the wider context of the Old World.

The thesis' new model attempts to reconcile the competing meanings of automata by introducing seven "currents of thought," or conceptualizations of these objects, in the studied periods' fiction, legend, and reality. In discussing this modeling scheme, the automata identified by the thesis will be named and used as examples. The seven posited currents of thought arise from automata and persist through many centuries, yet do not necessarily or exclusively operate along lines of power and social control. Identification of these currents is consistent with the Annales School's *longue durée*. "Current(s) of thought" is not synonymous with "discourse," which is why the latter term will be used sparingly.

Many historians who devoted serious work to the subject of early automata, including Silvio Bedini, Derek J. de Solla Price, and Alfred Chapuis, were active before the ascendance of "high theory" in academia. Any new situation of early automata in an analytical mode familiar to scholars who currently use deconstruction to criticize literature would hopefully stimulate the interest of these authorities in the pre-Modern and Early Modern automaton. This interest would not be inappropriate, and such scholars' engagement should be as productive as that of any other faction. Nevertheless, the posited "currents of thought" are more prominent than discursive formations in the thesis' analysis.

vanished had their counterpart[s] in actual machines of the time. It is, further, reasonable to assume that the operation of such machines was familiar to a substantial portion of the people."

⁴⁴ See Sherwood, 574–576: "The 13th century, in particular, along with its other great creations, underwent a "mechanical rebirth." [George Sarton's 1927 *Introduction to the History of Science* is here cited by Sherwood.] In the circles of the learned, on the one hand, there was not only speculation in the field of mechanical science, but experimentation as well. ... It was, however, the fact that Western researchers made important additions, through discoveries of their own, to the lore inherited from their Greek predecessors, that constituted the real revolution in science in the 13th century."

⁴⁵ See Farmer, 679: "In one way or another – either through literature or direct experience – Robert's moving monkey statues and other mechanical devices were probably inspired by models coming from the Islamic world." See also Truitt, *Medieval Robots*, 123.

With this distinction established, the argumentative method will briefly be outlined. Firstly, each current will be defined in a sequence which commences with the first and concludes with the seventh. Specific instances will be named and discussed for each identified current using the cataloged set of pre-Modern and Early Modern automata, which will, on occasion, be related to disciplinary society and the human body, two major loci of discursive analysis. While there is no comparative assessment of merit between distinct different analytical approaches, conceptions of automata which span the Annales' *longue durée* from the earliest Middle Ages to the latest Renaissance, and slightly beyond, will be elucidated.

Mounting a comprehensive analysis of pre-Modern and Early Modern automata via the philosophy of any major postmodernist is beyond the scope of this thesis. Recommendations are therefore made for subsequent research. Jean Baudrillard, author of *Simulacra and Simulation*, expounded theories relevant to the automata of all eras, and a rigorous implementation of his ideas in a treatment of automata would be most interesting.⁴⁶ Another theoretician apt for discussion in a monograph on the thesis' topic, since pre-Modern and Early Modern automata partake of both science and magic, would be Karl Popper, who argued that science emerges from rejections of magic in *Conjectures and Refutations: The Growth of Scientific Knowledge*.⁴⁷ By presenting these thinkers as contrasting representatives of the differing political ideologies construed to have permeated the social sciences' output, the thesis would hope that the transcendental appeal of fictive, actual, and legendary automata, objects at the intersection of many possible analytical approaches and disciplines, is crystallized to its readership.

⁴⁶ See Jean Baudrillard, *Simulacra and Simulation*, trans. Sheila Faria Glaser (Ann Arbor, MI: The University of Michigan Press, 1994). While this work was not read in the research underlying this thesis, it is suggested as the basis for further research on automata which may be of interest to critical theorists. Critical theory is, of course, predominant in American humanities and social science fields.

⁴⁷See Sir Karl Popper, *Conjectures and Refutations: The Growth of Scientific Knowledge* (New York, NY: Routledge Classics, 2002). Popper is a very different author than Foucault or Baudrillard, but his oeuvre is likewise suggested as a basis for further research and scholarship on pre-Modern and Early Modern automata because critical theory, and the ideological commitments it typically entails, is not the exclusive analytical and philosophical model available to or permitted for use by students of history, at least as of this writing. Cultivation of a "big-tent" approach to study of automata, with a diversity of methodological approaches and subject-discipline specializations, is considered best.

CURRENTS OF MECHANICAL THOUGHT.

Seven "currents of mechanical thought" are identified for automata. The first current, "The Divine, Classical Automaton," was especially developed in Greece under the Roman Empire; the second current, "The Secular, Islamic Automaton," was especially developed in the 'Abbasid caliphate. The second current inherits technology from the first current, but it does not inherit purpose or conceptualization. The third current, "The Fictive, Magical European Automaton" of the early Middle Ages, does not inherit technology or purpose from the second current, but it does show limited conceptualization from the second current.

The fourth current, "The Actual, 'Magical' European Automaton," is the first of two branched bifurcations from the third current, whereby existent, constructed automata are or are not considered "magical." This current inherits purpose and conceptualization from the third current but does not inherit technology from the third current, as the third current is unconcerned with technology. The fifth current, "The Actual, Secular European Automaton," is the second of two branched bifurcations from the third current, which inherits technology from the first current, as does the second current, and which inherits purpose from the second current, but does not inherit conceptualization from the second current, although it shows lesser or greater vestiges of conceptualization from the first current.

The sixth current, "The Automaton as Harbinger of Progress," is the first of two branched bifurcations from the fifth current, is argued to remain operative, and inherits technology, but not purpose or conceptualization, from the fifth current. The seventh and final current, "The Automaton as Harbinger of Death," is the second of two branched bifurcations from the fifth current, is argued to remain operative, and inherits technology, but not purpose or conceptualization, from the fifth current. That these last currents survive into the present, but are descended from the others, is the link by which twentieth-century automata, whether as material or popular expressions of culture, are connected to pre-Modern and Early Modern automata.

Of course, it is possible to envision the modeled scheme running in reverse. It would proceed from some cataclysm, represented by the seventh current; to the same motivation of preservation inherent in the sixth current, but in response to the cataclysm, with this motivation also characteristic, to some degree, of the second current; to a condition where automata are still ubiquitous, and understood secularly, even after this cataclysm, in accord with the fifth current, and perhaps owing, in their continued ubiquity, to the impetuses of the sixth current; to eventual erosions of the ubiquitousness and rational conceptualization of automata, such that their builders are again perceived as sorcerers; thence to the third current, where the magical conception of automata prevails, and the automaton as a material-cultural object is exceptionally rare; though, simultaneously, an identifiable body of persons, geographically and culturally distinct from a world otherwise in ignorance of automata as a species of lost knowledge, concern themselves with preserving the rational and technical understanding of automata, that is, the second current of thought, although this preservation proceeds as the penultimate step in a linear

sequence opposite that of the model's forward progression; and finally, in this reversed progression, whatever technical knowledge of automata has been preserved per its second current is subsumed into its first, and a religious conception of the automaton as a god-image becomes monolithic, the rational, or secular, conception of automata finally being lost.

However, one need not lose hope in the dystopian outcome this scenario presents; for, inasmuch as the model can run both forward and backward, whatever technical knowledge is applied in the reversed model's first current must remain for its automata to function, and not merely become statues with speaking tubes, which neither the postulated inhabitants of a world living with the cultural mentality of a post-cataclysmic first current, nor this thesis' author, would distinguish as automata, having knowledge, even vestigial, of real automata per this thesis' definitions --- and so long as even such technical knowledge remains, perhaps secreted by a priestly class, for a time, there is always a chance that, in the future following this scenario, such technology could be preserved and considered rationally and secularly by its preservers, likely after the fall of that postulated culture identifiable as a fully-regressed, post-cataclysmic registrant of the reversed first current. Thus, the cycle would begin anew, another culture claiming the technology of an older, fallen culture which had built automata for religious purposes, and that other culture, the former, would base its secular automaton technologies upon the knowledge gleaned from its study of the latter, even as some other cultures, bereft of such study, would view the products of the studious culture as works of magic, recapitulating the third current of thought. So, it would go, onward, through the rest of the currents, to that final current, death; and, with the cataclysm interpreted as the death-knell at the conclusion of the forward progression, it could cycle backwards, and then forwards, and then backwards again, ad infinitum. In this respect, the model, when taken to include the progressive and regressive variants in its totality, would not be unlike certain hydraulic designs of al-Jazari, which tilt to one side, and then to another, but are so designed as to fluctuate in this cyclical pattern.

The regressive variant of the model is, at this time, only conjectural, and historical argumentation can only be advanced in framing the structure of the progressive variant. As such, the thesis will now move to a presentation of each element, or "current," of the progressive model, and of exemplars for each "current" which were identified in the course of research. It is important to note, and indeed, to emphasize, that the progressive model is historical, inasmuch as it is based upon historical trends, and also, inasmuch as it itself forms a narrative for the history of automata as a topos in intellectual history. It can be stated that the thesis' model is a narrative, or it can equivalently be stated that the thesis' narrative is modeled. Regardless of whichever of these two statements is preferred, it is clear that the thesis' work is one of historical analysis, since pre-Modern material-cultural artifacts, textual works of fiction and nonfiction, and sketches, illustrations, and diagrams, which comprise the thesis' main historical bases, are all primary sources, given the established validity of material-cultural studies as a historical paradigm. The model's novelty and underlying research methodology necessitate emphasis on these points.

THE FIRST CURRENT OF THOUGHT.

While Heronic automata of the classical world fall beyond the thesis' temporal scope, these devices were used in polytheistic temple worship and there accepted by devotees of the Greek pantheon as objects which moved by authentically supernatural causation. Heron's automata were works of sophisticated technology by classical, and indeed medieval standards, but even simpler creations, such as Egyptian "talking statues," were similarly built for apprehension by audiences as material proofs of divine power, and as discussed, such statues were qualifying automata for purposes of the thesis' definitional terms. No known probative source contradicts the view that Hellenistic automata were perceived as miraculous by supplicants within ritualistic contexts. Thus, the first current of thought is that featuring the perception of automata as authentically supernatural and superhuman.

Other automata evoked the subject matter of the first current without retaining its ritual purpose. This was especially the case in the Renaissance and early seventeenth century. Yet religious subjects in pre-Modern and Early Modern automata were not limited to the polytheistic gods, heroes, and monsters of Greco-Roman antiquity. Just as constructions of classical deities in the medium of moving automata were neither given ritual worship nor intended for this purpose if described or fashioned in the Middle Ages or Renaissance, unlike Late Antique holdovers, neither were those which displayed Christian conceptions of angels and saints. Indeed, the presence of currents of thought other than the first in the Christian and European automata of the later Middle Ages and Renaissance is what distinguishes them as objects that at once have religious imagery and yet which were not venerated in the classical, ritual sense exclusive to the first current. Elizabeth King does note that at least one of these automata, a monk which likely represents Saint Diego de Alcalá, does have an undeniable religious gravitas, yet it was not built as a fetish object or idol. However, the association between machines and faith in the supernatural divine is still manifested in the pre-Modern and Early Modern automata built by adherents of a given faith with the iconographic conventions of that faith. By contrast to King's Diego-automaton, and unlike the other automata which recall the first current by virtue of religious association, the Boxley Rood of Grace was a unique exception believed to possess actual supernatural power, becoming the object of pilgrimages in a near-recapitulation of the classical first current. As with any of the limited examples mentioned in passing under this section, further details will subsequently be provided for all the instances of automata encountered by the thesis.

In addition to fictive automata wrought by deities, classical automata which survived the fall of the Western Roman Empire, postclassical automata created with the figures of classical monsters, heroes, and deities, and with Christian religious subjects, including angels, saints, and the trinitarian conception of God, still other automata participate in the first current by their emplacement in or on sites of ritual worship. The automata of the first and second astronomical clocks in Strasbourg Cathedral fall under this sense of the first current; in addition to figures previously named, both astronomical clocks contained automaton roosters, or cocks, and the

latter also contained allegorical figures displaying the four stages of man's life, as well as a personified Death shown to enter combat with the automaton Christ on the hour in an apocalyptic enactment.

The automata of the astronomical clock in Norwich Cathedral, which were built earlier than even those of the first Strasbourg clock, included a procession of monks. While the monk is certainly an individual associated with religion, he is neither a classical god, hero, or monster, a supernatural and spiritual being like angel, nor necessarily a saint, and while a very fitting subject for an astronomical clock in a cathedral, automaton monks do not denote the first current of thought in the pre-Modern and Early Modern context unless, in accord with the instant point, they are affixed to a place of worship. On the contrary, the representation of a monk in the medium of automata is more comparable, in the thesis' view, to the representation of other occupations or societal stations with humanoid automata; and one of the commonest representations of another social role in the automaton medium is that of the knight, a figure signified by the presence of armor, weaponry, and frequently a charger (mount). Wells Cathedral contains an astronomical clock with two rotating tiers which spin automaton figures of mounted knights in opposite directions, creating the appearance of a joust, while unmounted jacquemarts that similarly have the armored appearance of knights appear on the cathedral's exterior. Further, and as will later be discussed, a jacquemart named Jack Blandifer or Blandifers also appears inside the cathedral, where it exists distinctly from the astronomical clock's face and adjacent jousters. As with the monks of Norwich Cathedral, all these automata are identifiable as participants in the first current of thought because they exist in or on a place of worship; and as shown by the Wells Cathedral's exterior jacquemarts, this locational association is not limited to interior spaces, but also the outer structure and grounds of a church, shrine, temple, etc., provided that the relationship between the automaton and sacred ground is obvious.

The last type of pre-Modern and Early Modern automata that partake of the first current are those which do not satisfy the prior criteria, yet which operate using unambiguously Heronic mechanisms or otherwise have clear descent from antique automata, especially in terms of subject matter. Since Heron's automata were developed for use in religious ritual, any automaton which mimics their mechanisms, regardless of its form and figure, is related to the first current of thought on this basis. Since Heron's works prominently featured avian automata, many later automata with these same figures could be argued to have some descent from antiquity, as Heron firmly establishes these figural subjects.

Most automata so connected are descended directly from Heron, but at least one, Villard de Honnecourt's chantepleure, is a medieval reinterpretation of an independent antique design. The classical antecedent of de Honnecourt's chantepleure would not qualify as an automaton by the thesis' definition because its figure of Tantalus was not animated, but its design and function were otherwise comparable, however, and in combination with the chantepleure, this case demonstrates transmission of a principle in applied hydraulic engineering from Roman antiquity to the Middle Ages. Inasmuch as such a transmission is evident, the chantepleure

participates in the first current of thought via its lineage. Further, despite its lack of movement, the Roman predecessor of the chantepleure features a mythological subject, rather than de Honnecourt's secular and generic automaton bird, suggesting broad correspondence with the thesis' argumentative contentions.

Many examples of Heronic automata which partake of the first current on the ground of classical technology are found in works of medieval fiction. Descriptions provided by the romance authors suggest that automata they envisioned were derived from Heron's work, although the romances do not always demonstrate a clear understanding of these automata and often present them as magical; some are repurposed with minimal alterations.

Automata corresponding to Kang's third type, rather than the second, similarly partake of the first current by recalling or recreating Heronic designs. The automaton fountain birds in Captain Agostino Ramelli's technical manual *Le Diverse e Artificiose Macchine* recapture those of antiquity and the intervening medieval romances (662), although Ramelli's miniature fountain-tree for the home (667) is even more indicative of this Renaissance mentality. Just as the automaton birds of the romances' fountain trees participate in the first current, so too do the true fountain-trees actually constructed in the Byzantine court at Constantinople; the Mongol court at Karakorum; the 'Abbasid courts at Baghdad and Samarra; and at Hesdin, estate of the French nobility, which not only featured automaton birds on a fountain-tree, but also in a birdcage.

While these fountain-trees are suggestive of Heron's work by virtue of the subject matter selected for their conspicuous automata, others were frank recreations of classical technology. A grotto at the Villa d'Este, as reported by Lord Michel de Montaigne in his *Journal de Voyage*, contained a replica of Heron's owl and bird automata, one of the most famed displays of its type. Salomon de Caus' songbird in his 1615 work *Les Raisons des Forces Mouvantes, avec Diverses Machines tant Utiles que Plaisantes* likewise reproduces a Heronic mechanism. Other instances of avian automata about which little is concretely known, such as the birds exhibited at the Feast of the Pheasant in 1454, could conceivably also have shown greater or lesser influence from Heron, possibly falling somewhere between Villard de Honnecourt's eagle automaton, which probably appeared in a church, and the reappearance of indisputably Heronic automata in the sixteenth and seventeenth centuries.

During certain centuries of the medieval period, there was a reason Heronic automata were exclusively present in European literary romances, which frequently represented these automata within Islamic contexts. This reason, which also explains the resurgence of Heronic automata during the Renaissance, was the fall of the Western Roman Empire. The next section discusses the current of thought which emerged beyond Europe, yet which technologically linked continental Late Antiquity with the Late Middle Ages, even while profoundly influencing the perception of automata in the Early and High Middle Ages: the automaton in the Arab World.

EXAMPLES OF THE FIRST CURRENT OF THOUGHT.

It is perhaps useful to begin with a negative case. Fliegel, in his presentation of the Cleveland Table Fountain, mentions a second table fountain, although it is unclear if this second fountain contains automata, and as such, it was not entered in the thesis' catalog, although it could perhaps have been entered under Kang's fourth type if more descriptive information was available. Were it to have been entered in the catalog, it would have registered at least the first and fifth currents of thought, as this second fountain featured "a figure of Our Lady and two "angeloz" surrounded by prophets" as a product of a European culture.⁴⁸

King notes that "this was an age [Early Modernity] in which physical objects and inanimate things were believed by many to possess supernatural powers," and although her statement is offered without evidence, the "supernatural powers" to which she refers could register the first current of thought under the thesis' model, although another term, "preternatural," would be more appropriate with respect to that current.⁴⁹ In writing about one of the most celebrated instances of Early Modern automata, the praying monk, King's assessment of the same registers this thesis' first current of thought, in addition to others.⁵⁰

O'Brien, in his discussion of attitudes to scientific inquiry in Chaucer's "Summoner's Tale," makes statements that register the thesis' first current when applied to pre-Modern and Early Modern automata, with such automata being authentically divine through the divine agency controlling their makers. In elaborating upon this connection, O'Brien adds a registration of this thesis' fourth current, besides its first, and here is seen something rarely acknowledged, namely that ultimate evil must recognize the authority of ultimate good; thus, demons are commanded using the name of God in demonology.⁵¹ The ramifications of O'Brien's

⁴⁸ See Fliegel, "The Cleveland Table Fountain and Gothic Automata," pages 17 – 18: "While the decoration of the Cleveland fountain is completely secular in spirit – drolleries, dragons, lions, musicians – Charles V's second fountain is described as having a figure of Our Lady and two "angeloz" surrounded by prophets. Obviously sacred imagery was sometimes employed on table fountains."

⁴⁹ See King, "Clockwork Prayer," page 17 in the author's printed copy: "This was an age in which physical objects and inanimate things were believed by many to possess supernatural powers. The Mass itself, and the central belief in the transubstantiation of the Host, enacts the penultimate [word choice] miracle of the quickening of inanimate substance."

⁵⁰ See King, "Clockwork Prayer," page 18 in the author's printed copy: "He [the automaton monk] walks a delicate line between church, theater, magic, science. He circulates among – murmurs about – all of them. He is a synapse, transmitting a host of simultaneous signals."

⁵¹ See O'Brien, "Ars-Metrik," page 19: "Those who search into God's privities, who measure and demonstrate by arts and figures, and who become lost in employing and creating mechanical devices, are themselves the *instruments* of the arts and figures of an ultimate scientist/mechanic – i.e., Chaucer with his unforgiving irony and God with his providence. This view of God as scientist follows Wisdom 11:7 – wherein He is seen as having created 'all things in number, weight, and measure' – and also Grosseteste, for instance, who in discussing the physical world according to Euclidean geometry, refers to God as a mathematician: '*mensurator primus et certissimus*' (qtd. In McEvoy 175). Even though Chaucer exposes the mathematical/scientific templates of the lord and his squire as anal, mechanical

conclusions, that the tale satirizes medieval scientific reasoning, and that its characters are automaton-like, register the thesis' first current inasmuch as they frame this tale as a kind of medieval anticipation of the theistic clockmaker argument, and inasmuch as its "robots," who are fictive humans behaving robotically, in O'Brien's interpretation, are a medieval anticipation of Cartesian mechanicism.⁵²

That medieval fiction was primarily consumed by educated persons leads to the hypothesis that the secularism of the thesis' fifth current may be based, to some degree, in the disparate tradition of the medieval romances. In terms of the thesis' model, Sherwood's line of reasoning shows the influence of its first current, either by way of its second current, or by bypassing its second current in some cases of fictitious automata under Kang's first and second types, just as fictitious automata may also bypass the fourth current.⁵³ Sherwood's exposition demonstrates the progression from the first to the third current, bypassing the second, which may (or may not) be present in works of fiction. In the passage which delivers this exposition, reference is made to an article of technology which this thesis does not consider an automaton, although it is close in design to Villard de Honnecourt's chantepleure; however, Sherwood's point holds as regards the thesis' model. Here, educated persons reading the romance of *Huon de Bordeaux* were presented with a "magical" cup which they, according to Sherwood, may have been able to recognize as a real, real, non-magical technology, which thus presages the appearance of the modeled fifth current's secularism.⁵⁴ While Sherwood's work shows a midcentury exuberance for Western European triumphalism, another of its passages establishes the relationship between the first, second, and fifth currents, by way of the third and fourth currents, with the latter two not addressed by Sherwood.⁵⁵

and demonic, he nevertheless suggests that these circumscribed approaches cannot but express a divine, geometrical, mechanical appropriateness behind them."

⁵² See O'Brien, "Ars-Metrik," page 19: "The political implications of this ironic ending are intriguing. It leaves the tale without any viable figure of authority such as Arveragus or Theseus. On the one hand the tale exposes and rejects systems of thought as false authorities. On the other hand it imposes, through its undeviating irony, an authorial and divine authority that is as systematic and mechanical as anything in the tale. The mechanism called Thomas, in fact, becomes the instrument of that authority – he is no 'demonyak!'"

⁵³ See Sherwood, "Magic and Mechanics," page 574; this is the second of Sherwood's qualifications: "In the second place, the ultimate source of the magic "machines" of fiction is in many cases an ancient myth which was "modernized" to suit the contemporary [medieval] taste for mechanical toys."

⁵⁴ See Sherwood, "Magic and Mechanics," page 574; this quote ends the presentation of an episode from *Huon de Bordeaux*: "In the incident described here he is the victim of a practical joke which, to those among the author's public familiar with the 'tantalus cup' – and they were probably many – had an added piquancy. The ancient legend of the testing-cup was thus brought up to date. It is not the motif but its modernization that has its source in the 'engien d'esbattement.'"

⁵⁵ See Sherwood, "Magic and Mechanics," page 576: "The achievements of the Ancients in the field of mechanical science were preserved to a great extent by the Arabs and transmitted largely through Spain to the Western world. This work of transmission was accomplished by the close of the 13th century. [At least, in Spain – my comment]. But there were also translations made directly from the Greek. It was, however, the fact that Western researchers made important additions, through discoveries of their own, to the lore inherited from their Greek predecessors, that constituted the real revolution in science in the 13th century."

To Sherwood's credit, their work demonstrates the relationship between the first and second currents of thought, to the degree it acknowledges that both ancient Greek clepsydrae, and Islamic clepsydrae, featured automata. The body of research underlying this thesis did not feature identifications of ancient Egyptian automata which predate Heron, but if any existed, they too would fall under the modeled first current, for Alexandrine Egypt was part of the same Hellenistic world as Roman Greece.⁵⁶ Many lines in Sherwood support the thesis' model, except one line, which is unsourced: "Heron's *Pneumatics* and *Automatic Theater* were known in the West also, in the Middle Ages, in Greek, Latin, and Arabic translations."⁵⁷ While the design of at least one instance of pre-Modern and Early Modern automata, the notable case of the automaton Saint Prosper, suggests that at least one person in pre-Modern Europe indeed had these texts, there is far from a compelling case for their ubiquity.

In reading Sherwood, the sweep of automaton technology from Hero[n], to Arabic authors, to Latin authors, to French authors, to the French author of *Escanor*, and at one and the same time, to the automata at the Mongol court, shows the full intellectual-historical trajectory of the idea for the automata in *Escanor*, but thereby also shows the progression of the thesis' model through at least its first, second, and third currents of thought.⁵⁸ The Heronic source of the Amazon Camille's archer in another of the romances is also mentioned by Sherwood, showing the relationship between this thesis' first and third currents in a fictitious work; this relational progression can "skip" the second current in such works.⁵⁹

Sherwood, however, is only correct to a point; it is true that some of the romances of the late thirteenth, and especially the fourteenth centuries, were contemporaneous with the European automata to which they refer, but what they disregard is the fact automata are documented in the Arabic, Islamic world centuries before the European, Christian world, and that the later automata of the European, Christian world were inspired by, or derived from, Arabic, Islamic predecessors which were, in turn, inspired by, or derived from, those of the Greek, Hellenistic world. Taken together with the further fact that the romance tradition in Europe long

⁵⁶ See Sherwood, "Magic and Mechanics," page 578: "The water-clock is of ancient origin. It was known to the Egyptians, the Greeks improved it and the Arabs passed it on to the West."

⁵⁷ See Sherwood, "Magic and Mechanics," page 579: "The mechanical principles on which the machinery activating the puppets [automata] of such clocks and other 'magical' toys of the period, operated, were not discovered in the Middle Ages but were taken directly from two works of that master magician of the ancient world, Hero of Alexandria: the *Pneumatics* and the *Automatic Theater*. The Arabs, with their predilection for such ingenious playthings [*hiyal*], preserved the writings of Hero and followed his directions in the construction of their own automata. But Hero's *Pneumatics* and *Automatic Theater* were known in the West also, in the Middle Ages, in Greek, Latin, and Arabic translations."

⁵⁸ See Sherwood, "Magic and Mechanics," pages 579 – 580: "A remarkable instance of the extent to which such mechanics were familiar to the West occurs in the *Roman d' Escanor*, already mentioned. The magic tree with its trumpeting angel and singing birds, in the romance, recalls so strikingly, in certain respects, one or two of Heron's machines as to suggest that the author had a similar device in mind. In *Escanor*, the turning of the angel appeared to control the blowing of the trumpet and singing of the birds."

⁵⁹ See Sherwood, "Magic and Mechanics," page 580.

predates the centuries when European automata existed, the thesis' model is borne out – the foregoing is a delineation of the relationships between the first (Greek), second (Arabic) and third (European fictive, or “magical-realistic”) currents of thought.⁶⁰

Moving to Sullivan, an instance of pre-Modern or Early Modern automata noted in her article has the same mechanism as one of Heron's models, thus showing the jump from the first to the third current of thought in medieval European fictitious works, but not seen in the cases of automata categorized under Kang's third type (built automata).⁶¹ With respect to this noted automaton, the characterization of its music as “divine,” while admittedly rhetorical, is still a registration of this thesis' first current of thought. Interestingly, the automaton noted by Sullivan plays a hurdy-gurdy, a mechanical instrument, which is ironic, although most likely coincidental and of no greater meaning.⁶² Another automata in the same romance and scene under discussion by Sullivan was said to have “spiritual qualities,” suggesting it applies divine power in effecting miraculous healings, and thus registers the first current under the thesis' model – but since this automaton was not produced or provided directly by a deity, it cannot fall under Kang's first type in the latter's model. The mundane origin of this automaton, which is underscored in the succeeding line, places it under Kang's second type: the “great knowledge” referenced by Benoit de Sainte-Maure, the source romance's poet, is that held by the learned builders of the automata within the *Chambre de Beantes*, including both automata noted by Sullivan, within this romance's fiction.⁶³ An unambiguous delineation of the passage from this thesis' modeled first current to its modeled second current for real-life automaton technologies, and not those in fictitious conceptualizations of the same, is given by Swift on pages 59 – 60 of his article.⁶⁴

⁶⁰ See Sherwood, “Magic and Mechanics,” page 592: “The popularity of actual ‘engiens d'esbattement’ was responsible for the prevalence of automata in medieval fiction. The puppets of the poets were not so much, except by a kind of formula, the mysterious creations of magicians in distant lands and times as the rather more versatile literary counterparts of the animated toys which delighted their public.”

⁶¹ See Sullivan, “Medieval Automata,” page 7.

⁶² See Sullivan, “Medieval Automata,” page 15: “It [one of the four automata] was a source of such great delight, and played the rebec, the harp, the hurdy-gurdy, the rotte, the viol, the armonie, the psaltery, the cymbals, the tambourine, the monochord, the lyre and the chorus – these are the twelve instruments – so sweetly that neither the harmony of the heavens nor the celestial choirs are so delightful to listen to: it seems wholly divine.”

⁶³ See Sullivan, “Medieval Automata,” page 16: “A sweet smell comes from the gums burning inside the censer [held by the automaton] as soon as they begin to smoulder: no-one on earth can smell it and still be misled by foolish ideas. Their scent has spiritual qualities, for there is no sickness or pain you cannot be cured of once you smell it. It needed great knowledge to ensure that it would last and be stable for ever more; and so it would have been until the Day of Judgment, had the city not fallen as it did. (14918).”

⁶⁴ See Swift, “Robot Saints,” pages 59 – 60: “In the ancient world, writings on automatic machines with anthropomorphic qualities were concentrated in Hellenistic Alexandria, and much of this mathematical and engineering knowledge was translated and preserved in medieval Arabic libraries.”

Kang, in *Sublime Dreams*, names Hero[n] of Alexandria on page 1, paragraph 1, giving primacy to the foremost author associated with thesis' modeled first current.⁶⁵ Later, Kang includes a passage which contradistinguishes the "scientific revolution," a term cognate, for automata, with this thesis' modeled sixth current by way of its fifth current, with the term "magical," signifying this thesis' modeled third current for automata, and with the term "preternatural," which signifies this thesis' modeled first current for automata.⁶⁶ Interpreting Cohen, Kang imputes the appearance of the automaton concept to the divergence of this thesis' modeled fifth current from its modeled third current, and an ex-post-facto (post-fifth-current) "desire" to reconcile the two; this perspective disregards this thesis' modeled second current, but Kang is writing about Europe, not Arabia. In the same passage, Kang's mention of "divine power" is a return to the first current, and he is therefore suggesting Cohen contends that merging this thesis' modeled fifth current with this thesis' modeled third current (that is, science with magic), thus gaining a "true understanding of the nature of life" (perhaps an allusion to esotericism) would result in "divine power," which is taken to denote the presence of this thesis' modeled first current. Such argumentation is Frankenstein writ large – that one can admix the occult with science to animate the inanimate, and thus become a god.⁶⁷ In any event, Kang explicitly acknowledges the relationship between this thesis' first and second currents by naming Hero[n] as the "probable" source of Byzantium's "artificial wonders."⁶⁸

As a trend, Kang makes several references to the interconnection of the concepts of divinity and automata. By calling automata "wondrous creation[s] of ancient knowledge," he registers the first current, given that this first referent is the technology of the ancient world, which he distinguishes from an alternate characterization as "diabolical work[s] of heretical magic," one of his registrations of the third current, given that this second referent is the working of magic (and,

⁶⁵ See Kang, *Sublime Dreams of Living Machines*, page 1.

⁶⁶ See Kang, *Sublime Dreams of Living Machines*, page 19: "... the modern usage of the meaning [of 'automata'] that refers exclusively to the mechanical, a definition that arose in the seventeenth century in the context of the scientific revolution, when the word was established in direct opposition to the magical and the preternatural."

⁶⁷ See Kang, *Sublime Dreams of Living Machines*, pages 24 – 25: In response to John Cohen's work, Kang "deduces" as follows: "what is behind the robot fantasy is the desire to heal the apparent rift between the two worldviews [scientific and magical]. This could be achieved by gaining a true understanding of the nature of life, which would allow us to obtain mastery over the environment and transcend to a higher realm of existence through the divine power of bringing life to the lifeless."

⁶⁸ See Kang, *Sublime Dreams of Living Machines*, pages 55 – 56: "Even as he denigrates the Byzantines, Liudprand marvels at the greatness they inherited from the ancients, including the artificial wonders they possessed – probably based on the designs of Hero of Alexandria, such sophisticated mechanical knowledge having been lost in the Latin world after the fall of the Western Empire."

whenever this magic is necromantic, the seventh current would also apply).⁶⁹ A further reference to “divine automata” likewise registers the first current.⁷⁰

Of course, this thesis’ first current is not merely an identification of the religious significance attached to automata in the ancient world, but also the technologies which underlay these devices. Comprehension of this technology was regained by Western Europeans in the Renaissance, which constitutes the era and process associated by this thesis with its fifth modeled current, but this fifth current is intelligible as a secularization of the first current’s intellectual output, which Kang recognizes by his use of the phrase “ancient knowledge” when describing Long’s attribution of the classical heritage in the works of Kyeser and Fontana, the latter of whom was a notable builder of automata.⁷¹ This thesis’ first current is also present in the Renaissance-era writings of John Dee, which, per Kang, were informed by “the works of Ctesibius, and Hero[n];” the latter of these two authors is the best source from the classical world for this thesis’ definition of automata, as established.⁷² However, the intersection of this thesis’ first and fifth currents was not limited to the centuries traditionally associated with the Renaissance. Albertus Magnus’ description of a certain device, an aeolipiles, registers this thesis’ first and fifth currents centuries before the “Renaissance” in Kang’s citation of Lynn White’s scholarship, as the aeolipiles is of classical origin.⁷³ Near the conclusion of his book, Kang lists out disparate perspectives from European history on automata, and of these, the second “negative” perspective registers this thesis’ first and fourth currents.⁷⁴

⁶⁹ See Kang, *Sublime Dreams of Living Machines*, page 65: “So the automaton appears in literature alternatively as the wondrous creation of ancient knowledge and as the diabolical work of heretical magic, the former meant to arouse sublime awe and the latter horror.”

⁷⁰ See Kang, *Sublime Dreams of Living Machines*, page 75: “As for the oracular talking head itself, Arthur Dickson has pointed to a number of ancient sources for it, including Greek myths about divine automata, Egyptian animated idols, and Arabic stories featuring the use of a corpse’s head for prophetic purposes, also involving astrology.”

⁷¹ See Kang, *Sublime Dreams of Living Machines*, page 80: “And the historian of technology Pamela Long has shown that a number of new works on mechanics appeared in Germany and Italy in the fifteenth and sixteenth centuries – by such figures as Conrad Kyeser and Giovanni Fontana – that built on ancient knowledge with designs for original devices of mainly military purpose.”

⁷² See Kang, *Sublime Dreams of Living Machines*, page 90.

⁷³ See Kang, *Sublime Dreams of Living Machines*, page 322, endnote 71: “Lynn White has presented an interesting theory that the source of the talking head legends may be the description in Albertus’s *De Meteoris* of a device called an aeolipiles or fire-blower. Originally appearing in works of ancient engineers like Hero[n] and Vitruvius, it was a hollow metal vessel that was filled with water and heated. A blowing device then sent steam and water out of it through a hole and onto a fire, making the flames flare up. As verified by modern archaeologists through their findings in England, Germany, and other places, Albertus claimed that they were often made in the shape of a man, with the steam and water spraying out of its mouth or genitals. This report may have contributed to the legends, especially in connection with Albertus, but it is unlikely to be the source since the story attached to Gerbert is earlier and there are other more plausible origins of the talking head image. See White, *Medieval Technology and Social Change*, 90 – 91. For more on aeolipiles including archaeological findings, see W.L. Hildburgh, ‘Aeolipiles as Fire-Blowers,’ *Archaeologia* 94 (1951): 27 – 55.”

⁷⁴ See Kang, *Sublime Dreams of Living Machines*, page 305, *et seq.*

Understanding the prevailing perception of automata by their audiences is important for the correct understanding of this and other currents postulated by this thesis. Riskin, who writes that “divinity and vitality” were the hallmarks of this perception in the pre-Modern context, thereby delivers a statement which accords with the thesis’ model, as the notion of a “divine” automaton registers its first current, and also the first of Kang’s four types under his respective typology.⁷⁵ The “religious themes” noted by Riskin in these automata of the pre-Modern era register the first current of thought under my model.⁷⁶ Continuing associations drawn by Riskin between the physical locations of automata at pre-Modern worship sites, and therefore, between automata and religious practice, must also have been formed, perhaps implicitly, by medieval witnesses to religiously-inflected automata, which encapsulates the thesis’ postulated first current of thought.⁷⁷ Per Riskin, liturgical automata were the basis for later, secular automata, and this progression is illustrative of the trajectory from exclusively sacred subject matter, in sacred settings, under this thesis’ postulated first current of thought, to a mixture of secular and sacred subjects, in sacred settings, and eventually, in secular settings, under this thesis’ postulated fifth current of thought.⁷⁸ Thus, the “early intimacy between machinery and divinity” named by Riskin, perceptible in its own time, registers the first current of thought under the thesis’ model.⁷⁹

So, whether on the ground of setting, imagery, or technology, the heritage of the classical world looms large in the pre-Modern and Early Modern eras. Specifically, the classical corpus’ key figure, Hero[n] of Alexandria, remained the wellspring of the underlying mechanisms, which were linked to religious automata in

⁷⁵ See Riskin, “Machines in the Garden,” page 17: “From the early to mid-seventeenth century, at the hands of mechanist philosophers, matter and its mechanical combinations would be divested first of soul and then of life. This essay tours a mechanical culture that flourished before that development, in which machines represented precisely the capacities that the mechanists would later deny them: divinity and vitality.”

⁷⁶ See Riskin, “Machines in the Garden,” page 21: “Most early modern mechanical figures were found in cathedrals and exhibited religious themes. Many were connected with clocks, outgrowths of the church’s [capitalization?] drive to improve time-keeping for the better prediction of feast days, or with organs.”

⁷⁷ See Riskin, “Machines in the Garden,” pages 25 --- 26: “But automata were first and most extensively to be found in churches and cathedrals. Indeed, even before the clock and organ automata, as early as the mid-thirteenth century, the sketchbook of Villard de Honnecourt included rope-and-pulley controlled mechanisms, one for a mechanical angel that turned to point its finger at the sun and another for a mechanical eagle, the caption to which reads: ‘How to make the eagle face the Deacon while the Gospel is being read.’”

⁷⁸ See Riskin, “Machines in the Garden,” page 26: “Later, automaton Christs, angels, devils, and Virgins prepared the ground for mechanical animals of every variety and clockwork models of the cosmos itself. The Catholic Church was the cradle of the clockwork universe and its mechanical inhabitants. In the interest of calendar reform and of accurate predictions of feast days, the church sponsored both the astronomy and the technology of timekeeping. And the church also promulgated, in association with clock-work, the plurality of early modern mechanical images of people and animals.”

⁷⁹ See Riskin, “Machines in the Garden,” page 31: “The first part of this article has traced the predominantly Christian origins of androids and other mechanical creatures and described an early intimacy between machinery and divinity.”

his own designs; and when Riskin writes that “late medieval and early modern palace waterworks were informed by translations of ancient texts... and made virtually no changes to the ancient mechanisms,” and attributes these “texts” to Hero[n], this relationship between classical and medieval technologies clearly registers the first current under the thesis’ proposed model, even when the latter transposed the former to secular environments.⁸⁰ Indeed, the thesis’ first current must abet the secularization represented by its fifth, the rediscovery (Renaissance) of said first current’s technology in contexts that could be either sacred or secular, rather than exclusively sacred.⁸¹

Yet, importantly, it must also be acknowledged that reapplication of the classical technologies denoted by the thesis’ postulated first current is not exclusive to its postulated fifth current, but also to its second, since classical technologies were preserved in Islamic texts, which register the thesis’ second current, being products of Asian cultures.⁸² The first and second currents are differentiated by purpose and culture, but are alike in their close reliance upon Hero[n], which is underscored by De Solla Price in the latter’s remarks on the Islamic automata which partake of this thesis’ postulated second current; and these two currents are distinguishable from each other, and from the fifth current, by this formulation: the first was sacred, the second secular, and the fifth either sacred or secular, or by circumstance, potentially (or arguably) both.⁸³ It is this cultural dimension, the intent of the builders and audiences of automata, that is crucial to the analysis, since the same knowledge of the Heronic corpus which enabled the creation of automata was applicable in both the Islamic and Christian contexts, whether through the gradual transmission of this knowledge through this thesis’ postulated third and fourth currents, or through more direct transmission of the same via specific instances of migration, as when Moran presciently mentions “reintroduced Greek science and philosophy from the fall of

⁸⁰ See Riskin, “Machines in the Garden,” page 31, footnote 83: “Late medieval and early modern palace waterworks were informed by translations of ancient texts, notably the works of Hero[n] of Alexandria, and made virtually no changes to the ancient mechanisms.”

⁸¹ See Riskin, “Machines in the Garden,” Page 39: “A burgeoning literature on automatic machinery informed and accompanied installations such as the Palatine gardens waterworks. This literature began, as we have seen, with a series of ancient texts on mechanical and hydraulic automata, principally, in addition to Vitruvius’s *Ten Books*, the treatises of Hero[n] of Alexandria, which were repeatedly translated and printed over the course of the sixteenth century. In turn, these inspired modern works that borrowed extensively from the classical ones.”

⁸² See De Solla Price, “On the Origin of Clockwork,” page 25 in the author’s printed copy: “It is of the greatest interest to our theme that the Islamic contributions to horology and perpetual motion seem to form a closely knit corpus. A most important series of horological texts, including those of Ridwan and al-Jazari, have been edited by Wiedeman and Hauser. Other Islamic texts give versions of the water clocks and automata of Archimedes and of Hero[n] and Philo[n] of Alexandria.”

⁸³ See De Solla Price, “On the Origin of Clockwork,” page 26 in the author’s printed copy: “The Islamic tradition of water clocks did not involve the use of gears, though very occasionally a pair is used to turn power through an angle when this is dictated by the use of a water wheel in the automata. In the main, everything is worked by floats and strings or by hydraulic or pneumatic forces, as in Hero[n]’s devices. The automata are very elaborate, with figures of men, monkeys, peacocks, etc., symbolizing the passage of hours.”

Byzantium (1453)” – in that case, the relationship is instead between the postulated first and fifth currents, and through the mediation of the second current, and namely the Christian, West Asian civilization which had existed at Byzantium.⁸⁴

Regardless of the transmission route, once the first current’s automata reappeared in the context of the general European Renaissance, which extended beyond technological considerations, but also to every other civilizational dimension of that era’s European polities, their permeation into the curious minds of the Renaissance’s foremost intellectuals also became apparent. For instance, Moran notes that Leonardo da Vinci “...was reading classic Greek texts and had a keen desire to reproduce the science of these masters and perhaps to outdo them.” While da Vinci’s motivations cannot be ascribed at a personal level in this fashion, the relationship between the first and fifth currents is again discernible in the above quote.⁸⁵

While there is no hard evidence on offer to suggest that da Vinci was directly inspired by Pindar, Moran’s correct assertion regarding the relationship between da Vinci’s bell-ringer, an automaton design by the latter which is described by Rosheim, and ancient automaton-making technology shows the relationship between the first and fifth currents of thought under the thesis’ model. The mention of “magic” by Pindar is interesting, as that would register the model’s third current, but on the whole, there is nothing to suggest that the ancients found automata “magical” in the sense of the later usage of that term in the Middle Ages and Renaissance; yet the dismissal of “magic” by Pindar is akin to that found in the writings of Christian churchmen, and perhaps precisely because, as with the Christian authors, preternatural intervention, not magic, is taken to have a causative effect (although not necessarily exclusively, or in a literalistic sense, on motive action) for automata under this model’s ancient first current, that of the “divine” automaton (which has correspondences with, but is not a restatement of, Kang’s first type).⁸⁶

⁸⁴ See Moran, “The da Vinci Robot,” page 987: “Leonardo cultivated an early appreciation of classical knowledge and benefitted directly from the flow of newly reintroduced Greek science and philosophy from the fall of Byzantium (1453).”

⁸⁵ See Moran, “The da Vinci Robot,” page 987: “It was during this [Florentine] period that he [da Vinci] may have designed for Lorenzo Medici his first programmable, mechanical computer-controlled automaton. It is known that he was reading classic Greek texts and had a keen desire to reproduce the science of these masters and perhaps to outdo them. In 1478, his automaton was a three-wheeled mobile cart. It is almost a design to prove that he could create mechanical devices that might rival the Greek god, Haephestus. ‘... since he [Hephaestus] was working on twenty tripods which were to stand against the wall [of] his strong-founded dwelling. And he had set golden wheels underneath the base of each one so that of their own motion they could wheel into the immortal gathering, and return to his house: a wonder to look at.’” The “mobile cart,” if Rosheim’s interpretation is followed, was actually a component of (and therefore one and the same with) a figural automaton, a lion, making it a germane automaton under the thesis’ definitions for the same.

⁸⁶ See Moran, “The da Vinci Robot,” page 988: “Leonardo continued and advanced his fascination with ancient Greek science by developing fully animated automata, and by the age of 56, he designed a water-powered bell ringer using 12 interconnected chambers of actuate[d] float valves. His inspiration here was Pindar’s Seventh Olympic Ode (c. 520 B.C.) ... ‘And their ways teemed with sculptured forms like to beings that live and talk: and high waxed their renown. But in the man who has the craft-lore even the greater skill putteth itself forth without the guide of magic.’”

The figure of da Vinci, the most famed intellect of the Renaissance, is so well-known as to be clichéd. He was far from alone, however, in his consultation of ancient texts; and for other historical figures, the relationship between these ancient texts and their own output is less tenuous, and far more concrete. For example, the Manuscript of al-Muradi's technology is derived from the corpus of ancient technological treatises, not authors like Pindar; and aside from again demonstrating the presence of the modeled first current, even in later works, al-Muradi's activities illustrate the progression from the modeled first to second currents, inasmuch as they demonstrate the transmission of knowledge related to automata from the classical world (Heron et al.) to the Arab world (al-Muradi, the original author of the manuscript, and not Ibn Sid, its rediscoverer).⁸⁷ Moving from the medieval Arab world to medieval Western Europe, the contemporary archaeological recovery of a classical Tantalus bowl shows that Villard de Honnecourt's design for a chantepleure, one of the instances of pre-Modern and Early Modern automata cataloged in this thesis' fourth appendix, was a feasible design for a material-cultural object, and that this design was derived from classical predecessors, which is one indicator of the modeled first current. The technological provenance of Villard's bowl is thus demonstrated with a good standard of proof, and this connection to the classical world registers the thesis' first current, just as in the separate example of al-Muradi's text; of course, the design for Villard's bowl is surmounted by a true automaton per this thesis' definitions, whereas the recovered bowl merely incorporates the hydraulic "Tantalus" design while featuring a static figure within its interior.⁸⁸

The modeled first current is not limited to representations of classical culture in automata, such as, and quite often, especially the pantheon of deities, or to the automaton technologies of the ancient world, which were fundamentally religious in both subject matter and purpose, but to the linkage between religion and time, both as a concept and method of demarcation; and through that linkage, between religion and horology, with the understanding that automata have historically been most prevalent in horological instruments. Van Dyck, in his cited exhibition guide, writes "The astronomical determination of time had a special religious significance." This connection between timekeeping, science and technology, and religion persists from the classical world, where science and technology were used for religious-ceremonial displays of automata, but also for the non-automaton bearing Antikythera mechanism, which computed time for the purposes of marking religious observances; to the medieval Islamic world, where, once again, timekeeping had a religious purpose, but afforded the emergence of horological automata based in the automaton-making

⁸⁷ See Olive, "The Clepsydra of the Gazelles," page 11: "Ibn Sid was an Arab scientist working in the court of King Alphonse X of Spain, 'the Wise,' [who was] amazed to discover the hidden knowledge contained in the semi-destroyed pages of the Manuscript of al-Muradi, originally written in the XI cent. although the knowledge itself was reputedly of a much earlier origin: the mechanical principles which appear in the manuscript are attributed to a certain Seth, who has been variously identified as Philo[n] of Byzantium (? – 250 BC), Ctesibion [Ctesibos, Ctesibius, Ctesibus] (300 – 230 BC), Heron [of Alexandria] (c. 62 – 150) and Archimedes (287 – 212 BC)."

⁸⁸ See Weston, "Incredible Roman Tantalus Bowl," page 1 in the author's printed copy.

tradition of the classical world, and even in Islamic society, which generally prohibits representational art; to the early medieval Christian world, where time was mostly kept by the clergy for religious reasons of a similar nature, affording an opportunity for the emergence of horological automata, and especially after classical knowledge was recovered in the Renaissance.⁸⁹ Per Van Dyck, these religious connotations even persisted into the early seventeenth century. The “religious significance” of timekeeping, which was historically an impetus to the development of technology generally, and to horological technology specifically, and thence to the commonest material-cultural site of automata, registers the modeled first current of thought.⁹⁰

When Van Dyck writes that “...the clock was able to symbolize a more general idea that encompassed all the human arts and technology as an imitation of natural processes created by God,” this argument is reminiscent of both the “Intelligent Design” and “Clockmaker” arguments; but it also suggests the modeled first current, for if automata are construed as a development following from horological advancement (which need not be the case, but which will be assumed here *ad arguendo*), and if religion, the impetus to mimetic emulation of a deity’s ordering of the world’s time, is the basis of horological advancement, then observance of religion led to the development of automata --- and indeed, automata originally had religious purposes under the modeled first current, although they were not necessarily related to timekeeping in the classical world (since, as with later automata, the motions of automata would always occur within a fixed interval of time, and could also be triggered to recur at a fixed interval of time, without the moving automaton itself being intended or received as a clock); but yes, some were true timekeepers, such as the Gaza clock. This passage also resonates with Asimov’s Frankenstein complex, that the automaton *qua* concept is humankind’s attempt to actualize the ultimate emulation of the divine, the creation of a new consciousness, an act invariably construed by the Frankenstein complex as superbly vain foolishness which must end in failure, coded with moral righteousness, for the automaton-making project, the destruction of its automaton, and often the punishment or demise of the automaton-maker, which, in turn, registers the fourth current under my model as a narrative trope.⁹¹

⁸⁹ See Van Dyck, “Under Time’s Spell,” page 8: “It [the architecture of monasteries] introduced into the daily lives of the monastic inhabitants an order that could be a reflection of the Divine order of the cosmos. The astronomical determination of time had a special religious significance, as a result of which the monasteries played a crucial part in the cultivation of astronomy in the Middle Ages.”

⁹⁰ See Van Dyck, “Under Time’s Spell,” page 39: “This title page from an early seventeenth-century work [*Verclaringhe van ‘t ghebruyck des astronomischen ende geometrischen quadrants*] by the Ghent astronomer Philips Van Lansbergen shows two men carrying out measurements with astronomical instruments. As the inscription indicates, these actions always had a religious significance. But at the same time they were also very practical and enabled them to determine the time of day or the exact geographical location of the city they were in.”

⁹¹ See Van Dyck, “Under Time’s Spell,” page 73: “The clock has no input, such as the position of the sun, to transform into a measurement of time. All that could be said about it was that the virtually uniform movement of the cogwheels more or less imitated the rotation of the celestial sphere. It was the result of human inventiveness rather than of scientific insight. In this way, the clock was able to

As with Van Dyck's prior quote, which discusses the relationship between the observance of religion and the measurement of time, he offers another, "The clock imitates the divine order of the cosmos as measured using astronomical instruments. In a similar way, man had to endeavor to order his own life in imitation of the divine life of Christ," which relates to the modeled first current to the degree that automata frequently accompanied horological devices in the Christian world of the pre-Modern and Early Modern periods, but also in the Islamic world, meaning that it is generalizable, and not delimited to "imitation of the divine life of Christ." Whole species of automata, such as jaquemarts, emerged with clocks; and if clocks, in turn, emerged to imitate and understand the divine order of the world, so too did these jaquemarts, for instance. Of course, as already mentioned, there is the distinct question of whether automata are best understood as human attempts not so much to understand and imitate a divine being's ordering of reality, but to understand and imitate a divine being's creation of consciousnesses, the apprehension which leads to Asimov's Frankenstein Complex, the cliché that "there are some things man was not meant to know," and to tales which run from pre-Modernity, right down to modern speculative fiction, which make use of this plot device.⁹²

While the monotheistic religions, and in the West, Christianity, offer the concept of the soul, this concept is not limited to the doctrinaire sects of the same. Ensoulment, possibly through ancient *telestike*, or the occultic investiture described by Hermetic Ficinian magic (Ficino was the great *magus* of the Italian Renaissance), is suggested in a quote by Riskin, that "...designers of synthetic creatures have generally assumed a role for something nonmechanical, something other than a self-contained system of interacting parts," a thought which might register the modeled first or third currents; the first, if the animating energy of a deity, and the third, if a soul entrapped by magic, whether that of a mortal, or angel, or demon.⁹³ Per Riskin, the recognition of consciousness as a concept distinct from spiritual energy occurs ca. 1650, at the end of this thesis' period of study; in contradistinction to "consciousness," she also explicitly names "soul" as a possible animating source for lifeforms, including artificial lifeforms, and this is the understanding which gives rise

symbolize a more general idea that encompassed all the human arts and technology as an imitation of natural processes created by God."

⁹² See Van Dyck, "Under Time's Spell," pages 77 – 78: "This fifteenth-century miniature is on the first page of the French translation of Suso's extremely popular *Horologium Sapientiae*, 'the clock of wisdom.' This work explains in 24 chapters how one can lead a virtuous life by imitating Christ. This immediately explains the title and content of the miniature. The clock imitates the divine order of the cosmos as measured using astronomical instruments. In a similar way, man had to endeavor to order his own life in imitation of the divine life of Christ."

⁹³ See Riskin, "Introduction: The Sistine Gap," pages 1---2: "Together, the essays collected here offer an unexpected and far-reaching result: they find that attempts at artificial life have rarely been driven by an impulse to reduce life and mind to machinery. On the contrary, designers of synthetic creatures have generally assumed a role for something nonmechanical, something other than a self-contained system of interacting parts. These designers and the respondents to their work have produced many and varied accounts of what the nonmechanical something might be, and of how it might engage with bodily mechanism."

to the concept of Ficinian investiture, which is, crudely, the entrapment of an individual, energetic, and usually preternatural spiritual force within an artificial figure (although, in fairness, effigies are only animated by such energies in medieval romances).⁹⁴

The shift from the conceptualization of automata under the modeled “sacred” first current of thought, to the “secular” fifth current of thought, and thence to the sixth current of thought, in which the “human agency” would come to be celebrated in humanistic terms, is identifiable in another of Riskin’s statements, “...human agency was gradually replacing divinity as the source of the spiritual or lively presence within [automata].” Of course, this trajectory is appropriate because European automaton instances and history are discussed by Riskin, whereas if those of Asia were substituted, the modeled second current of thought would replace the fifth in this trajectory.⁹⁵ That this “replacement” was never truly complete, and that the sacred dimension of automata never totally disappeared, is confirmed by another of Riskin’s statements in her introduction to her edited anthology *Genesis Redux*, one concerned with King’s contribution to the same: an acknowledgment of the “...devotional belief with which he [Torriano’s automaton monk] and his mechanical kind were invested,” although the later date of this automaton monk’s appearance is incongruent with a narrative trajectory of continuous change. The above quotation registers the modeled first current of thought, given that Riskin notes King’s identification of the religious purpose and iconographic attributes of the automaton monk, a representation, per King, of Diego de Alcala, a saint associated with the preternaturally miraculous by his very hagiography.⁹⁶

Maisano, published in the same anthology, establishes for purposes of this thesis that the “quasi-spiritual” perception of automata, from its original ritual sense in the Hellenistic era, to the senses of subsequent recapitulations in the periods relevant to this thesis, did extend until the lifetimes of Shakespeare and Descartes, enduring until the close of this thesis’ period of study; and every such recapitulation

⁹⁴ See Riskin, “Introduction: The Sistine Gap,” page 6: “Efforts to create life and mind in machinery have spawned ever-new renditions of that other something, from consciousness in the mid-seventeenth century, to information in the mid-twentieth. From soul to consciousness to software, successive theories of life have retained central, nonmechanical elements, and these frequently steal center stage in this collection.”

⁹⁵ See Riskin, “Introduction: The Sistine Gap,” page 24: “At the same time, King writes, the monk exemplified a shift in the way such images were seen – the same shift chronicled in Grafton’s story of the automaton devils of Giovanni Fontana – in which human agency was gradually replacing divinity as the source of the spiritual or lively presence within [automata].”

⁹⁶ See Riskin, “Introduction: The Sistine Gap,” page 24: “Its [the automaton monk’s] potent combination of clockwork, artistry, iconic [as in a religious icon] imagery, and Christian legend brings King to a conclusion whose surprise is a shock of recognition: the monk epitomizes ‘the birth of the machine [as a concept] in the Age of Faith’ and the continued burden [a subjective term] of devotional belief with which he [Torriano’s automaton monk] and his mechanical kind were invested [by using the term ‘invested,’ Riskin inserts a possible pun, or allusion, to Ficinian magic, which would be antithetical to King’s hypothesis regarding the automaton monk’s intended use as a religious object].”

must register the modeled first current of thought.⁹⁷ One of the foremost identifiable automata of the sixteenth century, to which this and other works oft-times return, and which does recapitulate the first current, is Turriano's automaton monk; for, given Ambrosio de Morales' account in his history, *Las antigüedades de las ciudades de Espana*, Turriano's motivation in creating another one of his automata was to "create anew the ancient statues which moved and, on that account, were called automata by the Greeks," and there is no reason to disbelieve this was also, to some degree, his motivation in creating the monk, although the monk nevertheless would register the modeled first current, given its legend, appearance, and conjectured identity, notwithstanding an ex-post-facto interpretation of Turriano's mentality as its builder. That de Morales explicitly writes Turriano was inspired by the technology of ancient Greece, and that the latter sought to imitate and revive the same, is sufficient to identify at least two different senses of the modeled first current for the case of the monk.⁹⁸

King, in her contribution to Riskin's anthology, which concerns the monk, which is her subject of scholarly interest, makes a distinction between two groups of Renaissance automata: "animated figures of pagan myth (and often the figures of play: Diana, Cupid, or Bacchus)" and "pieces representing biblical figures and Christian themes." This distinction is dissolved by this thesis' model, under which both such groups register the first current of thought, in addition to the fifth current of thought, and potentially two others, the sixth or fourth current of thought, depending upon the context and historical circumstances surrounding any given instance of Early Modern automata. Delimitation to that period, as opposed to inclusion of the earlier pre-Modern period, is made necessary by King's invocation of "the sixteenth century" when establishing these groups (and, of course, delimitation to the fifth current also applies, since King is only discussing European automata).⁹⁹

⁹⁷ See Maisano, "Infinite Gesture," page 75: "Both the Cartesian [Descartes] cogito and Hamlet's thing 'within which passes show' are fantasy figures of consistency, competency, and self-control. So, too, are Renaissance automata. Elizabeth King's discussion in this volume of a sixteenth-century automatic monk who prays continuously, whether for himself or others, is a perfect example of how a machine's endurance and efficiency can set the (impossible) standard for human conduct. With this superhuman and quasi-spiritual dimension of Renaissance automata in mind, it is important to note not only that Hermione is believed to have been dead for some sixteen years prior to the final scene, in which she appears as 'a pretend automaton,' but also that the famous 'statue scene' is not the first time that Hermione has made a visit from beyond the grave."

⁹⁸ See King, "Perpetual Devotion," page 272: the following is King's translation of Ambrosio de Morales' Old Spanish passage from *Las antigüedades de las ciudades de Espana* (1575): "Juanelo as a diversion also wanted to create anew the ancient statues which moved and, on that account, were called automata by the Greeks. He made a lady more than one *tercia* high [about one foot tall] who, placed on a table, dances all over it to the sound of a drum which she meanwhile beats herself, and goes round in circles, returning to where she started. Though it is a toy and fit for mirth, it is nevertheless a great proof of his high intelligence."

⁹⁹ See King, "Perpetual Devotion," page 288: "'We continually remap the border between useful things and frivolous ones, regardless of the complexity of the objects themselves. Among classes of automata unique to the sixteenth century [this dimension of 'uniqueness' is ill-conceived, and probably erroneous] – figure clocks, musical tableaux, dancing animals, animated figures of pagan myth (and

The monk, despite the disproportionate attention it receives in scholarship, is far from the only automaton of interest to this thesis, just as the achievements of Western European culture it represents are not the singular achievements, from a single cultural zone, to have ever resulted in the realization of automaton technologies. In his foreword to Donald R. Hill's translated edition of al-Jazari's treatise, Lynn White, Jr. mentions "...Muslim transmission of Hellenistic, Far Eastern, and indeed Muslim inventions to the West." Here, the "narrative" progression from the first current, the Hellenistic world, to the second current, in this case, the Islamic world, and thence to the fifth current, the Europe of the Renaissance, sometimes at earlier, medieval dates, or in later, Reformation dates, by way of the third and fourth currents, ("magic" in fiction and myth, and persecution of the technologist on the ground of "magic," respectively), is clear.¹⁰⁰ That Muslim authors "transmitted" the "inventions" of the ancient, "Hellenistic" world demonstrates the presence of the modeled first current, regardless of whether the subsequent cultures under discussion are those of the Islamic Golden Age or the European Renaissance.

The technologies of the Islamic world were indeed based in those of the Hellenistic world; and if the designs for basins in another source, the treatise written by the Banu Musa, medieval Muslims, are among the "trick vessels" referenced by Donald R. Hill in his introduction to al-Jazari's later treatise, when Hill writes that they "are [were] very similar to the devices described by Philo[n] and Heron, and are [were] almost certainly derived from these," the connection to automata is complete, since the Banu Musa's designs for basins contained some figures which this thesis is prepared to consider automata by its own definitions.¹⁰¹ From Hill's preliminary presentation of another of al-Jazari's predecessors in the West Asian automaton-building tradition, "Archimedes" and his clock, a technical source known to al-Jazari, it is unclear if "Archimedes'" clock did or did not have automata; but even if automata were not present, this clock still a valuable evidentiary point, given that it clearly establishes the connection between the modeled first and second currents for other clocks and devices which indisputably contained automata.¹⁰² Whether the "Archimedes" clock did or did not feature automata, al-Jazari's and Ridwan's "constant-flow clocks" do contain automata (al-Jazari's castle and drummer-clock, and Ridwan's only clock, have figural automata), and the "transmission between the

often the figures of play: Diana, Cupid, or Bacchus) – one finds a considerably less ludic subgroup of pieces representing biblical figures and Christian themes."

¹⁰⁰ See al- Jazari, *Book of Knowledge*, Page XIII (13), from Lynn White, Jr.'s "Foreword:" "These examples, ['conical valves,' 'segmental gears,' and 'metal casting in closed mould (SIC) - boxes with green sand'] and others, suggest Muslim transmission of Hellenistic, Far Eastern, and indeed Muslim inventions to the West."

¹⁰¹ See al- Jazari, *Book of Knowledge*, Page 9, from Donald R. Hill's "Introduction:" "In design and operation these [the Banu Musa's 'trick vessels for dispensing liquids'] are very similar to the devices described by Philo[n] and Heron, and are almost certainly derived from these... The main differences between the Banu Musa devices and those described by the Greek writers, apart from the greater complexity of the former, is that the Banu Musa make use of properly fitted cone-valves, whereas Philo[n] and Heron mention only crude clack-valves and plate-valves."

¹⁰² See al- Jazari, *Book of Knowledge*, Page 10, from Donald R. Hill's "Introduction."

classical writers and the later Islamic craftsmen” identified by Hill is therefore of direct relevance to this thesis’ model, for it registers the first current, the passage of automaton-making technologies, including underlying motive methodologies, from the Hellenistic to Islamic worlds.¹⁰³

As regards pseudo-Archimedes, Hill cites Drachmann, who opined that “pseudo-Archimedes was the work of a Muslim inventor who put together details from several sources, one of them doubtless Philon, another probably Heron.” This intellectual-historical lineage demonstrates the relationship between the modeled first and second currents, that is, the transmission and reception of automaton-making knowledge from the classical world to the Islamic and Byzantine worlds of the Middle Ages.¹⁰⁴ Hill subsequently underscores this point, again demonstrating the relationship between the modeled first and second currents of thought, that is, how automaton-making technologies were transmitted from the classical world to the Islamic and Byzantine worlds.¹⁰⁵ The societies of these two worlds expanded upon the classical inheritance of automaton-making technologies, rather than simply reproducing it; yet even in the case of simple reproductions, such as a medieval Italian reproduction of Heron’s moving theater automaton design (which registers the modeled fifth current), every current other than the first, even when simultaneously applicable with the first, is still, of itself, distinct from the first on grounds of historical culture, even when the classical technologies of the first are reapplied in a given instance of pre-Modern or Early Modern automata without modification.¹⁰⁶

¹⁰³ See al- Jazari, *Book of Knowledge*, Page 10, from Donald R. Hill’s “Introduction:” “Drachmann has written a valuable criticism of this clock [the ‘Archimedes’ clock], based upon the translation of Wiedemann and Hauser, and comes to the conclusion that it was the work of a Muslim inventor who put together details from several sources, one of them doubtless Philo[n], another probably Heron. I [Hill] see no reason to contest this opinion, in view of the many similarities between this clock and the devices of the two earlier writers. Since both Ridwan and al-Jazari acknowledge the derivation of their constant-flow clocks from that of ‘Archimedes,’ we are safe in assuming that it is an important transmission between the classical writers and the later Islamic craftsmen.”

¹⁰⁴ See al- Jazari, *Book of Knowledge*, under Hill’s “General Notes,” page 271. Hill writes the following: “It was Drachmann’s suggestion that the pseudo-Archimedes was the work of a Muslim inventor who put together details from several sources, one of them doubtless Philon, another probably Heron. Vitruvius, particularly in his transmission of Ctesibios’s clocks, may also have been used as a source. The suggestion is credible, although many of the devices in Philo[n] and Heron’s treatises on pneumatica have more affinity with the Banu Musa than with the pseudo-Archimedes. Certainly jack-figures [automata], siphons, floats and air vessels occur in Heron and Philo[n], while Heron in his *Mechanics* has several examples of gears. (I tend to agree with Drachmann that much of Heron’s work on gears was purely theoretical.) In the Arabic MS of Philo[n] there is a tipping-spoon, very similar to that described in the pseudo-Archimedes, and this is described as ‘similar to the operation of a clock.’”

¹⁰⁵ See al- Jazari, *Book of Knowledge*, under Hill’s “General Notes,” page 271. Hill writes the following: “To summarize, we can say that there is little in the design of al-Jazari’s first and second clocks that is not found in the pseudo-Archimedes, and little in the pseudo-Archimedes that is not found in the Greek writers.”

¹⁰⁶ See al- Jazari, *Book of Knowledge*, under Hill’s “General Notes,” page 271. Hill writes the following: “There was therefore nothing new in the idea of a sinking float used as a timing device, rather like a simple clepsydra in reverse. I have, however, found no record, other than in al-Jazari, of the use of a *tarjahar* [sinking float] as the driving mechanism of a monumental water-clock. At the

Independently of whichever other currents may also be interpretatively assigned as applicable under the proposed model, re-use of classical technology in medieval automaton-bearing devices, as when Hill writes “floats are used extensively by the Banu Musa, probably deriving from the works of Philo[n]n and Heron, where they occur frequently,” registers the first current of thought.¹⁰⁷

Yet another rehearsal of the thesis’ model is offered by Hill, who writes “Jackwork appears in the works of Ctesibius, Philo[n], and Heron, and in Chinese and Byzantine machines. The Muslim craftsmen were particularly fond of these human and animal figures.” “Ctesibius, Philo[n], and Heron” comprise core primary source authors corresponding to the modeled first current of thought, whereas “Chinese and Byzantine machines,” and the works of “the Muslim craftsmen,” correspond to the second current of thought, with Hill’s recitation of the names “[pseudo-] Archimedes,’ the Banu Musa, Ridwan and of course... al-Jazari” in the continuation of this cited quotation providing core primary source authors for the proposed second current. It is tempting to suggest that automata like al-Jazari’s figures in “beaten copper” and “beaten brass” were the direct inspiration for “things of brass” under the modeled third current, but many of al-Jazari’s metal automata were subsequently cold-painted. Only those of al-Jazari’s brazen and copper automata which had a golden and “metallic” coloration could be advanced as evidence for such an argument, and there are some such automata in al-Jazari. The dragon-like serpents in al-Jazari’s elephant clock, and the two falcons in the castle clock, are some examples of “unpainted” brass that would presumably have had the coloration and sheen associated with “things of brass” in the medieval European imaginary. al-Jazari’s design for his standing automaton figure which performs the humorous action of extracting a proffered libation from a fish’s gullet is named by Hill as the sole design for a brazen automaton, in that case, one with cold-painting, which is given with highly specific fabrication and assembly details under the corpus of works in the West Asian automaton-making treatises.¹⁰⁸

beginning of 1.4 al-Jazari tells us that he made many clocks using the *tarjaha*, but makes no mention of any predecessors who built similar clocks. In the light of present knowledge the question as to the originator of this design must be left open – it may, of course, have been al-Jazari himself.”

¹⁰⁷ See al- Jazari, *Book of Knowledge*, under Hill’s “General Notes,” page 276. In the section for “Individual Components,” and under the subsection “Vessels and their Fittings,” Hill writes the following: “Floats are used extensively by the Banu Musa, probably deriving from the works of Philo[n]n and Heron, where they occur frequently.”

¹⁰⁸ See al- Jazari, *Book of Knowledge*, under Hill’s “General Notes,” page 277. In the section for “Individual Components,” and under the subsection “Miscellaneous Parts and Fittings; Materials,” Hill writes the following: “Jackwork appears in the works of Ctesibius, Philo[n], and Heron, and in Chinese and Byzantine machines. The Muslim craftsmen were particularly fond of these human and animal figures, which occur in the works of ‘Archimedes,’ the Banu Musa, Ridwan and, of course, in al- Jazari. Al-Jazari made them from beaten copper, beaten brass, wood, or papier mâché. I have not come across any detailed instructions for the manufacture of these figures, apart from al-Jazari’s description (II. 7.2) of the manufacture of a copper ‘man’ (*shakhs*).”

THE SECOND CURRENT OF THOUGHT.

After the fall of the Western Roman Empire, the decline of Greek in Western Europe ensured the Hellenic tradition of automata, as represented by the Heronic corpus of engineering, was accessible only to those holders of its texts who retained the Greek necessary for their comprehension. The two entities which met both such criteria were the Eastern Roman Empire, known to history as the Byzantine Empire, and the ‘Abbasid Caliphate. Both continued the tradition of automaton-building, yet importantly, these cultural centers neither produced automata in the form of gods nor liturgical applications of automata. While broad claims are difficult to adduce, the secularization of automata, a current of mechanical thought in the Byzantine Empire and the ‘Abbasid Caliphate, is attributable to the respective currents of religious thought in these polities: in the Byzantine Empire, the emergent theological trend of iconoclasm precluded figural automata in the forms, figures, and characters of God, His saints, His angels, and any other religiously-inflected category; in the ‘Abbasid Caliphate, the general Islamic injunction against any figural representations, and especially of Allah Subhanahu wa Ta‘ālā, firmly precluded religious automata, although impressive secular automata with human figures were nevertheless designed and built. Thus, two currents of thought respective to automata are already discernible – the first partakes of the Hellenic tradition and entails design and use of figural automata for religious display or veneration, while the second articulates automata as secular objects.

More specifically, the second current of thought associates automata with science, engineering, and craft expertise, and it makes this association respective to automata that are specifically intended to divert the attention of their audiences as marvelous or amusing contrivances. The automata of al-Jazari fall into to this trend. While it probably seems reductionist to draw a simple equation of the sacred automaton with the classical, Hellenized societies of ancient Greece and Rome and the secular automaton with the Dar al-Islam, it is nevertheless true that this thesis has found no evidence that automata were constructed in the form and figure of the deity, or in the forms or figures of Wali, the Islamic saints, in any area historically associated with Islam during any of the considered centuries. By contrast, the thesis has identified several instances where Jesus Christ, God the Son to Christians, and Christian saints including the Virgin Mary, Saints Balthazar, Caspar and Melchior (the Magi), Saint Diego Alcalá, and Saint George of Lydda were specifically depicted as automata in greater or lesser recapitulations of the first current of thought. Unlike these examples, the automata of the second current are uniformly secular and also generic in that, while unmistakably humanoid as figural (biological) automata, they depict neither deities, nor individual characters, such as the heroes of classical myths, nor specific historical figures. Here too is a point of divergence, as the European automata of forthcoming currents occasionally featured automata deliberately made in the images of Holy Roman Prince-Elector Augustus von Sachsen or Queen Elizabeth I of England, for example.

Another point of divergence which distinguishes the second current of thought from its predecessor and from the subsequent currents of thought is the consistent location of the secular, generic automaton, unconnected either with gods, monsters, existent people, the cults of heroes, or anything else suggestive of derivativeness from the religious or political lives of humans, in venues and settings which are correspondingly secular and mundane. Automata of the second current, more so than the others, are expressly intended to entertain within the sphere of entertainment. Whereas the automata of the other currents, including the first, were frequently situated in temples, cathedrals, or churches, those of the second current were frequently intended for use in courtly events understood by all participants to have been festive drinking-parties. While it might be contended that the automata of Hesdin were similarly intended to heighten the atmosphere of conviviality at courtly functions, Merriam Sherwood and E.R. Truitt have both noted, by presenting translations of the itemized amounts payable to the automaton-builder Colard le Voleur, that the European automata of Hesdin, which share some commonalities with those of the second current in that they were not emplaced in churches but in courtly settings, nevertheless operated in a distinctly different register: the amusement they provided came at the expense of those courtiers to whom the automata were first introduced, with automaton jesters having even been constructed to physically beat aristocratic visitors to Hesdin in the fifteenth century.

EXAMPLES OF THE SECOND CURRENT OF THOUGHT.

In discussing the second modeled current, one of its notable characteristics is a tendency to appear in conjunction with bypasses of other such currents. For example, Farmer notes that “during his sojourns in Sicily and southern Italy, Robert [II d’Artois] may also have learned about the mechanically driven Islamic sculptures and sculpturally adorned water clocks... [or] he would have become familiar with the idea of such wondrous artifacts through his reading of the *Cleomades*.” The modeled second, third, and fifth currents are in play here; the second, given Farmer’s interpretation of Islamic inspirations for Robert II d’Artois’ great project, the establishment of automata at his estate, Hesdin; the third, given that Farmer also interpretatively suggests that Robert II d’Artois’ reading of the *Cleomades*, a romance containing magical representations of automata, could also have also inspired Robert in this undertaking; the fifth, given that Robert II’s court constructed real-life, material-cultural automata; and yet not the fourth, as there is no evidence that Robert, who himself directed the program of improvements at Hesdin, persecuted those who realized his estate’s automata, which were, of course, fashioned at his own behest. This suggests an aristocratic bypass of at least the modeled fourth current in point of fact, but only for the highest levels of the medieval Western European aristocracy.¹⁰⁹

Farmer remarks that “In one way or another – either through literature or direct experience – Robert [II de Artois]’s moving monkey statues and other mechanical devices were probably inspired by models coming from the Islamic world.” This argument is again reflective of an aristocratic bypass of at least the proposed fourth current of thought, and possibly also the third current of thought if only “direct experience,” and not “literature,” exposed Robert II de Artois to pre-Modern automata. Thus, in this case, a jump would seem to be made from the proposed second to fifth currents, without acknowledging the third current; but as Farmer establishes, it is likely that the proposed third current was also a mediating factor, given that “an illustrated *envoi* to Count Robert” is present in early manuscripts of the *Cleomades*.¹¹⁰ However, in that case, it should not necessarily be assumed that Robert II d’Artois or his court believed in the magical efficacy of automata, particularly if he had personally observed discrete examples of this technology.¹¹¹ It can only be said, in this case, that high aristocrats could bypass the

¹⁰⁹ See Farmer, “Aristocratic Power and the ‘Natural’ Landscape,” pages 677 – 678: “During his sojourns in Sicily and southern Italy, Robert may also have learned about the mechanically driven Islamic sculptures and sculpturally adorned water clocks that had belonged to King Roger II of Sicily and the Emperor Frederick II. And even if he did not learn about those mechanical devices, he would have become familiar with the idea of such wondrous artifacts through his reading of the *Cleomades*, a French romance based on one of the tales of the Arabic *Thousand and One Nights*. Robert’s contemporary Adenet Le Roi wrote the French tale, and several of the earliest manuscripts of the text, which include an illustrated *envoi* to Count Robert, suggest that Robert was familiar with the text.”

¹¹⁰ Ibidem.

¹¹¹ See Farmer, “Aristocratic Power and the ‘Natural’ Landscape,” page 679: “In one way or another – either through literature or direct experience – Robert’s moving monkey statues and other mechanical devices were probably inspired by models coming from the Islamic world.”

fourth current, for their worldliness, travel, and especially education could mitigate superstitious apprehensions of automata, although not necessarily in all cases, or for every individual (and indeed, clergymen were most susceptible to the persecutorial, fearful apprehension of automata, even throughout the centuries of history examined by this thesis).

In her discussion of *The Cleomades*, Farmer references an early twentieth-century work by H.S.V. Jones, “The Cleomades, the Meliacin, and Arabian Tale of the Enchanted Horse,” at footnote 131. When Jones’ work is, in turn, consulted, it is evident, on page 236 of the same, that in the earliest narrative of the “hors of brass,” or “brazen horse,” tradition, the maker of this horse is presented as a craftsman, not as a sorcerer, at least according to an eighteenth-century account collected from a source with authentic knowledge of the tale. Interestingly, in some of these earlier versions, the horse is not even brazened, but has a dark coloration comparable to that of certain natural horse breeds, despite the horse being indisputably artificial, a technical work produced by human ingenuity. Thus, this thesis’ proposed second current of thought is again justified, as the original presentation of the “hors of brass” was secular, and is more akin to a fictitious extrapolation from the very real automaton-building history of the West Asian technicians, and less akin to the magical conception of automata which predominated in the medieval Western European romances, the romantic trope into which the notion of a mechanical horse was subsumed.¹¹²

The secular automata of the second current of thought are noted by Fliegel, although not in those terms; he references the “mechanical contrivances” of the “Byzantine and Muslim worlds,” which are precisely the same cultures which, by their outputs in the considered period, are the chief exponents of this thesis’ proposed second current.¹¹³ The progression from the second to third currents of thought is evident in Sherwood, who opined that “the similarity between the real automata of the Oriental courts and the imaginary ones of the romances cannot be due to chance,” with the “real automata” being those of the modeled second current, and the “imaginary ones” being those of the modeled third current; and, with this section being concerned with the former, second current, the “real ones” are its proof and index, with Fliegel’s “Byzantine and Muslim worlds” being one and the same with Sherwood’s invocation, in dated language, of “Oriental courts.”¹¹⁴

Sherwood makes an oblique reference to “a Moslem work on water-clocks,” and this work could be al-Muradi’s treatise, which contains many automata; if so, it represents how the proposed second current, bearing the knowledge of the proposed

¹¹² See Farmer, “Aristocratic Power and the ‘Natural’ Landscape,” page 679, footnote.

¹¹³ See Fliegel, “The Cleveland Table Fountain and Gothic Automata,” page 6: “Mechanical contrivances that spouted water or wine, that startled and entertained guests, and that impressed through sheer technical ingenuity are known to have existed in the Byzantine and Muslim worlds.”

¹¹⁴ See Sherwood, “Magic and Mechanics,” page 573: “Although the performances of the automata described by some of the poets undoubtedly surpass any recorded or even conceivable achievement of actual machines, the similarity between the real automata of the Oriental courts and the imaginary ones of the romances cannot be due to chance.”

first current, entered medieval Europe; Spain is usually noted in this connection.¹¹⁵ This is corroborated by Sherwood's scholarship, which can show a certain midcentury exuberance for "Western" triumphalism; but even so, in writing "The achievements of the Ancients in the field of mechanical science were preserved to a great extent by the Arabs and transmitted largely through Spain to the Western world," Sherwood is, essentially, stating elements of the model proposed by this thesis in outline, since this passage establishes the relationship between this thesis' first, second, and fifth currents by way of its third and fourth currents, with the latter two omitted in the cited source.¹¹⁶

The relationship between the first and second current of thoughts is demonstrated by technologies which may not immediately or necessarily be associated with automata, in transmission through Spain or elsewhere, such as clepsydrae. Both ancient Greek and Islamic clepsydrae could feature automata. This thesis' course of research has not revealed any ancient Egyptian automata which predate Heron, in clepsydrae or otherwise, but if these existed, they too would fall under the first current, especially as Alexandrine Egypt was part of the same Hellenistic world as Roman Greece.¹¹⁷ Sherwood's rehearsal of the modeled relationship is fairly straightforward: "...[automaton technologies] were taken directly from two works of that master magician of the ancient world, Hero[n] of Alexandria: the *Pneumatics* and the *Automatic Theater*. The Arabs, with their predilection for such ingenious playthings [*hiyal*], preserved the writings of Hero[n] and followed his directions in the construction of their own automata." Everything in this quotation supports the thesis' proposed model. One final contention advanced by Sherwood in this connection, that "...Hero[n]'s *Pneumatics* and *Automatic Theater* were known in the West also, in the Middle Ages, in Greek, Latin, and Arabic translations," could very well be true, and add nuance to the conventionalized simplification offered by the thesis' model (which is one of its advantages); but this contention is unsourced, and Sherwood makes no references to specific manuscripts, codices, or other documentary evidence of translations from the Heronic corpus in medieval Europe, where Greek translation is commonly considered to have been an extreme rarity.¹¹⁸

¹¹⁵ See Sherwood, "Magic and Mechanics," page 576: "In Spain, Alfonso the Wise caused a Moslem work on water-clocks to be translated from Arabic."

¹¹⁶ See Sherwood, "Magic and Mechanics," page 576: "The achievements of the Ancients in the field of mechanical science were preserved to a great extent by the Arabs and transmitted largely through Spain to the Western world. This work of transmission was accomplished by the close of the 13th century. [At least, in Spain – the author's comment.] But there were also translations made directly from the Greek. It was, however, the fact that Western researchers made important additions, through discoveries of their own, to the lore inherited from their Greek predecessors, that constituted the real revolution in science in the 13th century."

¹¹⁷ See Sherwood, "Magic and Mechanics," page 578: "The water-clock is of ancient origin. It was known to the Egyptians, the Greeks improved it and the Arabs passed it on to the West."

¹¹⁸ See Sherwood, "Magic and Mechanics," page 579: "The mechanical principles on which the machinery activating the puppets [automata] of such clocks and other 'magical' toys of the period, operated, were not discovered in the Middle Ages but were taken directly from two works of that

In one case identified by Farmer, that of the automaton-bearing device in the romance *Escanor*, the pedigree of this imaginary, intellectual-cultural machine can be traced in accords with the thesis' proposed model. As noted by Sherwood, its technology is Heronic, registering the proposed first current; per this thesis' modeling, this Heronic technology was transmitted via the Christian and Islamic civilizations of West Asia, although in Sherwood's own narrative, transmission through Europe itself would instead apply. If this transmission had a West Asian origin, which is considered likelier, the second current of thought would be registered. Regardless of how *Escanor*'s author became familiar with Heronic automata, the presentation of this technological article in a romance, in a fictitious setting replete with magical creatures, registers the third current of thought, moving from West Asia to realms of Latin, and finally French culture, whence *Escanor* emerges. A comparable device at the Mongol court, designed by a French engineer, is a mélange of modeled currents, evocative of both Heron and the romances in an East Asian setting, although the limitations of its particular circumstances, and intention of its use case, necessitated fakery. In the case of *Escanor*, the full trajectory of the idea for its noted automaton is shown by the progression of the thesis' proposed model through at least the first, second, and third currents of thought.¹¹⁹

Contrary to Sherwood, in this thesis' considered view, automata in medieval fiction were not placed in the "Orient" because it was a "land of enchantments," but because the proposed second current of thought predates the proposed third current as a historical development, that is, because the "Orient" had automata before the "Occident," even if it is emphasized, as in Sherwood, that the "Occident" produced its own pre-Modern automata (which is not presented as a point with much specific supporting evidence, at least in Sherwood's paper).¹²⁰ Indeed, Sherwood is only correct to a point; it is true that some romances of the late thirteenth, and especially the fourteenth centuries were contemporaneous with the European automata to which Sherwood does make reference, but what is disregarded in Sherwood's paper is the fact automata are documented in the West Asian Islamic world centuries before the

master magician of the ancient world, Hero[n] of Alexandria: the *Pneumatics* and the *Automatic Theater*. The Arabs, with their predilection for such ingenious playthings [*hiyal*], preserved the writings of Hero[n] and followed his directions in the construction of their own automata. But Hero[n]'s *Pneumatics* and *Automatic Theater* were known in the West also, in the Middle Ages, in Greek, Latin, and Arabic translations."

¹¹⁹ See Sherwood, "Magic and Mechanics," pages 579 – 580: "A remarkable instance of the extent to which such mechanics were familiar to the West occurs in the *Roman d' Escanor*, already mentioned. The magic tree with its trumpeting angel and singing birds, in the romance, recalls so strikingly, in certain respects, one or two of Heron's machines as to suggest that the author had a similar device in mind. In *Escanor*, the turning of the angel appeared to control the blowing of the trumpet and singing of the birds."

¹²⁰ See Sherwood, "Magic and Mechanics," page 592: "Not that the belief in magic was not prevalent. There is plenty of evidence to the contrary. Even in our atomic age, quite sensible people will touch wood or make a wish on the new moon. The marvelous inventions of the poets were placed by preference in the Orient as the traditional land of enchantments, but the authors of the tales and many who composed their public must have regarded the performances of the automata in somewhat the same spirit in which we watch a Magician pull a rabbit out of a hat."

European Christian world, and that the later automata of the European Christian world were inspired by, or derived from, Islamic predecessors which were, in turn, inspired by, or derived from, those of the Hellenistic Greek world. Taken together with the further fact that the romance tradition in Europe also long predates the centuries when European automata existed with ubiquity, the thesis' proposed model is borne out – the above sentences are an exposition of the relationships between the first (Greek), second (Islamic), and third (European fictive, or “magical-realistic”) currents of thought.¹²¹

The prevailing opinion, at least in old scholarship about this topic, is that the flow of ideas regarding automata went from the Islamic West Asian civilizations to the Christian European civilizations, movement from this thesis' posited second current to its third, fourth, and fifth currents (and the sixth current in the European cultural context, although the sixth current is not exclusive to that context). Of course, these ideas, including technologies, had first flowed from the Hellenistic Greek civilization to the Islamic West Asian civilizations, the movement from this thesis' posited first to second currents. Sherwood, writing in a roughly mid-century Modern context that challenged ideas developed in the nineteenth century, disputed the West Asian basis of the reintroduction of automata to the West, and instead made the case that Western Europe had an independent automaton-building tradition in pre-Modernity. On balance, this thesis does not find evidence that there was substantial development of automata in, for example, the European High Middle Ages, and as such, accepts the conclusions Sherwood contested, which are emblemized, per Sherwood, in a quote by Edmond Faral. When translated, this quote by Faral locates the origin of automata in the medieval romances to Asia, and especially to the Islamic world (“l’Orient”).¹²²

The progression from the proposed first to second currents of thought is exemplified in a quotation from Swift, who observed that “...[automaton-building] mathematical and engineering knowledge was translated and preserved in medieval Arabic libraries.”¹²³ From these libraries, it spread through the Arabic Maghreb, and thence to medieval Spain, where its establishment is attested by such points as the presence of al-Muradi’s treatise at the Alfonsine court. Moving from the proposed second current to the third, mythical tales of Gerbert, Pope Sylvester II, which were originally innuendo circulated against him, demonstrate that his multicultural and

¹²¹ See Sherwood, “Magic and Mechanics,” page 592: “The popularity of actual ‘engiens d’esbattement’ was responsible for the prevalence of automata in medieval fiction. The puppets of the poets were not so much, except by a kind of formula, the mysterious creations of magicians in distant lands and times as the rather more versatile literary counterparts of the animated toys which delighted their public.”

¹²² See Sullivan, “Medieval Automata,” page 8: “As Edmond Faral put it: ‘C’est ainsi que, dans leur desir d’etonner et de trouver mieux que leurs devanciers, les poetes ont quitte le curieux pour l’extraordinaire, et l’extraordinaire pour le merveilleux: ils depasserent l’Orient lui-meme d’ou leur etait venue la premiere inspiration.’”

¹²³ See Swift, “Robot Saints,” pages 59 – 60: “In the ancient world, writings on automatic machines with anthropomorphic qualities were concentrated in Hellenistic Alexandria, and much of this mathematical and engineering knowledge was translated and preserved in medieval Arabic libraries.”

Islamicate education was first understood as “magical,” and only as “scientific” once Europe “caught up” with the Islamic world’s scientific outlook, at least as regards Gerbert’s legendary automaton. The persecutorial fourth current is also at play here, since Gerbert’s legend was originally defamatory in nature.¹²⁴

Medieval Islam did produce a body of work that was comprehensible by medieval Europeans as “magical” literature, but without scrutinizing these works individually as primary sources, it should not be assumed that such works would necessarily have been understood as treatises of “magic” within their original Islamic cultural context. There are a limited number of Islamic texts that are unambiguously concerned with the practice of magic, such as the *Picatrix*, which really is an Islamic grimoire. However, generally speaking, “natural magic,” as explained by Kang, but especially by Truitt, is a medieval European term which is more or less synonymous with the contemporary term “science,” and when “natural magic” appears in relation to technical writings of the Dar al-Islam, identification or elucidation of the same should not carry the same connotations as would the traditional, supernatural understanding of “magic” in European discourse.¹²⁵

The Islamic corpus of technical writings is impressive, and can truly be established as a distinct genre with consistent, enduring characteristics over a period of many centuries. De Solla Price, a twentieth-century authority on the history of technology, wrote “...the Islamic contributions to horology and perpetual motion seem to form a closely knit corpus,” an assessment found agreeable by this thesis. Being products of (West) Asian cultures, these Islamic texts register the proposed second current, containing and recapitulating the automaton-making techniques of the ancient world, even as the proposed first current applies to the classical technology thereby preserved by these texts: specifically, according to De Solla Price, “...versions of the water clocks and automata of Archimedes and of Hero[n] and Philo[n] of Alexandria.”¹²⁶ The relationship between the proposed first and second currents is again evident in this connection.

¹²⁴ See Truitt, “Celestial Divination and Arabic Science,” page 217: “William [of Malmesbury] confirmed many prior accounts that mention Gerbert’s education in Spain and reiterated the claim that Gerbert was in league with the Devil, conjoining that with the story of the prophecy and the church where Gerbert fell ill. Although William repeated prior assertions that Gerbert trafficked with Devil, he did not present Gerbert’s oracular head as the product of demonic magic, as Beno had done, but rather as the product of astral science. Furthermore, he referred to specific authors and practices, revealing the extent to which Arabic scientific texts were known in England at that time [William’s time].”

¹²⁵ See Kang, *Sublime Dreams of Living Machines*, Chapter 2, “Between Magic and Mechanics,” page 58: “Crucial to the development of natural magic was the twelfth- and thirteenth-century transmission of Arabic works on alchemy and astrology that described such operations as transmuting metals, healing the sick, and making prophecies through arcane methods of observation, calculation, and manipulation of natural properties.” See Truitt’s *Medieval Robots* for an exposition of this phrase.

¹²⁶ See De Solla Price, “On the Origin of Clockwork,” page 25 in the author’s printed copy: “It is of the greatest interest to our theme that the Islamic contributions to horology and perpetual motion seem to form a closely knit corpus. A most important series of horological texts, including those of Ridwan and al-Jazari, have been edited by Wiedeman and Hauser. Other Islamic texts give versions of the water clocks and automata of Archimedes and of Hero[n] and Philo[n] of Alexandria.”

Unlike the automata of the proposed fifth current, which are typically driven by kinetic energy, especially in the Renaissance, the automata of the proposed second current are technologically distinguishable from the former by the source of their motive energy. On the contrary, while the proposed first and second currents are differentiated by purpose and culture, they are alike in the means by which energy is transferred by the designs of the devices identifiable under these first and second currents. De Solla Price wrote, in discussing “the Islamic tradition of water clocks,” that such clocks are mostly “...worked by floats and strings or by hydraulic or pneumatic forces, as in Hero[n]’s devices.” The reference to Heron registers this thesis’ first current, but, of course, Islamic automata partake of the second current, and both currents are distinct from the fifth; moving beyond the comparable internals of classical and Islamic automaton-bearing devices, including clocks, the thesis’ proposed first current is culturally sacred, the second current culturally secular, and the fifth, either culturally sacred or secular, or by circumstance, arguably both, as when automata with secular figures appeared in sacred spaces.¹²⁷ Returning to a technological analysis, it is accurate to note that the automata of the fifth current could have either kinetic, hydraulic, or pneumatic designs, whereas those of the first and second currents had hydraulic and/or pneumatic designs, with any kinetic mechanisms limited to very simple constructions, and very few components. This analysis itself demonstrates the modeled, narrative relationship between the proposed first and second currents.

The Manuscript of al-Muradi is a good case-in-point, for like the output of the Banu Musa and al-Jazari, its designs are hydraulic and/or pneumatic, as were those of its classical source matter. Olive, in presenting a summary of this manuscript’s contents, wrote “...the mechanical principles which appear in the manuscript are attributed to a certain Seth, who has been variously identified as Philo[n] of Byzantium (? – 250 BC), Ctesibion [Ctesibos, Ctesibius, Ctesibus] (300 – 230 BC), Heron [of Alexandria] (c. 62 – 150) and Archimedes (287 – 212 BC).” The proposed first current is registered by the technological heritage of the classical authors upon which the Manuscript of al-Muradi is based, but Olive’s quoted remark also shows the relationship between the first and second currents under the thesis’ model, inasmuch as it again demonstrates the transmission of knowledge related to automata from the classical world (Heron, et al.) to the Arab world (that is, to al-Muradi, the original author of this manuscript, and not Ibn Sid, its rediscoverer).¹²⁸

¹²⁷ See De Solla Price, “On the Origin of Clockwork,” page 26 in the author’s printed copy: “The Islamic tradition of water clocks did not involve the use of gears, though very occasionally a pair is used to turn power through an angle when this is dictated by the use of a water wheel in the automata. In the main, everything is worked by floats and strings or by hydraulic or pneumatic forces, as in Hero[n]’s devices. The automata are very elaborate, with figures of men, monkeys, peacocks, etc., symbolizing the passage of hours.”

¹²⁸ See Olive, “The Clepsydra of the Gazelles,” page 11: “Ibn Sid was an Arab scientist working in the court of King Alphonse X of Spain, ‘the Wise,’ [who was] amazed to discover the hidden knowledge contained in the semi-destroyed pages of the Manuscript of al-Muradi, originally written in the XI cent. although the knowledge itself was reputedly of a much earlier origin: the mechanical principles which appear in the manuscript are attributed to a certain Seth, who has been variously identified as

In discussing the transfer of knowledge from one civilization to another, it should be acknowledged that the heterogenous cultures of, say, Old-World Asia are considered homogenously for purposes of this thesis, which could perhaps be alleged as an argumentative weakness; however, it is instead presented as a strength, for the appeal of the proposed model is its simplification of considerable historical and geographic spans to a simple narrative that is an accurate representation of broad, observable trends. When White, in his foreword to Hill's edition of al-Jazari, names "the medieval Greeks," not the ancient Greeks, this reference registers the proposed second current, not the proposed first current, as White is presumably alluding to achievements of the Byzantine Empire, which, like the Islamic caliphates, retained automaton-building engineering knowledge in the early Middle Ages, whereas Western Europe lost such knowledge.¹²⁹ It can be said, therefore, that knowledge could pass between different cultures subsumed by the proposed second current without leaving the encompassing bounds of that current, as when White observes that "by the later thirteenth century, however, Yuan China was learning from Muslim engineers." When White questions "how much ['technological advance in Islam'] depended upon borrowings from China, South Asia, the medieval Greeks and the Franks," this thesis would situate all such "borrowings" within its second current except the example of "the Franks;" but then, this thesis is not aware that Frankish peoples were automaton-building societies during the Early or High Middle Ages, at least until the era of Villard de Honnecourt. Analogously, knowledge could pass between the various polities and peoples of Europe without leaving the bounds of the proposed fifth current, a phenomenon which is most conspicuous during the European Renaissance, when ways of thinking passed, for example, from Southern to Northern Europe over the duration of at least one century, however reckoned.

The narrative progression from the first current, the Hellenistic world, to the second current, in this case, the Islamic world, and thence to the fifth current, the Europe of the Renaissance, sometimes at earlier, medieval dates, or in later, Reformation dates, by way of the proposed third and fourth currents, ("magic" in fiction and myth, the proposed third current, and persecution of the technologist on the ground of "magic," the proposed fourth current), is clear when Hill, in his introduction, writes that the telltale appearance of certain technologies, and techniques, in the European history of technology "suggest Muslim transmission of Hellenistic, Far Eastern, and indeed Muslim inventions to the West."¹³⁰ That this

Philo[n] of Byzantium (? – 250 BC), Ctesibion [Ctesibos, Ctesibius, Ctesibus] (300 – 230 BC), Heron [of Alexandria] (c. 62 – 150) and Archimedes (287 – 212 BC)."

¹²⁹ See al- Jazari, *Book of Knowledge*, page XIII (13), from Lynn White, Jr.'s "Foreword:" "By the later thirteenth century, however, Yuan China was learning from Muslim engineers. Can it be that during the intervening four hundred years there was technological advance in Islam? If so, how much of it was generated internally, and how much depended upon borrowings from China, South Asia, the medieval Greeks and the Franks?"

¹³⁰ See al- Jazari, *Book of Knowledge*, page XIII (13), from Lynn White, Jr.'s "Foreword:" "These examples, ['conical valves,' 'segmental gears,' and 'metal casting in closed mould (SIC) - boxes with green sand'] and others, suggest Muslim transmission of Hellenistic, Far Eastern, and indeed Muslim inventions to the West."

Islamic transmission was, in turn, based upon the transmission of information and ideas to the Islamic world from the classical world is equally demonstrated by Hill's statement that "in design and operation these [the Banu Musa's 'trick vessels for dispensing liquids'] are very similar to the devices described by Philo[n] and Heron, and are almost certainly derived from these." Thus, it is again shown that technologies of the Islamic Golden Age, and in this case, devices in the early treatise of the Banu Musa, were based in those of the Hellenistic technological achievement, which, as regards the predominant designs of the first and second current, was based in Alexandria. Because the Banu Musa's "trick vessels," as described by Hill, include basins which produce the illusion of intentional action on the parts of static figures, Hill's above conclusions are relevant to the contentions of this thesis.¹³¹

This narrative progression is borne out by al-Jazari and Ridwan's "constant-flow clocks," which do contain automata, and the derivation of these clocks from a common predecessor, pseudo-Archimedes' clock. As described by Hill, the latter is of direct relevance to this thesis' model, for "it [pseudo-Archimedes' clock] was the work of a Muslim inventor who put together details from several sources, one of them doubtless Philo[n], another probably Heron [...] in view of the many similarities between this clock and the devices of the two earlier writers." Thus, pseudo-Archimedes' clock exemplifies the passage of automaton-making technologies, including underlying motive methodologies, from the Hellenistic to Islamic worlds.¹³² With regard to Hill's preliminary presentation of pseudo-Archimedes' clock as a technical source known to al-Jazari, it is unclear, from the same, if pseudo-Archimedes' clock did or did not itself feature automata; but even if automata were not present, it remains a valuable evidentiary point, given that the connection between the proposed first and second currents runs directly from the ancient world, through pseudo-Archimedes and his clock, and onward to al-Jazari and Ridwan, who were both designers and builders of horological automata.¹³³ While Hill hedges, and limits his conclusions on the succession of sources which culminated in al-Jazari's designs to those applicable for the latter's "trick vessels," it is a reasonable extrapolation to

¹³¹ See al- Jazari, *Book of Knowledge*, page 9, from Donald R. Hill's "Introduction:" "In design and operation these [the Banu Musa's 'trick vessels for dispensing liquids'] are very similar to the devices described by Philo[n] and Heron, and are almost certainly derived from these... The main differences between the Banu Musa devices and those described by the Greek writers, apart from the greater complexity of the former, is that the Banu Musa make use of properly fitted cone-valves, whereas Philo[n] and Heron mention only crude clack-valves and plate-valves."

¹³² See al- Jazari, *Book of Knowledge*, Page 10, from Donald R. Hill's "Introduction:" "Drachmann has written a valuable criticism of this clock [the 'Archimedes' clock], based upon the translation of Wiedemann and Hauser, and comes to the conclusion that it was the work of a Muslim inventor who put together details from several sources, one of them doubtless Philo[n], another probably Heron. I [Hill] see no reason to contest this opinion, in view of the many similarities between this clock and the devices of the two earlier writers. Since both Ridwan and al-Jazari acknowledge the derivation of their constant-flow clocks from that of 'Archimedes,' we are safe in assuming that it is an important transmission between the classical writers and the later Islamic craftsmen."

¹³³ See al- Jazari, *Book of Knowledge*, page 10, from Donald R. Hill's "Introduction."

deduce that Heronic and Philonic knowledge was also used to design the automaton-bearing devices described by al-Jazari.¹³⁴

While there is continuity between the first and second proposed currents on technological grounds, which is an element of the narrative progression between these currents, they are distinguished by cultural factors. Readers need look no further than the words of al-Jazari himself, words authored by the most important builder of pre-Modern automata, to apprehend one of the foremost distinctions between the proposed first and second currents. al-Jazari explicitly acknowledges the prohibition against figural images imposed by the religious strictures of Islam, and the injunction against such images is a principal reason for the distinguishment of the first current from the second current under the thesis' model: the first current positions sacred automata in sacred spaces, or in sacred activities, for ritualistic, liturgical, or cultural purposes, whereas the second current positions secular automata in secular spaces for the amusement of powerful patrons or the general public, despite the common technological bases for both such currents.¹³⁵

To underscore this point, there is only one instance in which, it is recalled, al-Jazari uses language with origins in supernatural or preternatural phenomena, and specifically, in this case, witchcraft. However, this does not make al-Jazari a believer in magic, or indeed, a believer in the supposition that a witch from the land of Egypt, the "Egyptian Witch," remains responsible, postmortem, for all spontaneous actions of siphons, any more so than a modern physicist can be called a demonologist, or one who believes in the existence of demonic beings, if that physicist should use the term "Maxwell's demon." The second current, except this lone, semantic outlier, remains distinct from cultural discourses of supernatural power in traditions of faith or magic, and accordingly remains secular.¹³⁶

¹³⁴ See al-Jazari, *Book of Knowledge*, pages 11 – 12, from Donald R. Hill's "Introduction:" "Only a brief mention can be made of those writers, Greek and Byzantine [together comprising the first current of thought under the proposed model], whose works were translated into Arabic. The *Mechanics of Heron* was translated into Arabic by Qusta b. Luqa about 250/864, every indication being that this is a genuine and accurate translation. Philon's pneumatics have also come down to us in Arabic, although we have no knowledge of the date or the author of this translation. According to al-Kindi Heron wrote about geography and pneumatic devices, and he also made clocks and other instruments for the measurement of time. Of Philon, al-Kindi says that he was skilled in the construction of water-wheels, mills, and ingenious devices (*hiyal*). Even without this evidence there could be little doubt, from an examination of the devices of the Banu Musa, that these were derived directly from the works of Heron and Philon. And since al-Jazari refers to the Banu Musa as one of his sources, our line of transmission, for trick vessels at least, is complete." Note that in footnote 8 on page 12, Hill clarifies that "This al-Kindi is not to be confused with the philosopher of the same name, but is Abu 'Umar Muhammad b. Yusuf b. Ya'qub al-Kindi, who lived about 359/970 – see Brockelmann I, p. 149."

¹³⁵ See al-Jazari, *Book of Knowledge*, page 25, al-Jazari: "This is the basis of the work. Individual parts may be omitted or added according to the place for which it is constructed. For mosques and shrines it may be limited to what is necessary for telling the hours; for the palaces of kings, what may be fitting, such as pictures and other things [automata]."

¹³⁶ See al-Jazari, *Book of Knowledge*, page 36, al-Jazari: "Next a thin copper tube is brought that is longer than this vessel is high, and this tube is bent in the middle until the two ends almost meet, one end being longer than the other by a half a link. This is called a siphon (*maquallab*) and also the Egyptian witch (*Sahhara Misriya*) [Fig. 26]."

There are at least two notable instances in al-Jazari where the design of a device calls for “sleight of hand,” as its activation is accomplished by the use of an “on switch,” and it was evidently thought that this switch would diminish the effect of the instance’s display if conspicuously actuated. However, this point neither makes either instance false by this thesis’ definition (in the absence of concealed or remote human operators), nor necessarily indicative of deception for some defined end (the perception of preternatural power in the working of each automaton, for example, as in the cases of certain ancient Greek automata), for once the “on switch” was thrown, or in one of these cases, pulled, everything else proceeded automatically. It would probably have coarsened the courtliness of any device’s spectacle when deployed if its servant-operator was seen pulling something like a ring, or handling any other obvious component, for such an action would not have lent itself to the grandeur of ceremony and wonderment of *hiyal*.¹³⁷ This tactic applies to the opening of a valve in the other example.¹³⁸ Reliance upon “sleight of hand” recurs more often in the work of the Banu Musa, and as regards both that Islamic treatise, and the work of al-Jazari, identifying its use as an indication of stage-magic trickery is a mistaken apprehension in the opinion of this thesis, given the secularism of its proposed second current.

Returning to the different views of the Christian and Islamic civilizations as regards figural artwork, the conclusion offered by the scribe who produced the manuscript mainly edited by Hill affords another opportunity to discuss this point in consideration of the proposed model. In the Islamic world, automata were exclusive to secular settings due to religious laws which would, on a conservative interpretation, prohibit their presence anywhere, or which would, on a liberal interpretation, still preclude their association with mosques, shrines, and suchlike places of Islamic religious significance, while allowing them as elements of public monuments or rarified private spaces, such as palaces. The latter arrangement is much like that of Christian civilizations with respect to secular zones, such as the aristocratic abode and its public approximation, the town square and its municipal buildings, but is unlike Christian civilizations with respect to places of worship, since automata, as in the classical tradition of the first current, continued to be present in Christian churches throughout pre-Modernity and Early Modernity (as evidenced by the Sketchbook of Villard de Honnecourt).

Religious perspectives on images are a foremost divergence between the first and second currents of thought. “Representations of live creatures” are mentioned by the scribe responsible for the manuscript copy of al-Jazari’s treatise most favored by Hill, but do not necessarily refer exclusively to illustrated diagrams of al-Jazari’s automata designs, since this manuscript also contains drawings meant to represent

¹³⁷ See al- Jazari, *Book of Knowledge*, page 152, al-Jazari: “When the basin is called for the servant places it in front of the master, pulls the ring quickly without anyone noticing, and waits. The water mixes, one part with another, and rises above the bend in the siphon and issues from the peacock’s beak on to the master’s hands.”

¹³⁸ See al- Jazari, *Book of Knowledge*, page 155, al-Jazari: “It is very clear that: water is poured into the castle while valve *k* is closed; the whole assembly is placed in front of the master and the servant opens valve *k* without being noticed, and then stands aside.”

real, biological animals as beasts of burden. Although the artistic style of the manuscript appears uniform, only those drawings of pumps and machinery using draft animals show “live creatures,” and indeed, these drawings of “live creatures” show figures which are indistinguishable from figures of non-biological and non-living automata. It would seem that this scribe’s manuscript copy of al-Jazari escaped censorship for that very reason, that most of its drawings were understood to show automata, not “live creatures.” Unfortunately for art historians, this was not the case in the manuscript separately used by Hill to produce his edited translation of the Banu Musa, for most two-dimensional representations of sculptural subjects in that manuscript had their faces blotted out, at some point in the distant past, by a censorious person or persons.¹³⁹

Another divergence between the first and second currents of thought are the cultural purposes for automata. Hill, in critiquing al-Jazari’s automaton-bearing devices for bloodletting, rather misses the point of including automata on the same. Rather than being a superfluous, or even dangerous complication included without a clear rationale, the idea was evidently to make the collection of blood, an unpleasant activity, “fun” for medieval patients subjected to frequent bloodletting, which was a course of treatment commonly recommended by medieval physicians. This dimension of “fun” is actually an idea more generally applicable to the automata categorized under the proposed second current of thought, which frequently exist to add interest, or to “enliven,” a variety of mundane objects and activities, such as goblets, pitchers, and basins, in some cases of objects, and drinking-parties in the cases of some activities (a prime example of an automaton-bearing device described by al-Jazari and intended for such a setting is his monumental wine-dispenser).¹⁴⁰ This, of course, is all by contradistinction to classical automata, which still had solemn religious meanings, even in festive processions, much like the sculptures with sacred subjects paraded through the streets by the adherents of certain faith traditions to this day.

Rather than being sacred and sacral, the automata of the second current not only enhanced everyday objects, and heightened the atmosphere of courtly social gatherings, but could also mask the necessary obtrusion of less glamorous material-cultural items into aristocratic spaces. To route flows of water, land surveying was in use in al-Jazari’s environment, which relates to the technological achievement

¹³⁹ See al- Jazari, *Book of Knowledge*, in Hill’s footnote 2, for the “Concluding passage to the Oxford Graves 27 manuscript.” Hill’s main manuscript source for al-Jazari’s treatise was completely copied by Muhammad b. Muhammad Abi al-Fath b. ‘Isa al-Sufi al-Kutubi al-Falaki, al Shafi’i, al-Misri, one scribe, as of noon on March 5, 1486: “*Khala al-suwar al-hayawaniya*. The scribe [Muhammad] seems to be saying that he did not draw the representations of live creatures – the human and animal jack-figures. Presumably, on religious grounds, he delegated this to another – probably a Christian. Or perhaps he simply could not draw animals and people.”

¹⁴⁰ See al- Jazari, *Book of Knowledge*, in Hill’s “General Description” for “Chapter 5 of Category III” on page 261. Hill writes the following for the first of al-Jazari’s phlebotomy devices: “One cannot but feel that the patient must have felt some apprehension at having the extraction of his blood measured by this device, and the similar ones described in the following chapters. Friction in the pulleys, or any slack in the system, would tend to decrease the amount indicated as against the actual flow. Why not simply use a graduated cylinder?”

underlying the material-cultural development of automata in the world of medieval Islam, that is, under the proposed second current of thought, and in al-Jazari's particular case, in the world of the palace at Amid; and this latter world is, again, comprehensible under the proposed second current of thought.¹⁴¹ In the case of one automaton design, aesthetic considerations were made by al-Jazari because, despite being an infrastructural work designed to distribute water, it had to be visibly emplaced within a courtly space for some unknown reason, rather than be concealed from such a space, and therefore required the suggestion of artistic intentionality for its presence, or, absent the perception or imputation of this suggestion, at least some implicit acknowledgment that its appearance would have been inappropriate without ornamentation. So, in either case, it would not be perceived as an ill-positioned, obtrusive object within the interior design of a palatial environment when outfitted with an automaton. This interpretation, that the addition of automata could prevent a purely technical device from ruining the atmosphere of a non-technical setting, provides another explanation for the purpose of automata under the proposed second current of thought.¹⁴²

Yet, even as they are unlike in terms of cultural purpose, the automata of the proposed first and second currents are alike in terms of technology. The relationship between these currents under the modeled scheme, that is, the transmission and reception of automaton-making knowledge from the classical world to the Islamic and Byzantine worlds of the Middle Ages, is borne out by Drachmann's analysis of pseudo-Archimedes' sources, as given in Hill's presentation: "pseudo-Archimedes was the work of a Muslim inventor who put together details from several sources, one of them doubtless Philon, another probably Heron. Vitruvius, particularly in his transmission of Ctesibios's clocks, may also have been used as a source."¹⁴³ The sum of these contentions, the narrative relationship between the proposed first and second currents of thought, that is, how automaton-making technologies were transmitted

¹⁴¹ See al- Jazari, *Book of Knowledge*, in Hill's "General Description" for "Chapter 1 of Category IV" on page 263. Hill writes the following: "For all these fountains [including the fountain of the instant chapter] it would have been necessary to site the house [the origin of the hydraulic flow used to feed such fountains] so that the static head above the pool was adequate. This presupposes the use of land surveying techniques."

¹⁴² See al- Jazari, *Book of Knowledge*, in Hill's "General Description" for "Chapter 3 of Category V" on page 265. Hill writes "Judging by the materials used in its construction – copper and marble – and the instructions given for adornment of the parts, its purpose would seem to have been at least partly decorative, not simply functional."

¹⁴³ See al- Jazari, *Book of Knowledge*, in Hill's "General Notes" on page 271. Hill writes the following: "It was Drachmann's suggestion that the pseudo-Archimedes was the work of a Muslim inventor who put together details from several sources, one of them doubtless Philon, another probably Heron. Vitruvius, particularly in his transmission of Ctesibios's clocks, may also have been used as a source. The suggestion is credible, although many of the devices in Philo[n] and Heron's treatises on pneumatica have more affinity with the Banu Musa than with the pseudo-Archimedes. Certainly jack-figures [automata], siphons, floats and air vessels occur in Heron and Philo[n], while Heron in his *Mechanics* has several examples of gears. (I tend to agree with Drachmann that much of Heron's work on gears was purely theoretical.) In the Arabic MS of Philo[n] there is a tipping-spoon, very similar to that described in the pseudo-Archimedes, and this is described as 'similar to the operation of a clock.'"

from the classical world to the Islamic and Byzantine worlds, is neatly traced by Hill, who wrote “there is little in the design of al-Jazari’s first and second clocks that is not found in the pseudo-Archimedes, and little in the pseudo-Archimedes that is not found in the Greek writers.”¹⁴⁴ Of course, al-Jazari’s first and second clocks contain numerous automata; the second is a simplification of the first, with the first being the Castle Clock, one of al-Jazari’s most spectacular automaton-bearing devices.

Just as there is continuity of transmission between the modeled first and second currents, so too is there internal continuity of transmission within the second current; as has already been noted, the progressive nature of the modeled narrative means that significant advances can occur within each current, not simply in the jumps from any given current to its adjacent current under the seven-current sequence. As another example of this tendency, Hill disagrees with al-Jazari as regards the latter’s disavowal of the Banu Musa’s fountain designs; thus, Hill believes al-Jazari was, in fact, influenced by these designs, and after all, al-Jazari does mention the Banu Musa by name. This is relevant because both al-Jazari and the Banu Musa, in addition to their fountain designs, also documented designs for systems which were themselves automata, or which contained automata, and an allusion to the work of the Banu Musa in al-Jazari, even if in a section concerning fountains, demonstrates that an extant source from the cultural space defined by the proposed second current of thought was aware of another extant source from that same cultural space (the second of these two “sources” being comprised of three people, the Banu Musa, or the Brothers Musa, and namely Ahmad, Muhammad, and al-Hasan, the three sons of Musa bin Shakir).¹⁴⁵

While there is no “tipping point,” per se, or at least one that can be concretely and consistently identified within the wide-ranging historical sweep of this thesis, at some point, the mentality and knowledge (including incomplete or incorrect knowledge) which is developed in one of the modeled currents is overextended from the cultural context of that current, and is augmented by other currents, if the cultural zone remains unchanged, as in the cases of the third, fourth, and fifth currents, when arranged in their narrative progression, in which case “overextension” has the sense of obsolescence, or at least, of competing mentalities. Alternatively, the mentality represented by a modeled current can transmit to a distinct cultural zone in a recognizable pattern, as when the technologies, but not cultural dimensions, associated by this thesis with the modeled first current move from Hellenistic Alexandria and the Roman territories of Greece and the Eastern Mediterranean to the Arab world of West Asia, and thence to the Arab polities of the Maghreb and Andalusia, to become the second current; and then, when bastardized understandings of these technologies are carried into Western Europe through various, identifiable

¹⁴⁴ See al- Jazari, *Book of Knowledge*, in Hill’s “General Notes” on page 271. Hill writes the following: “To summarize, we can say that there is little in the design of al-Jazari’s first and second clocks that is not found in the pseudo-Archimedes, and little in the pseudo-Archimedes that is not found in the Greek writers.”

¹⁴⁵ See al- Jazari, *Book of Knowledge*, in Hill’s “General Notes” on page 272, in the section for “Category IV [/] Fountains and Perpetual Flutes.”

channels, to produce the third current. These observations, of course, were developed for the specific topic of pre-Modern and Early Modern automata. There are more general connections between the technologies of the proposed second current and Western Europe, however, which will now be discussed because they have some relevance to automata.

The first noteworthy point observable in connections between automata of the proposed second and third currents is the presence of a “vaned wheel,” a kind of windmill, in one of al-Jazari’s non-automaton-bearing devices. While this “vaned wheel” is parallel to level ground, it is nevertheless turned by the wind as a component which uses aeolian energy within the context of a broader system. In response to Hill’s representations regarding this system, comparison to the automata of medieval romances is fruitful, as many automata in the romance traditions of Western Europe are similarly controlled and/or actuated by gusts of wind. As such, there seems to be a common denominator between the factual technologies attested under the proposed second current and the fictions developed under the conjunct of the proposed third and fifth currents, which together epitomize automata in the romances.¹⁴⁶ See the indexed fourth appendix for specific examples from romances.

Moving, momentarily, to the Banu Musa, it is of interest that they, on the basis of their contributions, could be characterized as the first fountaineers: Hill writes that “of these more complicated devices [‘fountains which change their shape’], nothing appears to have come to light of an earlier date than the Banu Musa.” The relevance of this point, and its interest, lies in the interrelatedness of automaton technologies and fountain technologies. Both such technologies were based in hydraulics in the milieu of the second current, and were concerned with the leisure environments and activities of the ruling class under the proposed second and fifth currents. This identification therefore situates “fountaineering” (a term prevalent in the European Early Modern period) as an Islamic innovation, and is relevant to the proposed second current of thought in light of the recurring relationship between fountains and automata in Western Asia, and later, in Western Europe.¹⁴⁷

¹⁴⁶ See al-Jazari, *Book of Knowledge*, in Hill’s “General Notes” on page 272, in the section for “Category IV [/] Fountains and Perpetual Flutes.” Hill writes the following for one of the Banu Musa’s devices, thus summarizing the workings of a device described by these three brothers, who lived centuries before al-Jazari: “In No. 90 water runs into a horizontal tank *q*, *l* which has a discharge nozzle at one end. This tank is mounted on a vertical axle which carries a horizontal vaned wheel at its upper end. The discharge from the rotating tank can be into one of two adjoining large tanks, *g* and *b*, the inner delivery pipe leading from one and the outer pipe from the other – in the usual way. Say the discharge is into tank *g*: the wind turns the vaned wheel, tank *q*, *l* rotates and the water now flows into tank *b*. No. 91 is similar to No. 90, but has two double pipes instead of one.”

¹⁴⁷ See al-Jazari, *Book of Knowledge*, in Hill’s “General Notes” on page 273, in the section for “Category IV [/] Fountains and Perpetual Flutes.” Hill writes the following: “The simple fountain must be an ancient invention, but of these more complicated devices, nothing appears to have come to light of an earlier date than the Banu Musa. Referring specifically to fountains which change their shape, there are no references in Heron, Philo[n]n, or Vitruvius, nor do they appear to have been known in China.”

Returning to al-Jazari, an offhand remark in this source insinuates the necessity of an escapement, which is noted by Hill because the escapement, as an article of technology, is (together with the fusee) one of the fundamental bases of mechanical clocks, but more importantly, clockwork automata. Therefore, al-Jazari, the author of an important treatise categorizable under the proposed model's second current of thought, anticipates technology which would later become integral to automata categorizable under the proposed model's fifth current of thought.¹⁴⁸ Yet, from prudence, it is best to consider Hill's assessments with caution, as they can be overexuberant. As an example, Hill also identifies al-Jazari as the first documentary source for the mechanical crank, and in so doing, again suggests that technologies like the crank may have emerged earlier in Western Asia than in Western Europe. This does accord with the proposed model, and with the appearance of the intervening third and fourth currents in Western Europe for the specific case of automaton technology.¹⁴⁹ However, in his edition of the Banu Musa, published some years after his edition of al-Jazari, Hill then contradicts himself by instead identifying the Banu Musa's treatise as the first attestation of the crank.

Ever the consummate mechanic, al-Jazari's use of the above-mentioned term "Egyptian witch" is the only suggestion of the proposed first or third currents of thought, the only reference to the supernatural or preternatural, to sorcery, miracles, or the mystical, in his entire treatise. Based upon al-Jazari and al-Khuwarizmi's use of what appears to have been a conventionalized industrial descriptor for siphons in Hill's quoted presentation, the "Egyptian witch," this thesis would contend, as it has elsewhere contended, that this does not itself mean either al-Jazari or al-Khuwarizmi necessarily subscribed to beliefs in religiously or non-religiously inflected "magic," that is, in the "powers" categorizable under the proposed first and third currents, respectively, any more so than contemporary physicists' reference to the *gedankenexperiment* "Maxwell's Demon" should be construed to mean that these scientists are intimate sincerely-held beliefs in the teachings of the Roman Catholic

¹⁴⁸ See al- Jazari, *Book of Knowledge*, under Hill's "General Notes" on page 273, in the section for "Category IV [/] Fountains and Perpetual Flutes." Hill writes the following: "Here, in addition to some inaccuracies in the translation, the following sentence is omitted [from al-Jazari's text] by Wiedemann: 'I [al-Jazari] say that even if the wheel caused a number of rods to fall in succession it would not be slow enough to display the changes of shape [adequately].' The design of these arms [rods], and their exact purpose, cannot be ascertained from so brief a comment, but the import is quite clear: that al-Jazari realized the necessity for an escapement, and had in mind some method for providing one."

¹⁴⁹ See al- Jazari, *Book of Knowledge*, under Hill's "General Notes" on page 273, in the section for "Category V – Water Lifting Devices." Hill writes the following: "The application of segmental gears for raising a flume swape, as in al-Jazari's devices Nos. v.1 and v.2, may have been his own invention. This appears to be the first application of segmental gears, at least with an appreciable applied torque. Similarly, the application of the crank for lifting the flumebeam, in v.4, is perhaps the earliest application of the crank in Islam and Byzantium, and may pre-date the application of the crank to machinery in Europe. I find no reason for doubting that al-Jazari devised and constructed these three machines, but I question whether they would have worked satisfactorily, without frequent breakdowns. In all of them there is a heavy, intermittent, torque at the axle of the beam, and this is transmitted to the machinery. It is very doubtful whether the anchorages, bearings, and cog-wheel teeth, in their contemporary state of development could have sustained this heavy torque for long."

Church, or any other faith tradition (including the religion of classical Greece and Rome, wherein “demons” also figure in a different sense), regarding demonology or demons; or for that matter, that these physicists’ use of the term “Schrodinger’s Cat,” when alluding to another famous *gedankenexperiment*, must mean that the hypothesized cat (or its scenario) ever actually existed, or will ever actually exist.¹⁵⁰

With this point established to defend the narrative model proposed by this thesis, and its conception of automata under al-Jazari’s second current as fundamentally secular, it is fascinating to observe how a folktale can nevertheless be reconstructed from even the few nearly-synonymous words which apparently comprised some of the possible proper nouns available in medieval Arabic to communicate the concept “siphon.” It would seem that at some point which probably long predated al-Jazari, the Islamic religion, and indeed, probably much recorded Arabian history, the reliable action of the simple siphon was ascribed to the spirit of a (presumably vengeful) witch who had legendarily been strangled to death in the land of Egypt, possibly in some scenario related to a siphon, although strangulation and drowning remain two distinct causes of death. The legend of the “strangled witch,” also called “the Egyptian witch,” is a mere guess, but it is clear that, independently of whether any simpleton or layperson truly believed this witch caused all siphons to function in the time of al-Jazari, courtier of the palace at Amid, the hypothesized legend probably circulated at some point, giving rise to a technical name as colorful as those used in the latter-day cases of the demon and cat already named, as well as many others; and this reconstruction is at least made possible by the consistency with which the “witch” language it is independently used by two extant scientific authors, al-Jazari and al-Khuwarizmi.¹⁵¹

There is remarkable continuity and durability in the technical prose style and technological designs of al-Jazari and his distant predecessors. This includes the example of the Banu Musa, although they are separated in chronological time from al-Jazari by the span of at least three centuries. This is doubtless because, regardless of whichever century of the Golden Age of Islam is in question, the technological basis for automaton-building was the classical corpus, or earlier Islamic authors who had themselves drawn from this same classical corpus, given the intellectual-historical lineage identified by Hill. For instance, the action of Muhammad, one of the three “Brothers Musa,” in his “collection and translation of earlier works,” represents the action which linked the automaton-making technologies of the ancient world, and

¹⁵⁰ See al- Jazari, *Book of Knowledge*, under Hill’s “General Notes” on page 276, in the section for “Individual Components,” and under the subsection “Water Equipment” and sub-subsection “Pipes, channels, siphons.” Hill writes the following: “Al-Jazari himself uses only the simple siphon, for which he generally uses the term *maqallab* and, in one place, *al-sahhara al-misriya* (the Egyptian witch). Al-Khuwarizmi calls it simply *al-sahhara* [the witch] or *Sariqa al-ma* – the (female) water-thief. [Note that ‘water-thief’ is typically given as the translation for the etymologically Greek term *clepsydra*, which denotes a water-clock, and usually one where time is measured by a known amount of water dripping or otherwise flowing from one receptacle to another]. The jacketed siphon is described above in the section on the Banu Musa. Al-Khuwarizmi calls this *al-sahhara al-makhnuqa* – the strangled witch.”

¹⁵¹ Ibidem.

that of the medieval West Asian, possibly East Asian, and Byzantine worlds: the re-use and elaboration of these technologies from the ancient Greek and Hellenistic civilizations.¹⁵²

Hill names the source matter of the proposed first current in connection with the proposed second current, this time in the front matter for his published edition of the Banu Musa's work, including a clause about how knowledge from the proposed model's first current "came to Baghdad in Hellenistic guise," that is, to the foremost cultural center of the proposed second current in the earlier Middle Ages. It is not denied that the currents of the proposed model are simplifications, or as Hill terms the approximation of knowledge transmission between the proposed first and second currents, an "over-simplification." Rather, it is contended that these simplifications are useful in gaining a narrative grasp of the historical sweep through time for a species of very consistent, persistent material culture which is, regrettably, poorly understood by non-specialists. Hill is correct in remarking that the Greek "written tradition" was not the "sole inspiration" for the automaton-makers of the second current, which he introduces in adding nuance to the so-called "over-simplification" he identifies; there were also material proofs of classical automata, such as the holdout Gaza clock, one of the instances described in the thesis' fourth appendix. However, Hill does not specifically identify the Gaza clock as a potential source of inspiration in the referenced passage. Instead, Hill points to a "tradition in Syria" involving the autochthonous Syrian "construction of water-clocks and associated automata," although he provides no specific Syrian examples of the same.¹⁵³

The existence of a city, Gondeshapur, that was "the center through which Byzantine learning passed to Baghdad" is indicative of the linkage between the proposed first and second currents, almost as a word-for-word indication, and similarly, the "preservation" of "a large corpus of Greek scientific writings" by the Sabeans is the reason, left explicitly unstated, but implied by Hill, that these Sabeans "were to be very influential in the development of Arabic science." In this case, the link between the proposed first and second currents is the Sabeans themselves, who transmitted the technical knowledge of the classical world, presumably including knowledge of automaton-building, to the generally-acknowledged center of the

¹⁵² See the Banu Musa, *Book of Ingenious Devices*, page 19, in Hill's "Historical Context of The Book of Ingenious Devices." Hill writes the following: "It is reasonable to suppose that Ahmad was the engineer of the family, al-Hasan the geometer, while Muhammad took a general interest in all the sciences, was the main force behind the collection and translation of earlier works, and also involved himself in politics and public works."

¹⁵³ See the Banu Musa, *Book of Ingenious Devices*, page 19, in Hill's "Historical Context of The Book of Ingenious Devices." Hill writes the following: "The documentary sources that may have been available to Ahmad were written in Greek, the most important being the *Pneumatics* of Philo[n], the *Mechanics* and *Pneumatics* of Hero[n], and the treatise on a water-clock attributed to Archimedes. In addition, there was a centuries old tradition in Syria, unbroken by the Arab conquest, for the construction of water-clocks and associated automata. The knowledge of mechanics therefore came to Baghdad in Hellenistic guise, but it would be an over-simplification to postulate a Greek written tradition as the sole inspiration of the Banu Musa and their successors, although it was perhaps the main inspiration." The entry for the referenced Gaza clock is in this thesis' fourth appendix.

medieval Islamic civilizations, Baghdad. It bears mentioning that none of this dissection of the provenance for intellectual-historical knowledge is a denigration of the Islamic civilizations, as a suggestion that they “stole” their science from others, but is rather an objective and dispassionate assessment of ideas in migration, with such a “migration” having broader, unrelated causes.¹⁵⁴

Sometimes, the effectuation of this migration is attributable to the contributions of specific individuals. For example, the work of Qusta b. Luqa is indicative of the transition from the proposed first to second currents, with b. Luqa himself being the junction of intellectual-historical knowledge. In the case of Heron’s *Mechanics*, the provenance of automaton-making concepts can be represented by a series of connected statements like “the proposed first current, from the person and mind of Heron, in the Hellenistic city of Alexandria, transmits through the person and mind of Qusta b. Luqa, who partakes of the proposed second current, and arrives in the persons and minds of the Banu Musa, at the House of Wisdom, in the city of Baghdad, who also partake of the proposed second current.”¹⁵⁵ This is not simply a surmise, or pure conjecture, but is a trajectory borne out by analysis of the characteristics shared by the classical and Islamic designs. The presence of the eleven identifiable points of commonality between the respective designs of Hero[n], Philo[n], and the Banu Musa indicates the classical technological heritage in the works of the Banu Musa. Hill’s presentation of these eleven points demonstrates the validity of the relationship modeled between the proposed first and second currents of thought.¹⁵⁶

¹⁵⁴ See the Banu Musa, *Book of Ingenious Devices*, page 20, Hill’s “Historical Context of The Book of Ingenious Devices.” Hill writes the following: “The main flow of ideas, on present evidence, seems to have been from west to east. Thus the center of learning at Gondeshapur (Arabic: Jundaysapur) in south western Iran was probably founded by Greeks, although it did not rise to eminence until the arrival of Nestorian Christians from Edessa and Nisibis in the sixth century. The language of instruction was Syriac, but there is a tradition that the introduction of medical studies, the main subject taught at Gondeshapur, was due to an Indian. It may be considered as the center through which Byzantine learning passed to Baghdad. Of importance also were the Sabeans of Harran in upper Mesopotamia, of whom Thabit b. Qurra was one. They had preserved a large corpus of Greek scientific writings, also in Syriac, and were to be very influential in the development of Arabic science in Baghdad.”

¹⁵⁵ See the Banu Musa, *Book of Ingenious Devices*, page 20, Hill’s “Historical Context of The Book of Ingenious Devices.” Hill writes the following: “We cannot say with certainty which of the Greek works were known to the Banu Musa, with the exception of Hero[n]’s *Mechanics*, translated by Qusta b. Luqa during their lifetime. It is probable that other works of Hero[n] were also available to them, since his reputation among the Arabs was already high in the tenth century.”

¹⁵⁶ See the Banu Musa, *Book of Ingenious Devices*, pages 20 – 21, in Hill’s “Historical Context of The Book of Ingenious Devices.” Hill writes the following: “Problems of this kind [intermixing of contributions from distinct Greek and Arabic authors in single manuscripts], together with the Banu Musa’s omission of any acknowledgment of the works of predecessors, makes identification of their sources and isolation of their own contribution a matter of some difficulty. It may be best to clarify the problem, for a start, by listing those models of the Banu Musa that have close counterparts in Philo[n] and Hero[n]; chapter numbers are taken from Prager and Woodcroft. [a table of correspondences then follows on page 21, in which 25 of the Banu Musa’s 100 devices are named, and then shown to have specific technological characteristics identifiable either in 12 designs by Hero[n], 15 designs by

It is clear, given the table of correspondences between technologies of the classical and Islamic worlds in the major automaton-building treatises of the latter, as offered by Hill, that engineering knowledge from the classical Hellenistic world, including designs for systems involving automata, was transmitted to the Islamic civilizations. That a comparable transmission could be said to have occurred into Byzantium is not as convincing, as the Byzantines, although disdainful of their Greek identity for some centuries, were an authentic extension of classical civilization, not an external culture. Whether Hill's reconstruction of the trajectory taken by specific manuscript copies of classical engineering treatises is accurate, this table again demonstrates that classical and Hellenistic knowledge in some part, and even if syncretized with other sources of knowledge, was likely a foremost basis of the automata-building activities of the Islamic civilizations, even allowing, as does Hill in the quoted sections from his "Historical Context of *The Book of Ingenious Devices*," that there may also have been independent automaton-building traditions in some areas of Western Asia, which only bespeaks the universal appeal of automata.¹⁵⁷

Of these major automaton-building treatises, it is possible to identify "the Andalusian" primary source noted by Hill as none other than al-Muradi, whose designs for automaton-bearing devices are included in this thesis' fourth appendix, courtesy of Olive's short article on al-Muradi's contributions.¹⁵⁸ Given that al-Muradi's work was one of the treatises translated by the Toledo school at the behest of Alphonsus the Wise, King of Spain, that point agrees with Hill's "Andalusian" nomenclature, although just as the Toledo translators were active hundreds of years after al-Muradi's likely period of activity, it is recalled that Olive does not characterize al-Muradi as an Andalusian, but rather a Muslim intellectual of the same West Asian civilization which produced all the other outstanding Islamic engineering treatises in the thesis' period of study, ca. 450 CE to 1650 CE. Olive's dating of al-Muradi to the mid-eleventh century (ca. 1050 CE) also agrees with Hill's characterization of the "Andalusian" source in the latter's rehearsal of primary source matter.

Philo[n], or in a combination of one or more designs from both Hero[n] and Philo[n], with three designs from one of these source authors being used with one design from the other author in one of the eleven cases of shared technology, and with three designs from one of these source authors being used with two designs from the other author in another one of the eleven cases of shared technology.]”

¹⁵⁷ See the Banu Musa, *Book of Ingenious Devices*, page 21, in Hill's "Historical Context of The Book of Ingenious Devices." Hill writes the following: "In the light of recent investigations, it is permissible to speak of a Greek school of mechanical engineering, stemming from Ctesibius (300 – 270 B.C.) and continuing through Philo[n] and Hero[n], probably into Byzantium, whence it passed into Sasanid Persia. The school is represented, not only by writings that have survived, probably only a small part of the original corpus, but also by archaeological evidence such as the 'Tower of the Winds' in Athens and the Antikythera geared computer. In Sasanid Persia the Greek system may have merged with Iranian, Indian, and Chinese elements, and it was this composite tradition that came to the attention of the Banu Musa in Khurasan and later in Baghdad. Without knowing the full content of this system, we cannot be certain how many of Ahmad b. Musa's original ideas are embodied in his work."

¹⁵⁸ See the extensive presentations, with citations to all named authors, in this thesis' fourth appendix.

In discussing the Banu Musa, whose work antedates that of both al-Muradi and al-Jazari, Hill's wording, "...the real predecessors of their [the Banu Musa's] devices are those in the works of Philo[n] and Hero[n]..." is yet another demonstration of the relationship between the proposed first and second currents of thought, that is, the relationship between the cultural originators of certain automaton-related technologies, and the cultural inheritors of this technological legacy. Hill is correct that most of the Banu Musa's devices are not automata by this thesis' definition. Many are technical variations on the so-called "assassin's teapot" and do not necessarily have figural designs. However, there are some devices in the Banu Musa, as discussed under the entries for these devices in this thesis' fourth appendix, which satisfy the definition of automata which applies here because they have figures which, while static, are nevertheless designed in such a way as to suggest agentive intentionality on the parts of these same static figures.¹⁵⁹ For instance, the Banu Musa's treatise contains memorable examples of fountains in the shapes of biological organisms which use feedback systems to seemingly toy with human operators, apparently behaving of their own volition in ways contrary to the limitations of inanimate fountains. Entries for the Banu Musa's devices in this thesis' fourth appendix should be consulted for explanations as to why figures without movement, typically considered the fundamental attribute of an automaton, may be considered automata by the definitions applied in this thesis and its appendices.¹⁶⁰

Again and again, Hill, the pre-eminent twentieth-century scholar of this topic, presents conclusions demonstrative of the relationship between the first and second currents of thought under the proposed model, with his phrase "the Banu Musa took Greek models as their starting point," and the explicit naming of Philon and Heron, corresponding to the model's first current; the Banu Musa corresponding to the model's second current; and the linkage between these two proposed currents being the Banu Musa's use of classical knowledge, as represented by Philon and Heron's respective outputs, in furtherance of pre-Modern automata design and construction. As discussed, this holds because this thesis defines a small number of the Banu Musa's models in the seemingly-paradoxical category of static automata, that is,

¹⁵⁹ See the presentations of the Banu Musa's automaton designs under the fourth appendix.

¹⁶⁰ See the Banu Musa, *Book of Ingenious Devices*, page 22, in Hill's "Historical Context of The Book of Ingenious Devices." Hill writes the following: "It is certain, from an examination of the content of their work, that the Banu Musa were interested mainly in exploring the area of pneumatics and aerostatics and that the real predecessors of their devices are those in the works of Philo[n] and Hero[n] which were concerned mainly with these two technologies. With very few exceptions, the only things that move in the *Book of Ingenious Devices* are fluids, and the components such as conical valves and tipping-tanks that are essentially part of the flow systems. Some six of the devices incorporate simple mechanisms such as pulleys, otherwise the effects are obtained largely by using combinations of the ten basic hydraulic components or Motifs [SIC] (see Introduction 5). The figures of animals, birds and humans are static, and there is no astronomical content. This approach differentiates the Banu Musa's work sharply from the work of the other Arabic writers known to us – including a treatise written in Andalusia in the 5th/11th century[;] Ridwan (book composed 600/1203); al-Jazari (book composed 602/1206); and Taqi al-Din (10th/16th century). All these writers were concerned with the application of hydraulic power to activate the biological and cosmographical automata on monumental clocks, and the last two named also described hydraulic machines."

figures that demonstrate apparent intentionality, and therefore sentience, without visible movement.¹⁶¹

Throughout his discussion of the Banu Musa, it is the considered belief of this thesis that Hill ought not to have replaced the phrase “he who knows how it works,” his own literal translation from the Arabic, with the looser term “Adept,” since this specific step in translation adds a degree of hierophantic mysticism to the Banu Musa’s treatise, and tends to wrongly regress the Banu Musa, in their authorial voice, from the proposed second current to the proposed first current. Contrary to the connotations invoked by language like “Adept,” the Banu Musa show no other indications that they considered the operator of one of their devices to hold the occult knowledge or title of a mystical initiate, and on the contrary, their language, and frame of reference, with respect to their designs is secular, per the definitional outline of the proposed second current of thought.¹⁶²

As regards the subject of “magic” in the Banu Musa, some instances are noteworthy, but can be shown, on analysis, not to have the same connotation of “magic” which was (wrongly) considered efficacious in the pre-Modern and Early Modern periods, and which gave rise to the persecutions of the proposed fourth current. Comparison to al-Jazari is fruitful, as the sort of customary exchange which is described by the Banu Musa with respect to their “Model 12,” one of the many trick vessels in their treatise, is comparable to a similar exchange with one of the few such vessels described in al-Jazari. This is of some cultural-historical, or anthropological significance.¹⁶³ In terms of the indicated functionality for “Model 12,” the Banu Musa’s introductory paragraph warrants transcription:

¹⁶¹ See the Banu Musa, *Book of Ingenious Devices*, page 23, in Hill’s “Historical Context of The Book of Ingenious Devices.” Hill writes the following: “For let it be emphasized that, although the Banu Musa took Greek models as their starting point [the very ‘oversimplification’ against which Hill elsewhere warns], they went well beyond anything achieved by Hero[n] or Philo[n]. In particular, it is their preoccupation with automatic controls that distinguishes them not only from their Greek predecessors but from their Islamic successors [al-Muradi, al-Jazari, Ridwan, and possibly Taqi al-Din]. Their [the Banu Musa’s] use of self-operating valves, timing devices, delay systems and other concepts demonstrate great ingenuity.”

¹⁶² See the Banu Musa, *Book of Ingenious Devices*, pages 34 – 35, in Hill’s “Presentation and Translation” section. Hill writes the following: “Usually the text has such phrases as ‘the pipe is marked (bd)’ or ‘the valve upon which is mark (k).’ In the interests of brevity, these phrases are replaced simply by ‘pipe (bd)’ and ‘valve (k),’ except where such a usage would disrupt the flow of a sentence. With a similar objective, the person who operates the trick vessels, referred to in the text as ‘he who knows how it works,’ is often called simply ‘the Adept.’”

¹⁶³ There is similar verbiage, a recalled highlight of “social interest,” in Hill’s “General Notes” for al-Jazari’s analogous device.

“Manufacture of another pitcher (*ibriq*) which is taken by the slave (*ghulam*) [‘black,’ as the term ‘ghulam’ has racial connotations] who pours from it ritual washings for those who please him, and, when he so wishes, refrains from pouring any water over the hands of someone. We can provide information about this pitcher [namely] that its owner says ‘it pours out ritual washings only for believers and does not pour out ritual washings for heretics (*zandiq*) and the like.’”

It is considered unlikely, upon examination of the available evidence, that the Banu Musa, who gave a clear and concise explanation of how the vessel’s effect is obtained, believed it was a kind of magical divining-rod, useful for the determination of whether or not any given member of a dining party did or did not adhere to certain tenets of religious orthodoxy; as the Banu Musa demonstrate, the effect is triggered by the actions of the slave, making this slave, absent any other contextual information, judge of whomever should receive ritual ablutions, and thus remain a proven “believer” in the party of onlookers’ consideration; and whomever should not receive ritual ablutions, and thus be humiliated as, among other possible, undesirable labels, a “heretic” amongst these onlookers. Since declaring someone a “heretic” in the world of Islam was a dangerous proposition during the Golden Age, as now, the servant’s choices with the pitcher could scarcely be considered a “joke,” except in the most liberal court cultures (such as that which perhaps existed under Nasir al-Din, in the palace at Amid where al-Jazari spent his working life).

Alternative explanations are that the Banu Musa, with their tongues firmly in cheek, repeat the understanding of the pitcher’s “owner” respective to this vessel, and do so as an oblique slight to the latter’s intelligence – or, in what is a still better explanation, the Banu Musa are reporting the way in which this “owner” used the pitcher to ostracize others. In that case, both the “owner,” and the “owner’s” (black) slave, were necessarily aware of the pitcher’s operating principles. The “owner” would have directed his slave to withhold ablutions from specific diners after introducing the pitcher’s “powers” in a calculated bid to precipitate courtly intrigue, perhaps when interacting with a party of diners which, on the whole, was so ignorant that its members would unhesitatingly accept the premise of the pitcher’s “magical” power. After the slave’s activation of the pitcher’s function, these diners would possibly have proceeded to antagonize the “heretic” in their midst, the one seemingly identified by the “magical” pitcher, but who had actually been identified by its knowing slave-operator, and at the behest of a conniving host.¹⁶⁴

Another model from the Banu Musa which warrants discussion on the basis of its relationship to the concept of “magic” is “Model 47.” In response to the lines “This device is marvelous because it has a deceit and an illusion. It is also possible with this jar for the person to give those with him a choice: he says ‘if I pour in water or another liquid into the top of the jar, what would you like from me – something to

¹⁶⁴ See the Banu Musa, *Book of Ingenious Devices*, page 64, in Hill’s edition of the Banu Musa.

flow from the outlet or nothing to flow from it,” it should be noted that this is an unusual inclusion of subjective praise on the parts of the Banu Musa for one of their devices, or a positive assessment of their devices’ reception by assembled audiences, signified by the Banu Musa’s use of the term “marvelous” (changed from the British to American English spelling convention in transcription). A possible interpretation of this passage is that it does register the proposed third current of thought, within the broader context of overwhelmingly secular cultural attitudes to automata technology. The terms “deceit” and “illusion” are suggestive of magic, which is why ascription of the third current is possible; but given that the device described as “Model 47” does not satisfy my criteria for automata, the proposed model, and its “current” descriptors, is not applicable in the first place. Therein lies the point – even if it is allowed that this device from the Banu Musa is deliberately intended to seem “magical,” and be received as such by its audience, “Model 47” is a simple vessel, not an automaton by this thesis’ definition, just like the “heretic detector” already discussed. As such, it by no means overturns the thesis’ conclusions, and if anything, supports these conclusions, which are intended to apply specifically to automata technologies, even if they are broadly extensible to other topoi in the histories of ideas and material-cultural technologies.

Even so, this device should be counted among those in the Banu Musa’s treatise which is closest to a “magic trick” as that term is understood today, since it produces what could be called the “illusion of disappearance,” distinguishable from the illusion of transmutation identifiable in the Banu Musa’s many other, “water-into-wine” trick vessels. Additionally, the line “When the Adept [“the person who knows how it works,” but here, Hill’s imposition of “Adept” could be appropriate] stops pouring he should occupy those with him by conversation or another distraction – this device [and it is unclear whether the Banu Musa are referencing their design, or a magician’s patter] permits many operations.” In proffering this direction, the Banu Musa sound very much like magicians, since the same technique is also advised in modern-day guidebooks addressed to aspirant stage magicians, and indeed, to children who receive instruction booklets in stage magic kits.¹⁶⁵ Yet the proposed model is not contradicted, for a trick vessel is not an automaton by this thesis’ definitions.

Next, with regard to “Model 51,” it can be said that, like some of the Banu Musa’s other devices, it is so designed as to make in-poured liquids appear to vanish, as the operator can block their outflow. Because this operator must cover a hole in the vessel to achieve this effect, “sleight-of-hand” is also evident in the following quote: “The user of this jar should be skillful, so that no one knows when he blocks the hole. Then he lets those with him choose what they wish when he pours in the water. He says ‘What do you want [to happen] when I pour in the water – for something to discharge from the outlet or for nothing to discharge from it?’” Here, as in the cases of a small number of other devices presented by the Banu Musa, the method for this device’s use is suggestive of stagecraft skills deployed by modern magicians.

¹⁶⁵ See the Banu Musa, *Book of Ingenious Devices*, page 132, in the Banu Musa.

Specifically, the operator is required to perform a subtle action which goes unnoticed by an audience of onlookers. However, it does bear mentioning that the cultural context of medieval Islamic civilization is crucial in avoiding presentism, that is, to distinguish the Banu Musa's intentions from those of latter-day stage magicians. While medieval Islam could admit of magic, just like medieval Christianity, the practice of magic in the pre-Modern world, or appearance of practicing magic, was not (generally) an acceptable activity. Even so, it should not be assumed that all persons alive in the medieval world genuinely believed in the efficacy of magic, or were even familiar with the concept of "magic" as that term is understood in modern English.¹⁶⁶

It is the considered opinion of this thesis that the literate audience of technical treatises being addressed by the Banu Musa, and the circles of both this reading audience and the Banu Musa themselves, would have perceived the "magical" devices described in their treatise as parlor tricks, like modern-day museum exhibits; by contrast, children, uneducated people with childlike degrees of credulousness, and counterintuitively, even those highly educated people who subscribed to literalistic religious interpretations, might all have accepted the Banu Musa's devices as authentically "magical." As in Heron, the purpose of these devices can accurately be framed as a demonstration of physical principles, with study of the same having given rise to both Heron's work, and in turn, that of the Banu Musa, in the first place – yet crucially, the automata in Heron had religious subjects, and were used for religious purposes, unlike those of the proposed second current. While true that automata of the classical world were used for religious applications, the Greek treatises also make clear that their contents were intended as demonstrations of physical phenomena. The shedding of these religious applications, and continued study of these same phenomena by the Arabic recipients of the Greek works, are important points in the distinction of the first current of thought from the second such current in this thesis' narrative modeling scheme. Finally, the Banu Musa's line "It is suitable to use this in fountains and drinking fountains, with a similar arrangement of the jar, and with a tap at the root of the handle, and a weight," is noteworthy. What this line indicates is that, by adding these features, it would be possible to produce a drinking fountain much like those in common use today, that is, a system where water only flows for immediate consumption by a user when the fountain is activated (accomplished, in this case, by the "tap at the root of the handle, and [the] weight").¹⁶⁷ Regardless of whether one is impressed by the practicality suggested by this addendum, or inclined to emphasize that "Model 51" was designed to suggest "magic," once again, "Model 51" is not one of the Banu Musa's automaton designs per this thesis' definitions, and therefore does not contradict the proposed model, and its second current of thought.

With regard to "Model 70," the Banu Musa's instruction that its operator should use concealed clumps of wax in conjunction with its "hole-in-the-handle" design is notable because it underscores the deceptiveness of this device as parlor

¹⁶⁶ See the Banu Musa, *Book of Ingenious Devices*, page 141, in the Banu Musa.

¹⁶⁷ Ibidem.

trickery.¹⁶⁸ “Model 70” is another potentially “magical” vessel, and like the others, is not one of the Banu Musa’s automata. Therefore, once again, “Model 70” cannot be said to contradict the model proposed by this thesis, and its second current of thought, on their own terms.

As in the foregoing cases, the Banu Musa’s “Model 73” suggests “sleight of hand” because, like a nineteenth-century parlor trick, this device’s use is intended to approach the sense of “magic,” but in a context where learned persons are addressing each other, and would be unlikely to regard such a device as a piece demonstrative of “authentic” magic, that is, the magic of the proposed third current, and the basis of the proposed fourth current. To this thesis’ knowledge, no inquisitorial proceedings or witch trials were ever launched in the Islamic world in response to devices like those of the Banu Musa, either in legend, fiction, or historical reality --- and this, yet again, indicates the distinction between the proposed second current of thought and proposed third and fourth currents of thought. The said distinction is by no means unrelated to the different cultures of the European Christian and West Asian Islamic worlds, and to the divergent histories of technology and religion applicable in these two cultures. These points should be uncontroversial, but a useful feature of the proposed model is that it supplies names for intuitive trends.¹⁶⁹ In any event, “Model 73” is another vessel, not one of the Banu Musa’s automaton devices, and therefore does not contradict the propositions of this thesis, even if it recalls the concept, practice, or stagecraft of “magic” in any sense of that term.

There are only a few other interesting examples which bear upon the relationship between the proposed second current and the other currents. One is the case of the Banu Musa’s “Model 90.” While this instance does not contain automata, the relationship between the proposed first and second currents is still in evidence because the etymological evidence, and Hill’s hypothesized reconstruction of the aeolian apparatus for this fountain, show the influence of the classical technological authors, and specifically Heron, who was arguably responsible for writing the most significant technical treatises on automata, and technologies related to automata, which emerged from the Hellenistic and classical world.¹⁷⁰ So, while the perception

¹⁶⁸ See the Banu Musa, *Book of Ingenious Devices*, page 180, in the Banu Musa.

¹⁶⁹ See the Banu Musa, *Book of Ingenious Devices*, pages 188, 189, in the Banu Musa. On page 189, the second page of this device’s description, “sleight of hand” is noteworthy in the following lines: “If we wish, we make a hole in the outlet [pipe] at position (r), instead of the hole in the handle, and bring pipe (xe) to it. Then when the person [the operator] closes outlet (k) he closes hole (r), which is nearer [and hence easier] for it not to be known. The arrangement with hole (r), if pipe (xe) goes into it, is like the arrangement with the hole in the handle of the jar. The person [the operator] gives the choice to those with him, as we mentioned, and if wine is requested from him he takes his hand away and wine comes out, and if water is requested from him, he blocks hole (r) with a little wax and takes his hand away, and water comes out. And that is what we wished to explain.”

¹⁷⁰ See the Banu Musa, *Book of Ingenious Devices*, page 222, in the Banu Musa. On page 222, with respect to “Model 90,” that model is wind-driven, aeolian, per the following introductory lines: “Construction of a fountain from which the water shoots up at one time like the shape of a lily-of-the-valley and at one time like a lance. It is worked by the wind as long as it blows, and we can also make it work and alternate by the flow of water.” In response to Hill’s addendum for this device on page 223, elements of this addendum, which is transcribed in full, corroborate the thesis’ first current of

of “magic” must be disregarded in the cases of some non-automaton-bearing designs in the Banu Musa, this does not itself mean that the clear heritage of the classical technical achievements in other non-automaton-bearing designs by the Banu Musa must be disregarded. Simply put, the “magic” of a pre-Modern or Early Modern device which does not contain an automaton does not detract from the narrative trajectory of the model proposed by this thesis as regards automata, but evidence from non-automaton-bearing devices which accords with the evidence marshalled for automaton-bearing devices does support this narrative trajectory.

Finally, with respect to the Banu Musa’s “Model 97,” this device would seem to register the proposed first current of thought on the ground of religion, rather than technology, despite the thesis’ belief that a “religious” automaton is inconsistent with the culture of Islam, and that religious conceits are therefore not a feature of Islamic automata. However, this device does not register the proposed first current of thought, as there is no initial specification of who, exactly, has invoked the name of God in its ascribed name, “The Lamp of God.” Unsurprisingly, those who applied this name, “The Lamp of God,” are (presumably) named in the concluding lines of its description, and when everything is taken together, the thesis’ proposed model is by no means refuted by its nomenclature.

Whomever wrote this description (according to Hill, the high-numbered models included in his edition might not be authentic works by the Banu Musa) states, in its conclusion, that “The people of the religions require this lamp – they who see it believe that it is a perpetual lamp, namely [that] the fire never goes out, and [that] there is always fuel in the fire-tubes. They are the Magians. And in churches, the Christians place the column and the reservoir for the oil in a wall, and [everything] is hidden except the lamp, [which is] more beautiful for the viewers of the lamp. And that is what we wished to explain.” This is the most memorable time Christians are explicitly mentioned in the treatise, and the speaker names them respectfully enough, although with an air of distinguishment, through the immediate replacement of “Christians” with “viewers of the lamp.” Of course, there is a comparable, disproven notion of the “holy flame” in some Orthodox traditions. In any event, the “Lamp of God” is not a preternatural device for the Banu Musa, and was only so, presumably, for some people associated with some of these other sects.

thought: “The illustration incorrectly shows tank (1) on two separate tanks; it should be a single tank with the axle passing through it. The word used for windmill (see note 2) probably derived from the Greek *onemurion* as used by Hero[n] in describing a wind-wheel which powered a mechanical organ. (See Wood[c]roft facsimile edition, p. 180, No. 77 and the illustration from original MS 184V on p. 141. The device is discussed by A.G. Drachmann in *Centaurus* 7, Copenhagen 1960 – 1961). Only the water-wheel is shown here – the wind driven alternative is not illustrated, the method of construction must be conjecture, but it seems likely that it was similar to that of Hero[n], with a horizontal wheel and a worm-wheel. A derivation from the wind-wheels on a vertical axle as used in Afghanistan seems less likely (White 1, 20 – 21; Needham 1, 560 – 561). The water-wheel illustrated here was probably of the vaned horizontal type as used by al-Jazari (Hill 1, 95 – 96). The vanes were formed by cutting a copper disc along about twenty of its radii, leaving a central circle intact, then bending the sections to form the vanes.”

Like the others which have been discussed, there is a suggestion of the supernatural, of magic, in “The Lamp of God,” since there is an element of concealment in its operating procedure. Technicians are directed to sequentially fill a secreted oil supply first (“It should be clear that when we pour the oil into hole (l) it enters pipe (ls) and flows through pipe (wz) into the reservoir which it [i.e. the pipe] is in”), and to then separately fill the visible oil supply (“We pour in the required amount of oil, lamp (fb) fills with oil, we light the wick – while we are observed”). The emphasis on performing the latter actions when the technicians are “observed” by onlookers underscores the distinction between these actions and those which are not “observed,” and, therefore, the trickery of the design.

Hill, in his addendum for this device, makes some remarks which seem incorrect at a technical level. The Banu Musa wrote “It is clear that we have made a lamp from which the wick emerges of its [own] accord, and it is possible with these arrangements to make a lamp that shows the [passage of the] hours, and whenever an hour elapses [,] a ball drops. This is not absolutely correct, but it is almost correct. If we wish, then whenever a day passes, float (t [dotted]), as it sinks, causes a ball to be discharged [,] so that if anyone wishes to know the time that has elapsed since this lamp was lit, he looks at the number of balls [,] and reckons each ball as a day.” In the illustration for this device from the Berlin manuscript, the one presented by Hill, two such balls are shown; the first, which is closer to the lip of the basin from which the wick protrudes, looks remarkably like a globus cruciger, having a decorative piece at its top, and the second, which does not, is smaller, lending a degree of pre-Modern perspective (the first ball is the one closer to viewers). Both balls are shown on the toothed piece which advances the wick.

In the thesis’ interpretation, these are the balls mentioned directly by the pseudo-Banu Musa speaker. However, Hill writes, in his addendum, “It is remarkable that the Banu Musa never described a water-clock, their reference to the adaptation of this lamp to serve as a timepiece is therefore of interest. The two circles drawn at the left may indicate, in rudimentary form, the float and pulley system necessary to operate such a timepiece.” These “circles,” as interpreted by this thesis, are the balls in the final paragraph, not elements of a float. Hill goes on to note that the dropping of balls, as a means to keep time, was also used in other Islamic devices, including many in al-Jazari’s treatise: “...for the release of balls to record the passage of time see, for example, Hill 1, Category 1, Chs. [Chapters] 1 – 4, 7 – 10 [the latter grouping being al-Jazari’s candle clocks, which are more elaborate, but which are nevertheless close conceptual analogues of the Banu Musa’s lamp]; Hill 2, 19 – 20.”¹⁷¹ Technical considerations are very infrequently discussed by this thesis, but in this case, offering an alternate interpretation of the medieval depiction in Hill’s edition of the Banu Musa seemed a useful step for future scholars.

¹⁷¹ See the Banu Musa, *Book of Ingenious Devices*, page 236 *et seq.*, in the Banu Musa. “Construction of a lamp: the wick comes out by itself and the oil flows by itself and everyone who sees it thinks that the fire has consumed nothing whatsoever from the oil or from the wick. This lamp is known as ‘the lamp of God.’” These are the first lines of the device’s description from the Berlin manuscript (note the monotony of the first sentence).

THE THIRD CURRENT OF THOUGHT.

As E.R. Truitt has noted, the continuing tradition of automaton-making in points east of what she consistently calls the “Latin West,” combined with the loss of the Heronic corpus, led to a distorted view of automata in the High Middle Ages of feudal Europe. Lacking the requisite technical grounding to construct automata, yet confronted by the encounters with automata recounted by travelers and introduced by material-cultural exchanges with the ‘Abbasids, the now-Christian Europeans were left to explain the operation of automata by making recourse to the conception of “magic.” This was neither the mystical supernaturalism of the Hellenic case, nor the secularized conception of automata operative in the Byzantine Empire and ‘Abbasid Caliphate, where automata were actually being built, but was an explanation of the inexplicable motion of automata within a Christian mentalité as necessarily informed by religion as the prior examples of polytheistic temple worship before animated figures considered gods and Islamic repudiation of any representation for the divine, including by the medium of automata. Truitt discusses how Christians of the High Middle Ages conceived of automaton-making as an activity based in the learned use of “natural magic,” which was heavily informed by astronomy and could be understood much like a science, or alternatively based in the similarly-learned use of outright necromancy. Unsurprisingly, the latter carried demonological associations not incomprehensible to the contemporary thought of fundamentalist Christians, and as will be seen, the ascription of motion in automata to necromantic power gave rise to its own current of thought.

This third current of mechanical thought, the “magical” automaton, appears again and again in medieval romances and *chansons* of the High Middle Ages, where it is consistently signified by specific attributes. Because the most recurrent characteristic is the material used to create a magical automaton, yellow metals like brass and gold, this thesis’ catalogue uses the descriptor “thing of brass” to tag automata which share this commonality. While the “magical” automaton is a feature of medieval fiction, this current of mechanical thought passed from literature to myth as medieval authors seized upon its trope, the brazen construct animated by arcane or forbidden knowledge and possible traffic with demons, to defame the character of those Europeans they legendarily purported to have been automaton-makers, or to offer moralistic didacticism with a legendary automaton as the conceit.

However, the first current of thought, that of the Hellenes’ sacred automata, was not abandoned in the High Middle Ages that ended with the turn of the fourteenth century, but existed contemporaneously and in parallel with the third current of “magical” thought in Europe and, of course, the second current of thought in Dar-Al-Islam and Byzantium. Some of the very early figural automata, including The Boxley Rood of Grace and La Virgen de los Reyes, are religious, and both are in fact representations of Jesus Christ; in the former He is shown crucified, and in the latter He is shown as a child with the Madonna. That these automata are direct representations of Christ is unsurprising in iconodule Western Europe. These two automata date from approximately the same era as some of the romances and

chansons containing “magical” things of brass; thus, while gold-colored literary automata reflected European flights of fancy inspired by the secular Heronic automata being fashioned to Europe’s east, the few automata actually being built in Europe were solidly religious. It is the contention of the thesis that these three currents of thought competed during this phase of the Middle Ages, as each was evidentially in circulation. Of course, as with all later uses of “compete,” the thesis is unaware of structured argumentative exchanges between adherents of these or any other currents of thought, and the term is meant as an indication of contested meaning for the referent of divergent ideas. An analysis of trends mounted by this thesis contends that the second current of thought, the equation of automata with secular rather than religious subjects, and with secular engineering and design, eventually came to predominate in Western Europe.

It has been contended that the appearance of gold-colored figural automata in the romances and *chansons* is explicable as an attempt to position the aristocratic patrons of *romans antiques* as heirs to the glories of classical antiquity. Yet the automata in the *Roman de Troie*’s Chambre des Beutes episode differ crucially from the constructed automata of the Hellenistic world. Unlike Heron’s temple artifices, these automata are sentient – and not only sentient, but also enforcers of idealized societal expectations. Further, they are not gods or monsters. While capable of extraordinary feats, they are anonymous human figures that are not specific representations of deities, and neither are they treated as deities by their audience *despite* these feats. While all who enter the Chambre des Beutes, or Alabaster Chamber, are overawed by the spectacles and acuity of discernment evinced by the four automata it contains, no character prostrates himself before these images. Such a reaction would probably be elicited by a realization of these automata from a historical Trojan onlooker, yet the *Roman de Troie* does not present the Alabaster Chamber’s automata as divine. This thesis would contend that the mediation of the second current of thought, that of secular automata, is responsible for this secular substratum of the third current of thought, much as incomprehension of Heronic mechanism is responsible for the “magical” stratum of the same third current.

Yet can there be concrete evidence to demonstrate that a continuing association exists between magic and works of high technology? The thesis can answer in the affirmative. According to a search conducted on Google Trends as of March 2020, there has been greater lexical prevalence for the phrase “computer wizard” than for “financial wizard” since January 2004, when Google Trends’ records open. This juxtaposition between “computer” and “financial” wizards was suggested by the entry for the term “wizard” on the online version of the Cambridge English Dictionary, where both phrases are given as examples. Of course, “computer” as a species of high technology is distinct from automata as such a species, although modern robotics has been driven by developments in computing since at least the mid-twentieth century. What matters is that both modern computer science and automaton-building in the pre-Modern and Early Modern past are alike in that they are subjects which seem incomprehensible, mysterious, and arcane to non-specialists.

EXAMPLES OF THE THIRD CURRENT OF THOUGHT.

Bedini, in his seminal work on automata, often invokes the proposed third current of thought, either knowingly or unknowingly, as interpreted here. By repeating the oft-told tales of Charles V's last days at the monastery of San Yuste, Bedini introduces the trope of a clergyman destroying automata after misapprehending them as works of demonic sorcery. While the European clerics of the pre-Modern and Early Modern periods were among the most educated in their societies, and were often properly "literate" by medieval standards, having knowledge of Latin, in addition to at least one vernacular language, their authentic faith could create an exceptional state where they, despite their learnedness, could be more prone to perceive unfamiliar technologies as works of magic, given that a religious worldview admits of supernatural and preternatural power. Thus, when Bedini cites a "disapproving Superior of the convent, who considered them [automata] works of sorcery," he is indicating a registration of the proposed third current, the identification of automata with magic, and also the proposed fourth current, the tendency to persecutorial behavior in accords with this worldview, as will later be discussed.¹⁷²

Once the trends identified and analyzed by this thesis' proposals are understood, they are recognizable in many scenarios involving fictitious, actual, and legendary automata, even those which extend beyond the conclusion of the considered period of study in 1650 CE, although this thesis does not warrant that its findings are universally extensible after 1650 CE, or for that matter, prior to 450 CE, the earlier periods which also fall beyond its scope. For example, it can be said that the proposed third and fourth currents were demonstrably replaced by the proposed fifth and sixth currents in 1780, when the most recognizable, and durable, "thing of brass" (in this thesis' nomenclature), the magical "brazen head," was reproduced by a variety of aristocratic inventors in a scientific contest opened for this purpose under the prestigious auspices of the Academy of Sciences, an organization based in Czarist Russia.¹⁷³ However, one need not look to such late dates to see empiricism, and skepticism, replace the magical ideation of the third current; this shift was well underway within the scientific community by the early seventeenth century, and permeated broader society, in the European context, through the succeeding centuries.

¹⁷² See Bedini, "Role of Automata," page 32: "On other occasions he would release little carved wooden birds which flew into every corner, to the consternation of the disapproving Superior of the convent, who considered them works of sorcery." The source used by Bedini to present these tales is given in the twentieth footnote in his work.

¹⁷³ See Bedini, "Role of Automata," page 38: "The next major advance in this field was made in about 1770 by Friedrich von Knauss of Vienna, who constructed not one but four speaking heads. That his project was not completely successful is attested to by the fact that in 1779 the Academy of Sciences in St. Petersburg used the production of a successful speaking head as the theme of a contest for mechanics and organ manufacturers, specifying that the machine be capable of speaking the five vowels. Three inventors produced results at about the same time: the Abbe Mical in 1778, the Baron von Kempelen and C.G. Kratzenstein, both in 1780. Numerous others constructed speaking heads within the next decades, but never with any marked degree of success."

Indeed, by the eighteenth century, the proposed third current could playfully be referenced in automaton works which registering the proposed fifth current, as when automata, by then understood as clever works of technology, were fashioned with the conceits of magic in their apparel and actions, like Malliardet's "Magician."¹⁷⁴ Yet semantic clues, even in the twentieth century, suggest that the legacy of the "magical" automaton, represented by this thesis' proposed third current, long outlived a sincere and broadly prevalent belief in magic, at least in the Atlantic world. Silvio Bedini himself, one of the foremost twentieth-century authorities on the intellectual-historical meanings of automata, could knowingly, or unknowingly, introduce the association between automata and "magic," as when, by spontaneously and rhetorically referencing "alchemy," he alludes to this thesis' proposed third and fourth currents, while also inadvertently overstating efficacy of a certain school of magic in the history of real-world automata, which were only functional to the degree that such functionality did not devolve to attempted "magic," which has no observable effect.¹⁷⁵ Mary Flowers Braswell also uses the term "magic," although in the sense of wonderment, rather than claimed occultic power; yet the semantic ambiguity created by "magic" as a term, and its freighted nature as a callback to the authentic belief in magical power prevalent at all levels of society in pre-Modern and Early Modern Western Europe, and to the persecutions which usually accompanied the same from the High Middle Ages to the Reformation, must register the association between magic and automata established by this thesis' proposed third, and fourth, currents of thought.¹⁷⁶

Braswell does have the correct understanding of this relationship between "magic" and automata, as shown by another passage where "magic" is used in an appropriate context while an identifiable and discrete instance of pre-Modern or Early Modern automata is described. Since the automaton figure in this instance is an angel, the cultural dimensions of the proposed first current of thought are also applicable. As such, Braswell's imputation of "magic" in the case of the automaton she discusses, which is cataloged in this thesis' fourth appendix, would best be borne out if this "golden" angel, with a brazen coloration, was what this thesis terms a "Thing of Brass," a brass figure, or one with a uniformly brazen coloration, that had signified a "magicked" construct, usually as the receptacle of a preternatural intelligence, since the era of the medieval romances; and indeed, since the Biblical episode of the brazen calf, an idol, which had the same conceptualization, if not any evidence of moving

¹⁷⁴ See Bedini, "Role of Automata," page 39: "Two other figures almost as notable are the Magician and the Draughtsman-Writer of Henri Maillardet (1745-?), a craftsman who had worked with the Jacquet-Droz. The Magician, seated upon a stage built over a clock music box, answers questions printed on oval cards inserted in a drawer on the stage. If the drawer is opened and closed without a question, the magician shakes his head. When a legitimate question is asked, he rises slowly, moving his head and eyes, and points to a small door behind him which opens to reveal the answer."

¹⁷⁵ See Bedini, "Role of Automata," page 40: "Certainly the temptation was always at hand to attempt to create life itself in giving birth to these lifeless figures by a combination of alchemy and mechanics."

¹⁷⁶ See Braswell, "The Magic of Machinery," page 103: "The artists created magic by designing automata."

elements. This same notion, that a brazen figure could be “invested” with an external intelligence through occult operations, would persist through the Hermetic corpus of late antiquity, and would be rediscovered and elaborated-upon in the Renaissance by Marsilio Ficino, who would make “investiture” a principal element in his own system of magical praxis.¹⁷⁷

While Braswell’s proposal that Chaucer’s “Franklin’s Tale” was actually performed using automata is purely conjectural, were such a performance to actually have been mounted, it would then have represented a fascinating interplay between the currents proposed by this thesis. Essentially, it would be an arrival at the proposed fifth current, a secular understanding of automata within the context of stagecraft, by way of the proposed third current, a magical understanding of automata, since the automata, understood not to be authentically magical by their audience, would nevertheless simulate magical phenomena within the fiction of the staged tale; and whether the proposed fourth current would also be registered by such a performance would depend upon the degree to which the audience homogenously held the mentality of the fifth current, or was more heterogenous, and was comprised of individuals who would take articles of automaton stage machinery as displays of sorcery (the hostile reception John Dee’s scarab automaton received in the context of the Reformation, as described in this thesis’ fourth appendix).¹⁷⁸

The question of the fourth current, and how it could be bypassed, as well as the narrative linkages between the proposed currents, is also evident in Farmer’s discussion of some likely intellectual-historical origins of the automata of the park at Hesdin. In considering these origins, the proposed second, third, and fifth currents are in play, and a bypass of the proposed fourth current is again indicated, but only in the courtly context of the highest medieval aristocracy.¹⁷⁹ These various currents are in

¹⁷⁷ See Braswell, “The Magic of Machinery,” page 105: “And like the one in the *Franklin’s Tale*, this one, too, is associated with magic, for it held a mechanical golden angel. Propelled by a simple device (probably a winch or windlass), the angel bent down and offered the crown to the young king. That automata such as this one were kept and reused, were indeed probably standard props, is suggested by King Richard’s pageant of 1392, when the castle and angel appear again.” For this instance, see the thesis’ fourth appendix; and for a meticulous presentation of Ficinian magic, see Lily Filson’s cited doctoral dissertation.

¹⁷⁸ See Braswell, “The Magic of Machinery,” page 108: “It is tempting, therefore, to believe that before its incorporation into *The Canterbury Tales*, *The Franklin’s Tale* was actually enacted to the delight of an audience knowledgeable of contemporary automata. In a world in which nominalism was beginning to gain ascendancy over symbol, in a society whose sophisticated members were insisting on verification through experience, it was not sufficient for the tricks of the Clerk of Orleans to be sheer illusion. For automates maneuvered by “viace,” capston [SIC] winch, clock mechanism, whatever – these marvels were indeed the magic of the late Middle Ages.” For Dee’s automaton, see this thesis’ fourth appendix.

¹⁷⁹ See Farmer, “Aristocratic Power and the ‘Natural’ Landscape,” pages 677 – 678: “During his sojourns in Sicily and southern Italy, Robert may also have learned about the mechanically driven Islamic sculptures and sculpturally adorned water clocks that had belonged to King Roger II of Sicily and the Emperor Frederick II. And even if he did not learn about those mechanical devices, he would have become familiar with the idea of such wondrous artifacts through his reading of the *Cleomades*, a French romance based on one of the tales of the Arabic *Thousand and One Nights*. Robert’s

play because Farmer proposes Count Robert II de Artois, master of Hesdin, may have directly seen automata of West Asian manufacture at southern Italian courts, making Robert himself a connection between the proposed second and subsequent currents; or that he might have been inspired to build automata to concretize the “magical” automata he encountered in a medieval romance, the *Cleomades*, which was itself based in the West Asian *Thousand and One Nights*, and was a work that he himself may have directly or indirectly patronized, meaning that Robert would then have been an early participant in the great enterprise of attempting to realize technologies encountered in the “science fiction” of his day (for *Cleomades*’ automata, see this thesis’ fourth appendix). So, Robert was either in contact with representative works of the proposed second or third current, or with representative works of both such currents, and after this contact, produced automata identifiable as works of the proposed fifth current. Again, this reflects an aristocratic bypass of at least the fourth current of thought, and possibly also the third current of thought – the proposed second direct jumping to the proposed fifth current, although possibly mediated by the third current, given the *Cleomades*’ “magical” automata, but not resulting in the construction of automata which were believed to have actual preternatural or supernatural powers by their observers, Robert II and his courtiers, at least to the knowledge of this thesis.¹⁸⁰

The relationship between magic and science is one to which many consulted authors return, as automata invite interpretation along this dipole. Of course, the chronological bounds of this thesis are also those in which Western European science *qua* science began to emerge, within the context of the Late Middle Ages, the Renaissance, and the Early Baroque periods, so the intersection of science and magic as concepts related to automata is even more pronounced within a Western European context that had admitted of magic as a real phenomenon, and continued to admit of it as such, with diminishing conviction, until the nineteenth century; and within limited circles, even to the present day. By contradistinction, there does not appear to have been a comparably pervasive or meaningful concern with magic in West Asia, particularly in the Islamic societies which produced the Banu Musa and al-Jazari. For these reasons, the narrative transition from the proposed third current to proposed fourth current is marked by King with a reminder that the experimentalism of Western Europe’s Paracelsian alchemy, for all its magical connotations, contributed some empirical knowledge, and some accurate observations, which is more than can be said for other varieties of European occult practice, and for that matter, earlier medical models, such as the humoral system.¹⁸¹ King then suggests that an automaton

contemporary Adenet Le Roi wrote the French tale, and several of the earliest manuscripts of the text, which include an illustrated *envoi* to Count Robert, suggest that Robert was familiar with the text.”

¹⁸⁰ See Farmer, “Aristocratic Power and the ‘Natural’ Landscape,” page 679: “In one way or another – either through literature or direct experience – Robert’s moving monkey statues and other mechanical devices were probably inspired by models coming from the Islamic world.”

¹⁸¹ See King, “Clockwork Prayer,” page 17 in the author’s printed copy: “When we remember that alchemy, for all its long association with forbidden knowledge, is the mother science of modern chemistry, and that Paracelsus was among the first to propose a theory of metabolism against the

of the Renaissance era, the famed monk upon which she has built an academic career, registers the proposed first (“church”), third (“magic”), and sixth (“science”) currents on the basis of this same cultural intersectionality of varied discourses. See the monk’s entry in the fourth appendix for this thesis’ holdings regarding that instance of pre-Modern or Early Modern automata.¹⁸²

Analysis of Chaucer’s *Canterbury Tales* as the basis for virtually any academic argument or topic is ubiquitous, as it is one of the most indicative works of its historical milieu. It is unsurprising, then, both that it contains an automaton, and that this automaton has already been a subject of scholarly interest. When Lionarons writes that “technological inventions, particularly mechanical devices, frequently function within the *Tales* as if they were in fact magical, while magic often reveals itself to be mechanically based,” this statement is comprehensible in terms of the proposed third current of thought; an automaton, in this case, the Hors of Bras, is considered magical to the degree that those exposed to it are ignorant of its technology, which gives rise to the inevitable corollary that something “magical” is a work of hitherto unknown technology, which can be exposed as such through careful examination, study, and technical knowledge.¹⁸³ The third current of thought is as much rooted in ignorance of technology as it is knowledge, or suspicion, of the occult practices applied to fill the void of such ignorance, and in the case of the Hors of Bras, Lionarons writes “it [the Hors of Bras] seems ‘a fairye’ (201), a fairy or magical thing, even though it is obviously mechanical, an attitude which seems to suggest that the essence of its magic could be that no one quite understands how it works.” This dimension not generally or simply of wonderment, which can register the proposed sixth current of thought, but of the imputation of “magic,” must register the proposed third current of thought.¹⁸⁴ Of course, as discussed in this thesis’ appendices, the Hors of Bras is indeed a “Thing of Brass,” and given the relationship of the latter concept to Hermetic magic, which would later be recapitulated in the Renaissance as Ficinian “investiture,” the connotation of “magic” is more than merely a semantic point, as a reading of Lionarons, without consideration of the Hermetic corpus, might suggest.

entrenched ‘four humors’ view of the body, we understand something of the paradox and complexity of this transformative period in history. (And we wonder what kind of gentler treatment Don Carlos might have received from the great Swiss physician). The alchemist moreover, sought equally a knowledge of the cosmos and an understanding of the living organism: these truths would be elementally interwoven.”

¹⁸² See King, “Clockwork Prayer,” page 18 in the author’s printed copy: “He [the automaton monk] walks a delicate line between church, theater, magic, science. He circulates among – murmurs about – all of them. He is a synapse, transmitting a host of simultaneous signals.” For the automaton monk, see its entry in this thesis’ fourth appendix.

¹⁸³ See Lionarons, “Magic, Machines, and Deception,” page 377: “Technological inventions, particularly mechanical devices, frequently function within the *Tales* as if they were in fact magical, while magic often reveals itself to be mechanically based.”

¹⁸⁴ See Lionarons, “Magic, Machines, and Deception,” page 378: “Even more interesting than the horse of brass itself, however, is the reaction Chaucer ascribes to the courtiers and common people who come to stare at this marvel in the courtyard: to them it seems ‘a fairye’ (201), a fairy or magical thing, even though it is obviously mechanical, an attitude which seems to suggest that the essence of its magic could be that no one quite understands how it works.”

Yet, even in the European medieval context, and to the surprise of those who espouse the Enlightenment view that this exclusively was an era of execrable benightedness, the semantic concept of “magic” is twofold: it encompasses both a sincere belief in efficacious magic, admittedly to a greater degree than perhaps at any other time, and also within the formalism of academic knowledge, but, at one and the same time, it encompasses the concept of stage magic, a subtype of theatrical display which persists in contemporary times, and which is arguably the predominant conception of “magic” in post-industrial nations. Thus, Chaucer’s inclusion of the attitude that such intellectual-historical automaton constructs as his fictive Hors of Bras are comprehensible as “sleight-of-hand and technical illusion” relates to the third current under the proposed model, but specifically to a subcurrent of this third current which identifies magic as it is perceived today, as stage or parlor trickery, rather than as works of “supernatural or demonic powers.”¹⁸⁵ This attitude was no doubt informed by the very real presence of actual automata in the pre-Modern and Early Modern worlds, as well as that of some other articles of material culture, in such places as West Asia, which are not automata by this thesis’ definitions, and which are not argued to have been widely perceived as true creations of occult practice in their own cultural environments (and which, even if so perceived, would not upset this thesis’ model, given that, for example, the “magical” devices of such authors as the Banu Musa are not automata, as discussed with many specific examples in the prior section on the proposed second current of thought). This sense of performance “magic,” as well as the other presented sense, that a “magical” thing could be defined as an identifiable article of technology, but of unknown operation, are two transitional approaches from the proposed third current to the proposed fourth current of thought in the thesis’ model, but are chiefly articulations of third current of thought, and can be distinguished from still another articulation of the proposed third current, that of a truly unqualified apprehension of automata as “magic,” which does not, on its face, allow progression to the proposed fourth and subsequent currents.¹⁸⁶

Discerning the difference between these three articulations of the proposed third current of thought, which are not necessarily exhaustive, is a concern in analyses of Chaucerian fiction. Lionarons, for example, argues that the displays produced by the Clerk of Orleans in the “Franklin’s Tale” could be understood as stage machinery with automata, which would then invite either or both of the two interpretations offered above which are concepts other than the idea of “real” magic. This example

¹⁸⁵ See Lionarons, “Magic, Machines, and Deception,” page 379: “Still others assume it is made by ‘som magyk / As jogelours pleyen at thise feestes grete’ (218 – 19). We should note that ‘magyk’ is here attributed to jugglers, whose craft is comprised of sleight-of-hand and technical illusion, not to manipulators of supernatural or demonic powers.”

¹⁸⁶ See Lionarons, “Magic, Machines, and Deception,” page 379: “The four gifts of the *Squire’s Tale* are magical insofar as they all require esoteric knowledge to make or to use, but that knowledge is conceived of as essentially technical; additionally, the mirror and the ring give their users access to hidden or esoteric knowledge. None of the magic in the tale necessarily involves the supernatural; none is clearly differentiated from the technological. Nevertheless, even if the so-called ‘magic’ is really technology, it is still suspect, precisely *because* it is based on uncommon knowledge and can therefore be used by the learned to deceive the ignorant.”

therefore relates to the proposed third current of thought, and to understandings of the same which are not based in “magic” as an actual phenomenon comprehensible, for instance, in the demonological terms of medieval Christian theology.¹⁸⁷ The interpretative versatility of the Clerk of Orleans’ scenes, as one or more of the three different senses of “magic,” mirrors the categorical ambiguity of an automata, which exists along such axes as living-dead, natural-artificial, divine-diabolical, scientific-magical, wondrous-terrifying, etcetera, per Truitt’s analyses in *Medieval Robots*.¹⁸⁸ The inability to discern the true nature of an automaton, upon being confronted by the same, is what makes automata such as the Hors of Bras troublesome to Chaucer, since in Lionarons’ analysis of *The Canterbury Tales*, “such devices rely, like magic, on knowledge that is not readily available to common people; like magic, they can be used to deceive the ignorant; perhaps, like magic, they also draw on knowledge improper for human beings to have, since they can tempt a person to try to go beyond the natural limitations of humanity.” In this respect, Chaucer, who presents works of automaton technology with suspicion, arguably provides a very early example of Asimov’s Frankenstein Complex.¹⁸⁹ It is in the dissection of the multitudinous meanings, whether positive or negative, which can be inscribed upon the idea of automata, that the trends modeled by this thesis become apparent, as when Lionarons writes “mechanical devices would seem merely useful; as magic, they can be objects of wonder,” which registers the proposed third current, but also suggests the proposed sixth current as it relates to wonderment, although of these two currents, the third is more apropos for Lionarons’ quoted observation.¹⁹⁰

Per the given allusion to the demonological understanding of magical power in pre-Modern and Early Modern Europe, addressing the question of negative preternatural energies, of Hell and its denizens, is unavoidable in any discussion of the relationship between ascriptions of “magic” to automata, this thesis’ third current, and the intellectual-historical and material-cultural automata of those eras. Chaucer again provides primary-source material indicative of the association between automata and magic, and thence from automata to the demonic. Analyzing medieval art in conjunction with his reading of Chaucer, O’Brien argues that there was an

¹⁸⁷ See Lionarons, “Magic, Machines, and Deception,” page 381: “Moreover, the illusions the clerk creates during Aurelius’ first visit could be elaborate versions of the same type of ‘apparences’ that the tregetoures were famous for: basically theatrical performances of automata on a revolving stage.”

¹⁸⁸ See Truitt, *Medieval Robots*.

¹⁸⁹ See Lionarons, “Magic, Machines, and Deception,” page 382: “Just as in modern science fiction stories, a certain amount of willing suspension of disbelief is necessary to make the technology work. But both tales also illustrate a profound distrust of the technological devices they contain; such devices rely, like magic, on knowledge that is not readily available to common people; like magic, they can be used to deceive the ignorant; perhaps, like magic, they also draw on knowledge improper for human beings to have, since they can tempt a person to try to go beyond the natural limitations of humanity. There is seemingly little to protect those who, like the crowd of spectators in the *Squire’s Tale*, ‘kan nat the craft’ (F 185), while those who do use technology for their own ends court a different kind of danger.”

¹⁹⁰ See Lionarons, “Magic, Machines, and Deception,” page 385: “As machines, mechanical devices would seem merely useful; as magic, they can be objects of wonder.”

“important cultural association... between the demonic and the mechanical,” which registers the proposed third current of thought inasmuch as the European mentality of the Middle Ages equated magical power with the intervention of inhuman demons, and which registers the proposed fourth current of thought inasmuch as this equation became a ground for the persecution of automaton-makers as sorcerers, given that automata, as discussed, tended to be perceived in accordance with one or more semantic senses of “magic.”¹⁹¹ While no automata (rare objects, it is admitted) are shown in either fantastical landscape, O’Brien notes that “in both Limbourg’s and Brueghel’s pictures hell is a realm of the technological grotesque,” and since automata were extraordinary exemplars of high technology in both the pre-Modern and Early Modern worlds, their presence would accord well with the envisionments of grotesqueries realized by Limbourg and Brueghel, and which otherwise display such technological accomplishments as the portable hurdy-gurdy. Thus, O’Brien’s conclusions register the proposed third and fourth currents, as well as the proposed seventh current, for they relate to the relationships established between demons, the source of magic in the view of the medieval Church; technology; the persecution which inevitably attended the formation of such an association between demons, and specifically, automaton technology in the European Middle Ages; and the whole concept of technology as it related to the representation of the undesirable afterlife, damnation in Hell.¹⁹²

By Chaucer’s time, science, as it is understood today, was emerging, and had been ascendant since at least the so-called Renaissance of the twelfth century, a common concept in medieval studies. O’Brien’s assertion that the “Summoner’s Tale,” like the “Friar’s Tale,” “ironically describes the triumph of the demonstrated knowledge of science over mystery and irrationality” is indicative of scientism, both historically, and in O’Brien’s own article, and suggests the replacement of the proposed third and fourth currents of thought by the proposed fifth and sixth currents of thought, that is, the replacement of the foremost signification of automata being “magic,” and the persecutions of the fourth current, the entailment of this signification under canon and secular laws, with the mundane, secular understanding of ubiquitous automata, the proposed fifth current, the same understanding previously and independently reached under the proposed second current; and, as under the proposed second current, the eventual valuing of automata (and comparable works of high technology) as an index of human achievement, the proposed sixth current.¹⁹³

¹⁹¹ See O’Brien, “Ars-Metrik,” page 6: “Actually, the Summoner *embodies* the important cultural association expressed in this picture between the demonic and the mechanical.”

¹⁹² See O’Brien, “Ars-Metrik,” page 6: “In both Limbourg’s and Brueghel’s pictures hell is a realm of the technological grotesque.”

¹⁹³ See O’Brien, “Ars-Metrik,” page 12: “Although Chaucer uses the friar to expose the difference between the apostolic ideal of the friars and their selfish behavior, he also focuses his satire on the way they have turned their human, spiritual activity into systematic, mechanical gestures. Research into the friars’ practices of composing sermons justifies this emphasis on the mechanical element in the friars’ activity. As Joseph Mosher and D.L. d’Avray have shown, the friars constructed their sermons from immense ‘*exemplum* books,’ arranged under such categories as *gloria* and *gratia*, books that amounted to what d’Avray calls ‘elaborate preaching machines’ (74-75; Mosher 86-87). To the extent that they

Empiricism began to replace pure logic as the basis of inquiry, again showing the passage from the proposed third and fourth currents to the proposed fifth and sixth currents in a general sense, as exemplified by an interdisciplinary disputation on epistemological methodologies which would not have occurred in the earlier Middle Ages, when the authority of extant classical and scholastic philosophers was undisputed.¹⁹⁴ O'Brien writes that Salutati, the representative of legalistic and purely logical argumentation in this disputation, opined that empiricism, as a competing epistemological paradigm, was contrary to respect for the divine, a sentiment that transcends automata, and indeed, all specific topics, but which could be construed as an articulation of the same reactionary and persecutorial tendency of the proposed fourth current. Chaucer, for his own part, is shown by O'Brien's analysis of the latter's phonological puns on "dee – mon" to also knowingly register the concepts of the third-fourth current conjoint: that preternatural and/or supernatural powers exist; that they are demonic, and therefore adversarial; that they should be opposed; that empirical inquiry is "demonic" ("...that demonstrations, or at least the technicalities of academic investigation which that term implies, are demonic activities"); and that empiricism should thus be opposed, which would necessitate the abnegation of any conception of automata as mere works of technology, rather than as receptacles for demonic energies, divine energies, or generally, some animating spiritual essence.¹⁹⁵ So, while automata are only obliquely referenced in O'Brien's work, his identification of "...conflict between these two academic procedures and moreover the giving way of the old, authoritative to the new, experimental method of arriving at solutions to problems in the physical world" shows, at a high level, the "transition" (O'Brien's own term) from the mentalities which underlie the proposed third and

relied on this system, the friars resemble Chaucer's version of the scientist, as developed through the Friar's summoner and also, in more specific terms, through the lord and squire at the end of the *Summoner's Tale*. The scientific quest shapes the plots of both the Friar's and the Summoner's tales: in both, the climax occurs when the curious poser of the question, the descendant of Bacon and Grosseteste in search of 'God's privities,' discovers the answer, and particularly one that depends on the senses rather than authority. The *Summoner's Tale* resembles the *Friar's Tale*, then, in that it ironically describes the triumph of the demonstrated knowledge of science over mystery and irrationality."

¹⁹⁴ See O'Brien, "Ars-Metrik," page 17: "These closing sections of the *Summoner's Tale* point to a real matter of dispute in Chaucer's world concerning the value of experimental science. According to Geraldine Branca, Chaucer may have, in fact, been present in Florence to witness a famous dispute as to whether 'the doctor of medicine or the doctor of laws was the more scientific in his training and procedures' (65)."

¹⁹⁵ See O'Brien, "Ars-Metrik," page 18: "According to Salutati's [the doctor of law's] Augustinian principles, scientific demonstrations of the kind Bacon proposes are essentially 'ars-metrik,' excursions into God's privities. Through word-play Chaucer emphasizes also the connection between scientific and demonic activities: he puns on 'demonstracioun' (2224), 'demonstratif' (2272), 'demonyak' (2240), and perhaps even 'deemen' (2236), as if to suggest that demonstrations, or at least the technicalities of academic investigation which that term implies, are demonic activities."

fourth currents, with respect to automata, to the proposed fifth and sixth currents of thought, again with respect to automata.¹⁹⁶

That “magic” as animating principle, often (but not exclusively) accompanied by its demonological associations in the medieval Christian world, was a ubiquitous discursive construction as specifically regards automata, at least before the unqualified acceptance of empiricism by the intellectuals who succeeded Chaucer, should not be controversial. It is this thesis’ narrative contention, per its model, that the “magical” perception of automata prevalent during the European pre-Modern and Early Modern periods was specifically based in ignorance of Greek technical knowledge which was known to West Asian societies, the divergence between the proposed second and third currents of thought. In then medieval Western European imaginary, indicative of the prevailing beliefs on automata at the time, magic is practically inescapable, and especially in its semantically supernatural/preternatural meaning. Some proofs of the third current’s “magical” automata are found in Sherwood, an early authority on specifically pre-Modern automata. When Sherwood writes “...in medieval tales, descriptions of automata, allegedly operated by magic, are of such frequent occurrence,” this is a statement of the proposed third current, although Sherwood, in arguing that the commonness of magical automata in medieval fiction indicates that real-world automata were likewise common in pre-Modern Europe, seems to be conflating the proposed third current with the proposed fifth current, since European automata were only truly common in the period of the international Renaissance, the period in which the proposed fifth current predominated, after passing through the late Middle Ages and early Italian Renaissance of the proposed fourth current.¹⁹⁷ In any case, Sherwood unambiguously lends support to the second type under Kang’s model, and to the third current under the proposed model, with the statement “their [automatons’] life-like actions are usually attributed to magic.”¹⁹⁸

¹⁹⁶ See O’Brien, “‘Ars-Metrik,’” page 18: “These puns develop further the connections in the *Friar’s Tale* between the scientific quest, the need for demonstration, and demonic power. They also point to a culture in transition and suggest Chaucer’s skeptical, even derisive, attitude toward some of the elements in that transition. For instance, on the one hand, the lord [a fictitious character] quite clearly represents the *via rationis*, which depends on demonstration *secundum imaginationem* and adherence to authority; he complains that the problem which the friar has brought him has never been discussed before in any works of ‘ars-metrik’ (2220-23). The problem is ‘devilish’ precisely because it has not received the attention of the authorities. The squire, on the other hand, represents the *via experientiae*, depending on the kind of demonstration that Bacon describes as deriving its final authority from the senses. Thus, far from being simply a self-reflexive display of academic discourse or a development of dramatic tension between the pilgrims, these closing sections of the *Summoner’s Tale* play out the conflict between these two academic procedures and moreover the giving way of the old, authoritative to the new, experimental method of arriving at solutions to problems in the physical world.”

¹⁹⁷ See Sherwood, “Magic and Mechanics,” page 567: “In medieval tales, descriptions of automata, allegedly operated by magic, are of such frequent occurrence as to attest their widespread popularity in Western Europe.”

¹⁹⁸ See Sherwood, “Magic and Mechanics,” page 569: “These are but a few of the examples of automata that abound in medieval tales, not only of France but of other European countries as well. Their life-like actions are usually attributed to magic.”

Gradually, the concept of “magic” is replaced by other, mundane explanations for the operation of automata. In one of Sherwood’s passages, the proposed third and fifth currents are contrasted when examples of such explanations are given; in the cases of these exemplars, the proposed fourth current does not appear because fictitious automata, not real automata under Kang’s third type, are considered by Sherwood, and fictitious automata do not generally register the proposed fourth current.¹⁹⁹ The only posited eventuality in which a fictitious automaton could indeed register the proposed fourth current, which was established in response to legendary and real-world narratives of persecutorial behavior towards automaton-builders, not fictitious ones, would be a situation where, within the fiction of a pre-Modern or Early Modern work, the builder of an automaton is likewise subjected to such persecution, and this thesis does not recall encountering a work of fiction which contained these plot elements, in presenting an automaton, when conducting research. However, even in the later part of the High Middle Ages, in the early thirteenth century, and contemporaneously with some of Sherwood’s identifications of the fifth current’s non-magical automata in the noted examples, “magic” is still unambiguously imputed as the motive force for historical automata in an extant primary source: Robert of Clari, a knight of the Fourth Crusade, describes ruined Byzantine figural automata in these terms, registering the third current of thought as an annalist of his times: “they [the figural automatons in the city of Byzantium] used in times gone by to perform by magic, but they no longer performed at all.”²⁰⁰

¹⁹⁹ See Sherwood, “Magic and Mechanics,” page 569: “Occasionally, however, an attempt is made to explain the phenomena as produced by natural causes: by wind, in the case of the singing birds in the hall of the Emir of Babylon, in *Aymeri de Narbonne*, of hollow birds on a golden linden-tree, in *Wolfdietrich*, and of some of the examples mentioned above; by forced currents of air in other instances. In the *Roman d’Escanor*, Esclarmonde, a fairy whose master in magic was Virgil, made a small tree, which she placed at the head of the bed. It appeared to bear both flowers and fruit continuously, and on every branch were birds which seemed alive and which sang sweetly. A golden pipe was set up inside the tree, on the top of which was an angel holding a trumpet to its mouth. The angel was on a pivot enabling it to turn in any direction. Apparently, when the angel was in position, a pipe inside it connected with the large pipe in the tree. Presumably, also, there were similar pipes inside the birds. The blowing of the trumpet was the signal for the birds to begin to sing. The movements of the angel are not very fully described. It is stated, however, that if the angel turned ever so little to one side all the sounds ceased, which would seem to mean that this movement shut off the vent of air from the main pipe. If the angel turned back ‘towards’ the pipe – that is, moved directly over it – the birds began to sing. If it removed the trumpet from its lips the birds stopped singing, but when it held it again to its mouth, the melody broke forth once more. Difficult as the interpretation of this passage is – nor am I entirely satisfied with my reading of it –, enough of it is clear to establish the fact that the author of *Escanor* had in mind an actual machine which he had seen or heard of.”

²⁰⁰ See Sherwood, “Magic and Mechanics,” page 572, footnote 23: “Some 250 years after the Bishop’s journey, there is an apparent reference to the automata of the Magnaura Palace, destroyed long before, in the account of the Fourth Crusade written by the French Knight, Robert de Clari. Describing the Hippodrome in Constantinople, he states that there were, on a wall 15 feet high and 10 feet thick, ‘images of men and women and horses and oxen and camels and bears and lions and many kinds of animals cast in copper, which were so well fashioned and formed so naturally that there is not in Pagany or Christendom a master who could portray or fashion images so well as those images were fashioned, and they used in times gone by to perform by magic, but they no longer performed at all...’

Therein, again, is the crucial difference between the proposed second and third currents: to Robert of Clari, broken automata once moved by magic, whereas to a knowing Byzantine, these broken automata once moved by their operating principles, and have stopped moving because they are out of repair. This is the distinction that gives rise to the “magical” automata of the medieval romances, which are clearly based on practical automata in some cases, but are presented as “magical” in origin, in operation, or through their connection with magical beings, persons, and settings by the romances’ authors. Thus, in Sherwood’s words, “the similarity between the real automata of the Oriental courts and the imaginary ones of the romances cannot be due to chance.” Sherwood introduces two qualifications to this statement, and one of these bears discussion, but as a statement, this quoted observation reflects the progression from the proposed second current of thought to the proposed third current of thought.²⁰¹

Medieval fiction was primarily consumed by educated persons, and the secularism of the proposed fifth current may be based, to some degree, in the romances. When Sherwood writes, in the second of two qualifications (the first not bearing discussion), that “...the ultimate source of the magic ‘machines’ of fiction is in many cases an ancient myth which was ‘modernized’ to suit the contemporary [medieval] taste for mechanical toys,” this quote shows the influence of the proposed first current, either by way of the proposed second current, or through a bypass of the second current which is seen in certain cases of fictitious automata under Kang’s first and second types, just as fictitious automata can also bypass the proposed fourth current (since the fourth current is generally not evidenced in pre-Modern and Early Modern fiction, was conceived, and is chiefly concerned with reactions to real-world automata).²⁰² While the influence of the proposed first current upon the automata of the proposed third current is evident in the Sherwood’s presentation of this second qualification, “mechanical toys” are not in great evidence in the Europe of the High Middle Ages or thirteenth century, and properly “mechanical” automata would not proliferate, in this thesis’ interpretation, until the sixteenth and seventeenth centuries, suggesting that Sherwood’s use of the phrase “mechanical toys” is rhetorical.

Sometimes, the same historical phenomena, or trends, proposed by this thesis can also be discerned in contemporaneous cultural outputs of the pre-Modern and Early Modern worlds which are not automata by this thesis’ definitions, and not categorizable under Kang’s typology. When Sherwood presents the case of a “Tantalus cup” presented in a work of medieval fiction, this case is of interest,

[emphasis original] – Robert de Clari, *Conquete de Constantinople*, Phillipe Lauer, ed. (Classiques francais du moyen age, Paris), p. 88, ch. XCI.”

²⁰¹ See Sherwood, “Magic and Mechanics,” page 573: “Although the performances of the automata described by some of the poets undoubtedly surpass any recorded or even conceivable achievement of actual machines, the similarity between the real automata of the Oriental courts and the imaginary ones of the romances cannot be due to chance.”

²⁰² See Sherwood, “Magic and Mechanics,” page 574, the second of Sherwood’s qualifications: “In the second place, the ultimate source of the magic “machines” of fiction is in many cases an ancient myth which was “modernized” to suit the contemporary [medieval] taste for mechanical toys.”

because, given that the Tantalus cup is a species of classical technology, it again demonstrates the same tendency, progression from the proposed first current to the proposed third current, which would apply to fictitious automata, were a Tantalus cup without moving figures within the thesis' topical scope of material-cultural and intellectual history. The Tantalus cup discussed by Sherwood is certainly close to Villard de Honnecourt's chantepleur, only missing a figure tripped by the outflow of water. As is also the case with automata, something like the given Tantalus cup (another work of technology) may bypass the proposed second current of thought, which may, or may not, be present when automata are represented in works of pre-Modern or Early Modern fiction; sometimes automata are depicted as elements of exoticized "Eastern" societies, and sometimes they are presented without such trappings, solely in a European context, which suggests the unknown linkage between the classical and medieval European worlds that this thesis has elsewhere conjectured was an oral tradition bereft of technical knowledge. Returning to the particular Tantalus cup noted by Sherwood, any educated persons reading the romance *Huon de Bordeaux* were presented with a "magical" cup they, according to Sherwood, may have been able to recognize as real, non-magical technology, thus presaging the proposed fifth current's recontextualization of automata as non-magical, non-preternatural works of technology, regardless of secular or sacred setting, in the broad European Renaissance, or Renaissances.²⁰³ The latter pluralization of "Renaissance" is indicated by the many developments prior to the traditional affixture of the European Renaissance in the mid-fifteenth century which demonstrated the emergence of empiricism, a mentality other than the proposed third current in the broader sense of *weltanschauung*, and not as exclusively regards automata. When these developments are considered through the examples of assertions by pre-Modern authors such as Roger Bacon and William of St. Cloud, their only specific relation to the model proposed by this thesis can only be the discarding of its third current, and not progression to its fourth current, since the proposed third current's foremost association, "magic" in contradistinction to empiricism, is a loosely generalizable concept, whereas the persecutions which are the hallmark of the proposed fourth current are not general, but only applicable for the topic of pre-Modern and Early Modern automata.²⁰⁴

²⁰³ See Sherwood, "Magic and Mechanics," page 574: the presentation, an episode from *Huon de Bordeaux*, ends with "In the incident described here he is the victim of a practical joke which, to those among the author's public familiar with the 'tantalus cup' – and they were probably many – had an added piquancy. The ancient legend of the testing-cup was thus brought up to date. It is not the motif but its modernization that has its source in the 'engien d'esbattement.'"

²⁰⁴ See Sherwood, "Magic and Mechanics," pages 575 --- 576: "Roger Bacon, in his treatise entitled *Of the Secret Operations of Nature and Art and of the Nullity of Magic*, asserts: 'thus we see that it is not necessary for us to aspire to magic, since art and nature are sufficient.' Bacon was not the only one, or even the first, of his contemporaries, to entertain such ideas. William of St. Cloud remarked, some thirty years later, referring to the powers of mirrors and lenses: 'These marvels and many others have been performed in ancient times, not by magic art, as some would have it, who are ignorant of the secrets of nature and of scientific industry, but solely by the force of nature and the aid of art.'"

Examples comprehensible through this thesis' proposed model are presented by Sherwood. For example, the case of the automata-bearing fountain tree at the court of the Mangu Khan showcases the complete intellectual-historical and material-cultural trajectory from Heron, to the civilizations of West Asia, where fountain-trees with automata were present at multiple rulers' courts in both Byzantium and the Islamic caliphate; to the civilizations of Latin Europe, and thence to the French court, and to the romance *Escanor*; but also to the Mongol Court, since the fountain-tree at the latter was built, in accordance with the imaginary of the romances, by a French engineer. The idea for the automata in *Escanor* thus bears out the progression of the proposed model through at least its first, second, and third currents of thought.²⁰⁵ Sherwood gives the Heronic source of the Amazon Camille's archer in another of the romances, showing the relationship between the proposed first and third currents in a work of fiction; in this case, it again bears mentioning that the relational progression of the model proposed by this thesis can bypass the second current in works of fiction, as previously noted. In such cases, a hypothesized oral tradition, or as-yet unknown textual tradition, meant that classical automata could reappear in medieval romances without first passing through a West Asian cultural reception, with the understanding that the medieval European romances shroud such automata in "magic," and betray ignorance of the workings and history of the same.²⁰⁶

A review of this thesis' appendices will demonstrate that the proposed currents are not assigned in a one-to-one relationship per instance of pre-Modern or Early Modern automata, and operate more like tags. In discussing "...the question of the relation of the automata of fiction to the real automata of the period," Sherwood obliquely notes that this thesis' proposed third current, which is registered by "magical" automata in the romances, can be present concurrently with what, to this thesis, are other currents, such as the proposed fifth current, although its emergence still predates the later currents in European culture, and in terms of chronological clock time.²⁰⁷ In an attempt to aggrandize the reputation of medieval Europeans, Sherwood dismisses the conception that the proposed third current of thought was monolithic. However, the examples cited by Sherwood in furtherance of this dismissal are drawn from a time when the proposed third current would not have been solely operative in the history of ideas, if it was ever solely operative (this time being the later Middle Ages at the earliest, and in contradistinction to the early Middle Ages, or so-called "Dark Ages," when Western Europeans would have had no

²⁰⁵ See Sherwood, "Magic and Mechanics," pages 579 – 580: "A remarkable instance of the extent to which such mechanics were familiar to the West occurs in the *Roman d' Escanor*, already mentioned. The magic tree with its trumpeting angel and singing birds, in the romance, recalls so strikingly, in certain respects, one or two of Heron's machines as to suggest that the author had a similar device in mind. In *Escanor*, the turning of the angel appeared to control the blowing of the trumpet and singing of the birds."

²⁰⁶ See Sherwood, "Magic and Mechanics," page 580.

²⁰⁷ See Sherwood, "Magic and Mechanics," in the last few paragraphs on pages 591 – 592: "Even this brief sketch of the extent and character of the attainments of Western Europeans in the Middle Ages in the field of mechanical science and, particularly, of mechanical playthings, throws, it seems to me, a new light on the question of the relation of the automata of fiction to the real automata of the period."

reference point for automata other than preternatural, supernatural, or magical concepts).²⁰⁸ The positioning of Western Europeans in such a way as to minimize the proposed third current of thought is consistent with Sherwood's overall argument for European sophistication, as evidenced by some laudatory prose.²⁰⁹

The observation from Sherwood that what this thesis terms its proposed third current of thought could be present concurrently with other proposed currents, although predating the others in pre-Modern European culture, is again noted in Sherwood's line "It is, further, but reasonable to assume that the operation of such machines was familiar to a substantial portion of the people," but here, this thesis is disposed to challenge Sherwood.²¹⁰ There is, on the contrary, little evidence that "a substantial portion of the people" understood the technical operation of automata, especially in pre-Modern Europe; even in contemporary times, technologies such as household appliances and electronics may not be well-understood by laypeople, despite their indisputable ubiquity. By the international European Renaissance of the sixteenth century, it was less likely that automata would be considered works of magic, but not improbable, depending upon the context – per this thesis' appendices, the atmosphere of the Reformation, together with suspicion of occult practice, was still enough to render an automaton built by a figure such as John Dee "magical," even centuries after the juncture indicated by Sherwood's assertion (given the argumentative reference made by Sherwood to Henri de Mondeville).²¹¹

An overconfident view of pre-Modern European sophistication as regards automata is not the only conclusion offered by Sherwood which this thesis would dispute. Another is that automata in pre-Modern fiction were placed in the "Orient" because it was a "land of enchantments," Sherwood's phrase. Rather, these automata were placed in West Asia by the romance authors, and in a more generalized, amorphous, imaginary Dar al-Islam, because this thesis' second proposed current of thought predates its third proposed current of thought, that is, because the "Orient" had access to automaton technologies before the Occident, even if it is emphasized, as

²⁰⁸ See Sherwood, "Magic and Mechanics," in the last few paragraphs on pages 591 – 592: "The knowledge of the mechanical principles involved in the antics of the latter was not confined to the erudite, the commentators of Aristotle, the experimenters with the inventions of Hero and others. Those who worked round the cathedral would know how the organ operated, would understand the machinery which caused the puppets to put on their act when the hours struck in the great clock, or the far simpler trick that made the eagle turn its head at the reading of the Gospel."

²⁰⁹ See Sherwood, *ibidem*: "Mangu Khan employed a goldsmith of Paris, not an eastern workman, to construct his silver tree. The 'engiens' at Hesdin were kept in repair, generation after generation, by a specially appointed family of French mechanics." In this thesis' reading, there is a certain degree of pride, and perhaps triumphalism, in the language of these statements.

²¹⁰ See Sherwood, "Magic and Mechanics," in the last few paragraphs on pages 591 – 592: "The sum of contemporary scientific knowledge, world history, philosophy, was set for all who could to read. Medicine and surgery were explained to the public by such authorities as Henri de Mondeville. The laws were codified, not in Latin but in the speech of the people. It is not surprising, therefore, that statues that moved, images that spoke or sang and goblets from which the wine mysteriously vanished had their counterpart in actual machines of the time. It is, further, [592] but reasonable to assume that the operation of such machines was familiar to a substantial portion of the people."

²¹¹ See this thesis' appendices, and for Dee's automaton, its fourth appendix.

in Sherwood, that the Occident had its own automata (which is not presented in the text of the cited paper by that author as a point with much specific supporting evidence).²¹² Sherwood is only correct to a point; it is true that some romances of the late thirteenth, and especially the fourteenth centuries were contemporaneous with some European automata, but Sherwood disregards the fact that automata are documented in the West Asian Islamic world centuries before the European Christian world, and that the later automata of the latter world were inspired by, or derived from, Islamic predecessors which were, in turn, inspired by, or derived from, those of the Hellenistic Greek world. Taken together with the further fact that the romance tradition in Western Europe also predates the centuries when Western European automata began to be built independently, the proposed model is borne out in an exposition of the relationships between the proposed first (Greek), second (Islamic), and third (European fictive, or “magical-realistic”) currents of thought.²¹³

The work of other authors agrees with this thesis’ interpretations, which are outlined in its offered model. Sullivan’s work describes a fictitious instance of pre-Modern or Early Modern automata from romance literature which recognizably has the same mechanism as one of Heron’s real-life models, although it is not represented by the romance in these specific terms, but rather, in a “magical” setting, and a reader thus must have prior knowledge of Heronic technologies to identify the intellectual history of the romance’s imagery. This, once again, shows the bypass from the proposed first to the proposed third currents of thought noteworthy in fictitious works, since this fictive, “magical” setting is not represented as culturally “Eastern,” but which bypass is not necessarily seen in the cases of automata categorizable under Kang’s third type, the real-world automaton designs which typically passed through West Asian civilizations before, in turn, passing to East Asian civilizations, and eventually returning to Europe in the late Middle Ages and the early Renaissance, including Western Europe (which admittedly, in some regions, may never have known Alexandrine automaton technologies when they were first described).²¹⁴

That it was possible for the cultural memory of Europe to preserve the physical appearance and action of some discrete instances of classical automata, and so bypass the intervening influence of the West Asian cultures which retained or acquired ancient technical designs and documentation for realizable automata, is quite extraordinary, even if actual automata in the romances are only given visual

²¹² See Sherwood, “Magic and Mechanics,” page 592: “Not that the belief in magic was not prevalent. There is plenty of evidence to the contrary. Even in our atomic age, quite sensible people will touch wood or make a wish on the new moon. The marvelous inventions of the poets were placed by preference in the Orient as the traditional land of enchantments, but the authors of the tales and many who composed their public must have regarded the performances of the automata in somewhat the same spirit in which we watch a Magician pull a rabbit out of a hat.”

²¹³ See Sherwood, “Magic and Mechanics,” page 592: “The popularity of actual ‘engiens d’esbatement’ was responsible for the prevalence of automata in medieval fiction. The puppets of the poets were not so much, except by a kind of formula, the mysterious creations of magicians in distant lands and times as the rather more versatile literary counterparts of the animated toys which delighted their public.”

²¹⁴ See Sullivan, “Medieval Automata,” page 7.

descriptions. Whenever such a “bypass” does not apply, automata in romances are often situated in environments that are culturally “Eastern.” It has long been the opinion of scholars that these “magical” automata in the pre-Modern European romance tradition were based in cross-cultural understandings of West Asian cultures, but what this thesis intends to underscore is that this development is comprehensible in terms of the progression of technical documentation and skill from Hellenistic Greece to West Asia, in accord with the trajectory of historical developments which link its proposed first and second currents, and not because of any other belief held by Europeans about Asian civilizations, at least as the principal basis of the identifiable association between automata and the romances’ representations of the cultural “East.” Sullivan offers a quote by Faral which, when translated, expresses the conclusion that Sherwood aimed to dispute, but which this thesis finds agreeable: that the origin of automata in the medieval romances can mostly be located in Asia, and especially the Islamic world (“l’Orient”).²¹⁵ This relationship is modeled by the thesis’ currents of thought.

Without providing a name for the trend, Sullivan describes the third current of thought under the proposed model, to wit, that romances of the Middle Ages describe “highly complex and technically sophisticated works of art [figural automata in the contexts of both Sullivan’s paper and this thesis] which waver to and fro across the ill-defined boundary between mechanical curiosities and supernatural phenomena.” This intermingling of “magic” (here, “the supernatural”) with representations of figural automata arises because of the disconnect between the technological levels of development in the Islamic and Christian worlds, especially in the earlier Middle Ages, with the latter using the semantic language and conceptual imaginary of “magic,” as previously discussed in this section, as its reference frame of recourse, in a state of technical ignorance, to express its perceptions of automata.²¹⁶ As an example, most of Sullivan’s cited work is concerned with the “Chamber of Beauties” episode in the *Romance of Troy*. The automata which this chamber contains do not “seem” preternatural per Sullivan’s characterization, they *are* preternatural within the fiction of the romance, and thus register the proposed third current as works of magic.²¹⁷ In her translation of the “Chamber of Beauties” episode, one of the automata presented by it instantaneously generates matter, making it, and the episode

²¹⁵ See Sullivan, “Medieval Automata,” page 8: “As Edmond Faral put it: ‘C’est ainsi que, dans leur desir d’etonner et de trouver mieux que leurs devanciers, les poetes ont quitte le curieux pour l’extraordinaire, et l’extraordinaire pour le merveilleux: ils depasserent l’Orient lui-meme d’ou leur etait venue la premiere inspiration.’”

²¹⁶ See Sullivan, “Medieval Automata,” page 8: “The descriptions of the automata in the ‘Chambre de Beutes’ are not isolated phenomena in medieval literature. Many other works of the twelfth and early thirteenth centuries contain similar descriptions of highly complex and technically sophisticated works of art which waver to and fro across the ill-defined boundary between mechanical curiosities and supernatural phenomena.”

²¹⁷ See Sullivan, “Medieval Automata,” page 12: “The manner of its [the Chamber, and by extension, the automata which it contains, which are the works of the same persons] construction – by ‘trei poete, sages dotors, / Qui mout sorent de nigromance’ (11.14668-9) – reflects the intellectual and artistic resources of the nation, which are so highly developed as to seem almost praeternatural.”

as a whole, unambiguously indicative of this thesis' proposed third current, "magic" in relation to pre-Modern and Early Modern automata.²¹⁸

Provided that Sullivan's translation is accurate, the term "magic" is explicitly used in the passage, as well, to describe a phenomenon analogous to the alteration of matter in another registration of the thesis' proposed third current of thought, this time by an eagle automaton in the Chamber of Beauties, rather than by one of the humanoid automata it contains, which had the figures of youths.²¹⁹ Without naming a trend, as this thesis has done by its proposal of the third current of thought, Sullivan essentially identifies some characteristics of this proposed third current, although without acknowledging the derivation of the proposed third current as an ignorant reaction to the automata of the proposed second current, writing that "...references to the quasi-supernatural powers of their [fictitious automatons'] inventors," and "...a complex perception of the relationship between science and nigromance [black magic]" are both in abundant evidence within the intellectual-historical source matter afforded by extant pre-Modern European romance literature.²²⁰ As will subsequently be discussed in this thesis' presentation of its proposed fourth current, with exemplars, the identification of automata as "magical" constructs inevitably gives rise to the imputation of magical powers to their makers, the "inventors" referenced by Sullivan. Sometimes, this leads to an interplay amongst the proposed currents. For example, the tales of Gerbert of Aurillac, a historical figure, show that his multicultural education was first understood as "magical," and was only understood as "scientific" once Europe regained the Islamic world's secular detachment in matters of technology, including as regards his legendary, "magical" automaton head. The persecutorial fourth current is also at play here, for Gerbert's legend was originally defamatory in nature.²²¹ Truitt quotes a passage from John of Salisbury

²¹⁸ See Sullivan, "Medieval Automata," page 15: "After playing the instruments this youth, who is so attractive, takes lovely, fresh, sweet-smelling flowers of many different kinds and strews them so liberally on the mosaic-bordered floor that in the end it is completely covered by them: and this happens both summer and winter. The figure does this at frequent intervals and no-one can tell either how it holds so many flowers or how it comes by them."

²¹⁹ See Sullivan, "Medieval Automata," page 15: "As soon as it [the eagle automaton in the Chamber of Beauties] flies over the flowers, the wise men's magic makes them so completely dried up and aged, before they have had the time to wilt, that no-one knows what becomes of them; then they are replaced by other beautiful fresh flowers of a different colour. This happens twice a day."

²²⁰ See Sullivan, "Medieval Automata," page 18, endnote 12: "A substantial number of descriptions of automata contain similar references to the quasi-supernatural powers of their inventors (e.g. Troie, ll. 14668-9 and 14743-6). Such references imply a complex perception of the relationship between science and nigromance [black magic] which will form the subject of a future article." The thesis is not aware of the forthcoming article mentioned at the close of these lines.

²²¹ See Truitt, "Celestial Divination and Arabic Science," page 217: "William [of Malmesbury] confirmed many prior accounts that mention Gerbert's education in Spain and reiterated the claim that Gerbert was in league with the Devil, conjoining that with the story of the prophecy and the church where Gerbert fell ill. Although William repeated prior assertions that Gerbert trafficked with Devil, he did not present Gerbert's oracular head as the product of demonic magic, as Beno had done, but rather as the product of astral science. Furthermore, he referred to specific authors and practices, revealing the extent to which Arabic scientific texts were known in England at that time [William's time]."

which provides the “magical” method by which Gerbert of Aurillac’s brazen automaton head was supposedly animated. The “Hors of Brass” in Chaucer, and Albertus Magnus’ legendary android, were also said to have been animated in their respective textual sources by the implementation of this same method, which relates to the thesis’ model inasmuch as it is distinguishable as an articulation of the proposed third current of thought, the learned use of magic to create automatons.²²²

Kang, in his book, reviews these “magical” instances, and gives an explication of the narrative history of automata as intellectual-historical subjects in an early passage in this work, with the progression from this thesis’ proposed third – sixth currents identifiable in the same.²²³ The Renaissance sources Agrippa, Dee, and Campanella are presented by Kang in the sense of the third current, although none of these figures is one-dimensionally a sorcerer, and it is doubtful that any would have blithely accepted this characterization.²²⁴ In another passage, several of this thesis’ named currents, or trends, are identifiable: as regards the history of pre-Modern and Early Modern automata, the phrase “scientific revolution” describes the sixth current by way of the fifth current, while the word “magical” signifies the third current, as always, and the word “preternatural” best signifies the first current.²²⁵

Kang’s interpretation of Cohen, in this thesis’ interpretation, emphasizes the nonequivalence of this thesis’ proposed fifth current and proposed third current, and an *ex post facto* (post-fifth current) “desire” to reconcile the two; this is Eurocentric, as it disregards the proposed second current, but Kang is writing about Europe. In a return to the proposed first current, signaled by the phrase “divine power,” Kang suggests Cohen’s opinion is that merging this thesis’ proposed fifth current with its proposed third current (the rationality of secular “scientism” with the methods of “magic,” respectively), to thus gain a “true understanding of the nature of life” in what would then seemingly be a recapitulation of esotericism, would result in “divine power,” which emblemizes the supposed method of animating automata, and representational purpose of automata, under this thesis’ proposed first current. This is *Frankenstein* writ large – mixing science with the occult in an attempt to animate the inanimate, and thus become a god.²²⁶

²²² See Truitt, “Celestial Divination and Arabic Science,” page 222: “Twenty-five years later [after William of Malesbury’s text was disseminated], John of Salisbury, courtier, scholar, and bishop of Chartres, spoke out against divination and astrology in his *Policraticus* (1154). Some people were so misguided “they say that it is possible to form an image under the position of certain constellations, and which might be formed... so that it would receive the spirit of life at the nod of the stars and will reveal the secrets of hidden truth.”

²²³ See Kang, *Sublime Dreams of Living Machines*, page 6, paragraphs 2 – 3.

²²⁴ See Kang, *Sublime Dreams of Living Machines*, page 9.

²²⁵ See Kang, *Sublime Dreams of Living Machines*, page 19: “...the modern usage of the meaning [of ‘automata’] that refers exclusively to the mechanical, a definition that arose in the seventeenth century in the context of the scientific revolution, when the word was established in direct opposition to the magical and the preternatural.”

²²⁶ See Kang, *Sublime Dreams of Living Machines*, pages 24 – 25. In response to John Cohen’s work, Kang “deduces” as follows: “what is behind the robot fantasy is the desire to heal the apparent rift between the two worldviews [scientific and magical]. This could be achieved by gaining a true

The thrust of the proposed third current is essentially stated by Kang, who wrote "...throughout the Middle Ages and the Renaissance many regarded such marvels [automata] and the arcane learning necessary for their construction as magical, with all the ambivalence that concept carried in the Christian world."²²⁷ Three senses of the resonance between "magic" and automata are provided by Kang, and unlike this thesis' prior explication of how distinct semantic meanings of the term "magic" can respectively be interpreted with respect to automata, Kang's analysis situates the relationship between "magic" and "automata" in the worldview and apprehensions of the lay and intellectual audiences of pre-Modern and Early Modern Europe. This analysis, in the cited passage, articulates this thesis' third and fourth currents of thought. It is of interest, in this connection, that Kang writes "...advocates of natural magic themselves regarded mechanics as a type of neutral magic, closely related to or subsumed under the rubric of mathematics," since "Leo the Mathematician" is the name of the figure reputed by legend to have built the Throne of Solomon and Solomonic automata of the Byzantine imperial palace at Constantinople.²²⁸

These are not the only concordances between Kang's work and this thesis' proposed currents, that is, identified trends. It bears repeating that a contribution offered by this thesis is the assignment of names to oft-repeated concepts encountered in scholarship concerned with its topic. Thus, when Kang references "necromancy," his characterization of how such magic could also be associated with automata registers this thesis' proposed third, fourth, and seventh currents of thought, although only the third and seventh are typically registered in discussions of fictitious automata. The thesis' proposed third current is registered by the consideration of "magic," and the proposed seventh current by the consideration of "...the raising of the dead."²²⁹

understanding of the nature of life, which would allow us to obtain mastery over the environment and transcend to a higher realm of existence through the divine power of bringing life to the lifeless."

²²⁷ See Kang, *Sublime Dreams of Living Machines*, page 56: Page 56, "Throughout the Middle Ages and the Renaissance many regarded such marvels and the arcane learning necessary for their construction as magical, with all the ambivalence that concept carried in the Christian world. So the automaton motif in the premodern context can only be explicated through an understanding of the complex link between the mechanical and the magical."

²²⁸ See Kang, *Sublime Dreams of Living Machines*, page 60: "First, to return to Arthur C. Clarke's dictum, any machine whose operation or purpose was not apparent to the viewer was liable to be regarded as magical, especially for an object, like the automaton, that was evocative of theurgy. Consequently, both fictional and actual automaton-makers were often regarded as sorcerers and necromancers. Second, the advocates of natural magic themselves regarded mechanics as a type of neutral magic, closely related to or subsumed under the rubric of mathematics. During the Renaissance, people like Agrippa, Dee, and others explicitly pointed to the automaton as a type of marvel that could be achieved through the use of natural or mathematical magic. Third, for reasons detailed in the last chapter, the automaton was such as captivating but unstable object in terms of its conceptual significance that it was deployed in the ongoing debates on the nature and legitimacy of magic."

²²⁹ See Kang, *Sublime Dreams of Living Machines*, pages 64 – 65: "Second, in contrast to those positive depictions, automata also appear as the products of diabolical magic practiced by evil witches and warlocks, especially in the form of 'necromancy,' a condemned form of magic associated with the raising of the dead and the summoning of demons."

Similarly, in summarizing some of his other conclusions, Kang writes that an automaton, in the fictive imaginary of pre-Modern and Early Modern Europe, can be “as the wondrous creation of ancient knowledge and as the diabolical work of heretical magic;” of these, the first option registers this thesis’ proposed first current, given that its referent is the technology of the ancient world, and the second registers this thesis’ proposed third current, given that its referent is the working of magic. Whenever this magic is necromantic, the seventh current also applies.²³⁰

There are a few closing points of note for this section, just as in Kang’s book, where disparate perspectives in European history on automata, comprehensible under this thesis’ proposed model, are listed near its conclusion.²³¹ These perspectives are offered by Kang in two lists, the first giving “negative” interpretations of automata, and the second “positive” interpretations of the same. In these two lists, the first of the “negative” interpretations registers this thesis’ proposed third and fourth currents, and the sixth of the “negative” interpretations registers this thesis’ proposed third current, and possibly also its proposed seventh current.²³² For the “positive” interpretations, the first registers this thesis’ proposed third, fourth, and fifth currents. Certain of Kang’s “negative” and “positive” interpretations from these respective lists which only concern human beings, and their attitudes to automata, are omitted from the above reconciliation of these two lists of historical perspectives with this thesis’ proposed model.²³³

In considering the overall question of “magic” in relation to automata, Riskin’s observation is interesting: “... designers of synthetic creatures have generally assumed a role for something nonmechanical, something other than a self-contained system of interacting parts.” If Riskin is alluding to ensoulment, possibly through ancient *telestike*, or the occultic investiture described by Hermetic Ficinian magic, this quote might register the first or third currents, respectively, under the proposed model.²³⁴ The recognition of consciousness as a concept ca. 1650, at the end of this thesis’ period of study, is noted by Riskin, as is its replacement of “soul” as a possible animating force for lifeforms, including artificial lifeforms. Genuine pre-Modern and Early Modern belief in human and inhuman souls permitted the

²³⁰ See Kang, *Sublime Dreams of Living Machines*, page 65: “So the automaton appears in literature alternatively as the wondrous creation of ancient knowledge and as the diabolical work of heretical magic, the former meant to arouse sublime awe and the latter horror.”

²³¹ See Kang, *Sublime Dreams of Living Machines*, page 305, *et. seq.*

²³² See Kang, *Sublime Dreams of Living Machines*, page 305, *et. seq.*

²³³ See Kang, *Sublime Dreams of Living Machines*, page 305, *et. seq.*

²³⁴ See Riskin, *Genesis Redux*, “Introduction: The Sistine Gap,” pages 1--2: “Together, the essays collected here offer an unexpected and far-reaching result: they find that attempts at artificial life have rarely been driven by an impulse to reduce life and mind to machinery. On the contrary, designers of synthetic creatures have generally assumed a role for something nonmechanical, something other than a self-contained system of interacting parts. These designers and the respondents to their work have produced many and varied accounts of what the nonmechanical something might be, and of how it might engage with bodily mechanism.” For *telestike* and Marsilio Ficino’s Hermetic magical system, including its contended application to real-world automata at Pratolino, a Medici villa, see Lily V. Filson’s doctoral dissertation as cited in this thesis’ bibliography and fourth appendix.

intellectual-historical development of Ficinian investiture, or crudely, the entrapment of preternatural consciousnesses in artificial figures (although, in fairness, effigies were only indisputably animated by such energies in the romances).²³⁵

Excluding semantics, there is “magic” which, in the Ficican tradition, is actual “magic,” sorcery, for purposes of this thesis; and there is “magic” in things of interest which function by unknown operations, or have unknown properties, for purposes of this thesis. Unless “magic” in its truest, indisputable sense, that is, formal, ritualized practice of the occult, is found in association with any given instance of pre-Modern or Early Modern automata, this thesis is not disposed to necessarily or exclusively associate pre-Modern and Early Modern automata with magic, especially given the multiplicity of other associations shown by this thesis’ model. Hill affords a closing example of this point: many automata in the medieval romance traditions of Western Europe are controlled and/or actuated by gusts of wind, but in the Banu Musa’s designs, there are devices which are truly Aeolian, powered by wind, and as such, there seems to be a common denominator between the factual technologies attested under the proposed second current, and the fictions under the proposed third-fifth current conjoint.²³⁶ Knowing the magic of pre-Modern and Early Modern automata can mean knowing how magic was worked with these devices, the actual star charts, astrological portents, incantations, and so forth; or, it can mean knowing how these devices functioned, independently of “magic” as occult praxis, and independently of the wonderment of novel technology, with the latter being a semantic meaning; or, it can mean that an understanding is gained, through the narrative of history, as to why “magical” automata were often, but not exclusively, represented in connection with West Asian cultures, which is nothing more or less than what is modeled by the sweep through this thesis’ first, second, and third proposed currents of thought. The thesis will now move to its fourth proposed current of thought.

²³⁵ See Riskin, *Genesis Redux*, “Introduction: The Sistine Gap,” page 6: “Efforts to create life and mind in machinery have spawned ever-new renditions of that other something, from consciousness in the mid-seventeenth century, to information in the mid-twentieth. From soul to consciousness to software, successive theories of life have retained central, nonmechanical elements, and these frequently steal center stage in this collection.”

²³⁶ See al- Jazari, *Book of Knowledge*, under Hill’s “General Notes” on page 272, in the section for “Category IV [/] Fountains and Perpetual Flutes.” Hill writes the following for one of the Banu Musa’s devices, thus summarizing the workings of a device described by three brothers who lived centuries before al-Jazari: “In No. 90 water runs into a horizontal tank *q*, *l* which has a discharge nozzle at one end. This tank is mounted on a vertical axle which carries a horizontal vaned wheel at its upper end. The discharge from the rotating tank can be into one of two adjoining large tanks, *g* and *b*, the inner delivery pipe leading from one and the outer pipe from the other – in the usual way. Say the discharge is into tank *g*: the wind turns the vaned wheel, tank *q*, *l* rotates and the water now flows into tank *b*. No. 91 is similar to No. 90, but has two double pipes instead of one.”

THE FOURTH CURRENT OF THOUGHT.

In the Late Middle Ages, after centuries of contact with Dar-Al-Islam and the Byzantine Empire, the frequency of Western Europeans' automaton-building intensified in a development concurrent with the popularization and widespread adoption of mechanical clockwork. E.R. Truitt speculates that Eastern Europe may have been a zone of acculturation in the appearance of automata.²³⁷ Spain is another place of cross-cultural contact which could have contributed to the rise of European automata. It does bear mentioning that the earliest European clocks did not have automata, so the mechanical (as opposed to hydraulic) automaton clock was a convergence of two independent factors. Unlike the prior automata in medieval Europe, those produced at this juncture included secular jacquemarts. While it is difficult to authoritatively state that the reception of these jacquemarts' predecessors, such as the Boxley Rood of Grace and La Virgen de los Reyes, was equivalent to that of the Hellenistic automata, later Protestant authors certainly maintained that a cult formed around the former example, the Boxley Rood of Grace, due to a benighted and uncritical acceptance of its supposed supernatural power. Evidence exists to dispute the contention that medieval people uniformly perceived constructed automata as supernatural or magical, and that evidence surprisingly suggests a more skeptical perspective to automata did not necessarily skew along lines of literacy and education, but as with all else in this period, along lines of religiosity and theology.

The heterogeneous reactions to the more numerous Western European automata of the Late Middle Ages and Renaissance caused a current of thought to emerge in this era with respect to their new European builders. Heron's *Pneumatica* was finally translated from the Greek during the Renaissance, and even before this event, a growing multiplicity of automata in public and private spaces ensured that larger swaths of the Western European population gained exposure to these figural constructs. Some, drawing upon the literary tradition of the "magical" and potentially demonic automaton, perceived the designers and fabricators of automata to be sorcerers, and several examples exist of religious figures, certainly or ostensibly literate in the medieval sense of having mastered both Latin and a vernacular language or languages, duly destroying automata in both mythical and factual accounts. This fourth current of thought therefore rearticulates the third current by ascribing its "magic," distinguishable from the divine power of the first current, to the real-life automata with which those who demonstrated the hostile fourth current were confronted, at least in their own minds. The fourth current of thought, in its condemnation of things perceived as works of magic within the historical context of this thesis' considered scope of years, accords with the "persecuting society" model put forth by R.I. Moore, as commonly known and understood in medieval studies.

²³⁷ See Truitt, *Medieval Robots*.

EXAMPLES OF THE FOURTH CURRENT OF THOUGHT.

Perhaps the trope which most epitomizes the fourth current of thought is that of Christian clergymen in the pre-Modern or Early Modern periods, and beyond, physically destroying assembled automata in the belief that these automata were “works of sorcery.” One of the most-cited examples of this act attested in a historical account occurred during the last years of Charles V’s life, when he had secluded himself at the monastery of San Yuste, in the company of Gianello Torriano of Cremona, his court mechanic; when the latter constructed automata for his amusement, and, seemingly, to divert Charles from morbid ideation, the religious authority of the monastery (called “[the] Superior of the convent”) proceeded to destroy the automata, presumably in the belief that they had been animated by demonic energies. This tale indicates the proposed third and fourth currents, with the third registered by the apprehension of automata as “magical,” and the fourth by the impulse to destroy these automata on the basis of this apprehension, an act which surely wronged and was an attack upon their builder, Torriano.²³⁸

It also indicates, in what was seemingly a durable and enduring phenomenon, how members of religious orders, who were formally “literate” and typically fluent in one or more vernacular languages aside from Latin, could tend to take the same view of automata usually articulated by the very ignorant, but could counterintuitively do so on the basis of their received religious studies – this is what the thesis terms the great “religious exception,” where (presumably) intelligent and educated individuals, exponents of the pre-Modern and Early Modern Roman Catholic Church, tended to behave with greater hostility to automata than any other notable class of persons, doing so on the basis of their sincerely-held worldview, which admitted of the demonic animation of inanimate figures as an actual, real-world hazard. That this persecution of automaton-makers continued into the century beyond this thesis’ period of study is shown by the comparable tale of Vaucanson, the famed eighteenth-century inventor of the “digesting duck,” whose mechanical juvenilia were destroyed by his “provincial,” the cleric who was in authority over the young Vaucanson during the latter’s seminary studies. Thus, articulations of the proposed fourth current can postdate this thesis’ period of interest.²³⁹

As time progressed in the course of European history, the proposed third and fourth currents were replaced by the fifth and sixth currents. While Vaucanson is said to have encountered a registration of the fourth current firsthand, by the later years of the eighteenth century, when a secular scientific organization held a contest to

²³⁸ See Bedini, “Role of Automata,” page 32, footnote 20, recalled to be a quotation from Stirling-Maxwell’s *The Cloister Life of Charles V*: “On other occasions he would release little carved wooden birds which flew into every corner, to the consternation of the disapproving Superior of the convent, who considered them works of sorcery.”

²³⁹ See Bedini, “Role of Automata,” page 36: “During his training period, however, Vaucanson indulged his mechanical interests by creating automatically flying angels. This impelled the provincial of the order to destroy his makeshift workshop, and Vaucanson used the incident as an excuse to be relieved of his clerical vows.”

recognize which participant could best replicate the fabled brazen head of the medieval romances through technological innovations, this evidence suggests that, by that time, a mounting intellectual consensus had finally overturned the apprehension, even amongst learned religious authorities, that even such a fundamentally “magical” (and specifically, Hermetic) species of automata as the brazen head was necessarily and actually “magical,” and thus demonic, when constructed as a real-world material object.²⁴⁰ Of course, when the Church conducts an investigation of a fictitious brazen head in the second part of *Don Quixote*, in the cultural context of the early seventeenth century, its agents can discern that the head is a false automaton, a case of fakery, and do not proceed to destroy it, suggesting either that clerical violence against automata was highly attenuated to particular circumstances, and not least the individual clerics or cleric involved, or that Cervantes, writing in his own time, had an optimistic stance as regarded the prevalence or intensity with which the proposed fourth current could be articulated in society.²⁴¹

Like the proposed third current of thought proper, the proposed fourth current of thought can be complicated or obfuscated by the question of semantics. Bedini, by referencing “alchemy” as a method of animating automata, registers the proposed third and fourth currents when writing that “...the temptation was always at hand to attempt to create life itself in giving birth to these lifeless figures,” which ascribes specific intent and recourse to magic on the parts of automaton-makers even if, in this thesis’ reading, this remark is merely a rhetorical flourish. In delivering it, Bedini also seems to overstate the importance and efficacy of a certain school of magic in the history of real-world automata, for while alchemy was certainly a foremost tradition of magical and scholarly inquiry in the European Renaissance, the ancient Greek magical tradition of *telestike*, transmitted through the Hermetic corpus, had acknowledged meaningfulness to the development of automata as an identifiable concept.²⁴² Similarly, when Braswell wrote that “The [pre-Modern] artists created magic by designing automata,” this is a registration of the proposed third and fourth currents, even if Braswell’s authorial aim was to apply the semantic sense of “magic” as mere wonderment, since one possible, valid reading of the above statement is that the act of making an automaton attracts, channels, or generates supernatural power.²⁴³

²⁴⁰ See Bedini, “Role of Automata,” page 38: “The next major advance in this field was made in about 1770 by Friedrich von Knauss of Vienna, who constructed not one but four speaking heads. That his project was not completely successful is attested to by the fact that in 1779 the Academy of Sciences in St. Petersburg used the production of a successful speaking head as the theme of a contest for mechanics and organ manufacturers, specifying that the machine be capable of speaking the five vowels. Three inventors produced results at about the same time: the Abbe Mical in 1778, the Baron von Kempelen and C.G. Kratzenstein, both in 1780. Numerous others constructed speaking heads within the next decades, but never with any marked degree of success.”

²⁴¹ See this thesis’ fourth appendix for the fictitious brazen head in Cervantes’ second part of *Don Quixote*.

²⁴² See Bedini, “Role of Automata,” page 40: “Certainly the temptation was always at hand to attempt to create life itself in giving birth to these lifeless figures by a combination of alchemy and mechanics.” For *telestike*, see Lily V. Filson’s doctoral dissertation.

²⁴³ See Braswell, “The Magic of Machinery,” page 103, at the second paragraph.

The transition from the proposed fourth current to the proposed fifth current is marked by the ubiquity of automata in the European Renaissance, by comparison with their rarity in the Middle Ages, and the by the corresponding loss of their novelty as a species of technology. Per Braswell, "...the audience soon became acclimated to this kind of mechanical magic," and it was precisely the familiarity of the Renaissance audience with automata, through automaton displays in public spaces, such the seats of religious and civic life (the churches and cathedrals, and places of secular assembly, such as the town squares), which denuded the automata of "magic," either in its semantic meaning, as the wonderment of new technology, or as the misapprehension that a self-moving device is necessarily energized by demonic forces.²⁴⁴ In this context, the figure of the "tregetour," a mechanical artificer, registers the proposed fourth current, inasmuch as those called by this term were the early technicians who actually began constructing automata and other wonderments in the late Middle Ages, after the general absence of these devices from European material culture in the preceding centuries. So too does the appearance of the "tregetour" mark what is perhaps the earliest transition between the fourth and fifth currents, in Braswell's characterization, since they were not considered wizards, but were nevertheless viewed as the distinct class of persons responsible for accomplishing impressive feats of technology, with the inscrutability, and potential suspicion, which are typically attached to such classes by laypeople.²⁴⁵

Braswell conjectures that an articulation of the proposed fifth current of thought could have occurred as early as Chaucer's lifetime, if the Clerk of Orleans' scene in *The Franklin's Tale* was "enacted to the delight of an audience knowledgeable of contemporary automata," that is, if a mechanical tableau was presented to this audience, and this tableau was perceived by that audience to merely be an entertainment, a purely secular diversion removed from any belief that this tableau, or its builder(s), used actual magic to achieve its effects. That the scene in question from *The Franklin's Tale* involves The Clerk of Orleans' magic would heighten the strength with which the fifth current would then have been registered, as the irony of an automaton not acknowledged to be magical in nature functioning to represent acts of magic, but in a way not perceived as authentically supernatural, is highly ironic, and is itself a conceit that would be used to good effect in the designs of countless small automata of the nineteenth and early twentieth centuries. If Braswell's conjecture is correct, although there is no concrete evidence to support the staging of The Clerk of Orleans' scene with automata, it would register this thesis' fifth current by way of its proposed third and fourth currents, and at an early date, given that The Clerk of Orleans was a fictitious magician concerned with conjuring convincing visual illusions.²⁴⁶

²⁴⁴ See Braswell, "The Magic of Machinery," page 104.

²⁴⁵ See Braswell, "The Magic of Machinery," page 106.

²⁴⁶ See Braswell, "The Magic of Machinery," page 108: "It is tempting, therefore, to believe that before its incorporation into *The Canterbury Tales*, *The Franklin's Tale* was actually enacted to the delight of an audience knowledgeable of contemporary automata. In a world in which nominalism was beginning to gain ascendancy over symbol, in a society whose sophisticated members were insisting

While the idea that the feats of the Clerk of Orleans were staged with automata is purely conjectural, the case of Juanelo Torriano is not; he, his patron, and the goings-on at San Yuste are all historically attested, and that Torriano, in Stirling-Maxwell's terms, earned "the dangerous fame of a wizard" as the result of fashioning automata is directly indicative of this thesis' proposed fourth current of thought.²⁴⁷ In the Renaissance and Early Modern period, science and "magic" were not distinct and irreconcilable concepts, so it is unsurprising that makers of automata were deemed to be practitioners of magic, especially by those most disposed by religious scruples, or simple ignorance, to believe in magic; and because science and magic were indistinct, alchemists such as Paracelsus, while certainly being occultists, could make real advances in science, whether as theoretical or practical contributions. This development, the movement from "magic" as a scientifically baseless and irrational phenomenon, to "magic" as a useful paradigm through which means objective knowledge could be gained, under the pretext of metaphysical ends, is as equally indicative of the transition from the proposed third to the proposed fourth currents of thought as the persecution of automaton-builders as sorcerers; for even if the automaton-builder, in such a cultural context, really did envision himself as a sorcerer and magus (as was likely the case with John Dee), but that same automaton-builder did not regard the act of creating an automaton as inherently magical, a threshold in European history was still reached, in which automata were actually being built, rather than merely imagined as fictitious flights of fancy. Paracelsian innovation, while unrelated to automata and this thesis' proposed model, can thus be considered a concrete improvement in a progressive trajectory for the history of science and technology as a whole, and Paracelsus' cultural setting was one of many, at different moments and places, which reflected the transition from the proposed third current to the proposed fourth current.²⁴⁸

In this connection, the stereotypical antagonism between organized religious systems and organized scientific systems becomes more comprehensible within European history, for while religion and science are two different approaches to the concept of truth, some varieties of science and technology had their origins in

on verification through experience, it was not sufficient for the tricks of the Clerk of Orleans to be sheer illusion. For automates maneuvered by "viace," capston [SIC] winch, clock mechanism, whatever – these marvels were indeed the magic of the late Middle Ages."

²⁴⁷ See King, "Clockwork Prayer," at page 7 in the author's printed copy, quoting from Sir William Stirling-Maxwell: "Other puppets were also attributed to [Torriano]; minute men and horses which fought, and pranced, and blew tiny trumpets, and birds which flew about the room as if alive; toys which, at first, scared the prior and his monks out of their wits, and for awhile gained the artificer the dangerous fame of a wizard."

²⁴⁸ See King, "Clockwork Prayer," at Page 17 in the author's printed copy: "When we remember that alchemy, for all its long association with forbidden knowledge, is the mother science of modern chemistry, and that Paracelsus was among the first to propose a theory of metabolism against the entrenched 'four humors' view of the body, we understand something of the paradox and complexity of this transformative period in history. (And we wonder what kind of gentler treatment Don Carlos might have received from the great Swiss physician). The alchemist moreover, sought equally a knowledge of the cosmos and an understanding of the living organism: these truths would be elementally interwoven."

“magic,” such as the noted case of alchemy, and the advancement of technology has ever been an effort to master and make real the fantastical, since the old dream of creating true androids and gynoids through technology alone remains very much alive in the second quarter of the twenty-first century. King, using the same quote from Stirling-Maxwell, writes that “we have some record that automata too roused the disapproval of the Church.” One explanation for the appearance of the proposed fourth current of thought as specifically regards the condemnation of automata by the Church, and persecution of automaton-makers, is that the Church was not mistaken in its apprehension that automata were descended from ancient speaking-statues and Hermetic *telestike*, but could overgeneralize this association between automaton technologies and magic to instances of real-world automata which had no basis or purpose in magical rituals or other occult practices.²⁴⁹ Of course, automata did historically appear in churches in the pre-Modern and Early Modern periods, but perhaps because they were constructed under the direct patronage and supervision of ecclesiastic authorities (and, as such, not likely to be used in the practice of Ficinian magic, and “invested,” like the automata of Pratolino, per Filson), this practice was allowed throughout much of the period considered by this thesis.²⁵⁰

Lionarons, in various recapitulations and permutations of the famed chestnut by Arthur C. Clarke, writes that in Chaucer’s *Squire’s Tale*, “...even if the so-called ‘magic’ is really technology, it is still suspect, precisely *because* it is based on uncommon knowledge and can therefore be used by the learned to deceive the ignorant,” which applies to that tale’s *hors of bras*, a “thing of brass” in this thesis’ nomenclature. This line of reasoning, once again, is one transitional approach from the proposed third current to the proposed fourth current, a willful unwillingness to differentiate “magic,” as a genuinely efficacious power, from “magic” as demonstrations of poorly-understood, highly sophisticated technologies, when enculturated to accept the existence of the former, but when confronted by the existence of the latter.²⁵¹ Interestingly, in another work of fiction, the second part of *Don Quixote*, the rationale stated by the inquisitors who disapprove of a false automaton represented in that work, a brazen head, is almost exactly what Lionarons states as the ground of suspicion against the wondrous gifts, including the brazen horse, in *The Squire’s Tale*, namely that laypeople could be led to error by the existence of an automaton which (falsely) seemed to possess the same powers as

²⁴⁹ See King, “Clockwork Prayer,” at Page 17 in the author’s printed copy: “And likewise, we have some record that automata too roused the disapproval of the Church, as when Turriano gains ‘the dangerous fame of a wizard.’”

²⁵⁰ For Ficinian magic and the automata at Pratolino, see Lily V. Filson’s doctoral dissertation.

²⁵¹ See Lionarons, “Magic, Machines, and Deception,” page 379: “The four gifts of the *Squire’s Tale* are magical insofar as they all require esoteric knowledge to make or to use, but that knowledge is conceived of as essentially technical; additionally, the mirror and the ring give their users access to hidden or esoteric knowledge. None of the magic in the tale necessarily involves the supernatural; none is clearly differentiated from the technological. Nevertheless, even if the so-called ‘magic’ is really technology, it is still suspect, precisely *because* it is based on uncommon knowledge and can therefore be used by the learned to deceive the ignorant.”

those in medieval legends, all within Cervantes' satirically incisive fiction.²⁵²

These concepts are reinforced by a similar quote, "...those who have technical knowledge, especially if it is secret or in some way exotic, are suspect, as are the devices they construct," which registers the proposed fourth current of thought, although this thesis would add, as before, that one basis of this suspicion was a conflation of distinct semantic meanings for the term "magic," as discussed in the previous section on the proposed third current.²⁵³ Another basis, at a deeper level, is opposition to the whole project of automaton-building as an exercise in the application of "forbidden knowledge," which does have theological ramifications. Essentially, if one believes that the creation of automata is an act of supreme hubris in defiance of a perceived, divinely-ordained moral order, then one corollary is that any knowledge or technology associated with this project must also defy this moral order, with the meanings of "magic" associated with automata then being the subordinate class of "forbidden knowledge" prerequisite to successful attainment of a superordinate "forbidden knowledge," which would be the realization of an automaton in sacrilegious imitation of divine power. To this way of thinking, such an automaton must be the so-called "man after one's own image" featured in the traditional, morally-inflected warning against the pursuit of artificial life.

Isaac Asimov coined the term "Frankenstein Complex" to signify negative attitudes towards the contemporary intellectual-cultural conception of robots, and was positioned to do so because his twentieth-century oeuvre of science fiction had definitive significance in establishing that very conception, both for the science fiction genre, and ultimately, for laypeople who have encountered representations of robots and robotics which continue to be shaped by his influential works. Fear that the creation of robots, and their pre-Modern and Early Modern antecedents, automata, represent an aspiration to possess "forbidden knowledge" epitomizes the Frankenstein Complex, but in what is either a resounding confirmation of the complex's timelessness, or the identification of an inspiration possibly known to Asimov, the Frankenstein Complex is evident in scholarship on pre-Modern and Early Modern automata reviewed by this thesis. Lionarons identifies "...a theme that runs throughout many of the *Canterbury Tales*, that it is dangerous to inquire too closely into secret matters, especially those that may be construed as "Goddes privetee," [God's privy knowledge,] that there are types of knowledge that trespass beyond humanity's needs and/or capabilities." This is one avenue to the thesis' proposed fourth current of thought, as it is such ideation that leads directly to persecutorial

²⁵² See this thesis' fourth appendix for both the *hors of bras* and Cervantes' brazen head.

²⁵³ See Lionarons, "Magic, Machines, and Deception," page 383: "The Yeoman's revelation of the secrets of both canons follows the pattern we have already seen: those who have technical knowledge, especially if it is secret or in some way exotic, are suspect, as are the devices they construct. Chaucer exhibits such intimate knowledge of both the technical processes of alchemy and the ways in which innocents can be duped that critics have occasionally speculated that he himself was either a master of the art, or an angry dupe determined to avenge himself by revealing all the tricks of the trade."

intent and actions.²⁵⁴ So, following Lionarons, the registration of the proposed fourth current can be prompted by the apprehension that technology, and for this thesis' topic, automaton technologies, "can be used to deceive," but at a higher level "...it is even more dangerous in that it can sometimes deceive the technician into believing that it can provide both god-like control over the natural world and the ultimate answers." Since this is a statement of Asimov's Frankenstein Complex, it can be said that the Frankenstein Complex therefore registers the fourth current under this thesis' proposed model, and in the pre-Modern and Early Modern eras, which are far removed from the twentieth century, when Asimov flourished.²⁵⁵

So, the negative reaction to automata, when they began to appear and proliferate in Europe, could be caused by the association of automata with magic, which was based in fictitious representations of automata – and these representations were, in turn, byproducts of the loss of automaton technologies in Western Europe in the early Middle Ages, and were highly informed by the retention of these technologies in West Asia. The negative reaction to automata could also be informed, at a higher level, by the idea that the creation of biological simulacra was fundamentally sacrilegious, with magic being the natural method to accomplish what was, for those who held such an opinion, the unnatural and terrifying project of seemingly bestowing life upon the non-alive. Yet both of these reactions are linked by a third basis for the emergence of the proposed fourth current of thought in reaction to the early, real-world automata of the late European Middle Ages and Renaissance: the belief that any system of magic, which was necessarily contrary to Christian authority and orthodoxy, and that any undertaking perceived as hubristic, a monument to the deadly sin of pride as developed in Christian theology, originated with Christianity's font of error, and author of evil: Satan. O'Brien's analysis, that "the important cultural association expressed in this picture [a painting of Hell] between the demonic and the mechanical" is a central expression in Chaucer, is relevant to this thesis because this "cultural association" is a registration of this thesis' proposed fourth current of thought, even if there are no obvious automata in the depiction of Hell discussed by O'Brien (although, as in the extant illustrations from manuscript copies of al-Jazari's treatise, it is only possible to tell if a figure is an automaton, or not, with prior

²⁵⁴ See Lionarons, "Magic, Machines, and Deception," page 384: "Chaucer's treatment of alchemy thus becomes the clearest example yet of a theme that runs throughout many of the *Canterbury Tales*, that it is dangerous to inquire too closely into secret matters, especially those that may be construed as "Goddess privetee," that there are types of knowledge that trespass beyond humanity's needs and/or capabilities, and that it is often best merely to accept one's limitations and one's powerlessness and leave control of the natural world to God."

²⁵⁵ See Lionarons, "Magic, Machines, and Deception," page 385: "But technology is also dangerous. It is dangerous in part because it so often relies on uncommon, new, or secret knowledge and thus can be used to deceive; it is even more dangerous in that it can sometimes deceive the technician into believing that it can provide both god-like control over the natural world and the ultimate answers to philosophical, instead of merely technical, questions."

knowledge, since the illustrations of al-Jazari's figural automata do not distinguish their appearances from those of organic beings).²⁵⁶

This tendency to regard ways of thinking which did not originate with Church dogma, but with empirical observation, as having demonic origins and nature was a specifically Augustinian reaction, per O'Brien, not just to the appearance of automata, but to the rise of scientific methodology and advances in technology, with new European automata being corollaries to these developments. Under this reaction, Hell was "a realm of the technological grotesque," a characterization which registers the proposed third and fourth currents, as well as the proposed seventh current, inasmuch as automata were works of technology (and often grotesque), and inasmuch as it relates to one possible afterlife.²⁵⁷ Thus, O'Brien's identification of the "Augustinian, authoritative stance" under which "...the ultimately demonic nature [supposedly] of the new movement during Chaucer's time toward experimentalism, or experience, as the Wife of Bath calls it" was articulated, must be an avenue to the persecutorial fourth current of thought, for the natural impulse of churchmen was to eradicate all things they perceived as evils contrary to divine order.²⁵⁸ This contest between scientific and religious postulates as the sources of ultimate truth is not unfamiliar in contemporary times, when such evidentiary findings as the mechanism of biological evolution, and the age of the natural universe, remain contested on religious grounds in some quarters. O'Brien writes that "In the *Friar's Tale*, then, Chaucer does much to depict the summoner in terms of the relation between scientific and demonic activities;" and indeed, as O'Brien discusses in his same article, Chaucer's description and characterization suggests that the summoner was authorially intended to recall sufflators, pre-Modern and Early Modern devices which this thesis considers to be a class of automata in certain cases, whenever the steam they discharged was designed to issue in a manner recalling behaviors exhibited by living organisms. With respect to automata, specific reference to the "relation between scientific and demonic activities" registers the proposed fourth current of thought.²⁵⁹

²⁵⁶ See O'Brien, "Ars-Metrik," page 6: "Actually, the Summoner *embodies* the important cultural association expressed in this picture between the demonic and the mechanical."

²⁵⁷ See O'Brien, "Ars-Metrik," page 6: "In both Limbourg's and Brueghel's pictures hell is a realm of the technological grotesque." See this thesis' fourth appendix for many automata that have overtly demonological imagery.

²⁵⁸ See O'Brien, "Ars-Metrik," page 9: "If the tale were to go only this far, it would serve to satirize – from an Augustinian, authoritative stance – the ultimately demonic nature of the new movement during Chaucer's time toward experimentalism, or experience, as the Wife of Bath calls it. The summoner, however, is intractable even in the face of demonstration through his senses, as the episodes involving first the carter and then the widow suggest."

²⁵⁹ See O'Brien, "Ars-Metrik," page 9: "In the *Friar's Tale*, then, Chaucer does much to depict the summoner in terms of the relation between scientific and demonic activities. He does this by having the summoner ask 'scientific' questions of the fiend. He also, I think, plays upon traditional associations related to the cart – which is not just a symbol of the agrarian, working class. The allegorical cart, as Curtius explains, 'was a favorite motif in the twelfth and thirteenth centuries;' science itself is depicted by Walter of Chatillon as a cart, and Ovid's cart of the sun has grammar for pole, logic for axletree, etc. (120n). The association of the cart with intellectual curiosity operates both here in the *Friar's Tale* and in the coda to the *Summoner's Tale*, where the cart's wheel is the

Chaucer, amongst the authors considered by this thesis, does seem at pains to take the positions encapsulated by Asimov's "Frankenstein Complex," at least according to O'Brien, who writes "The scientific quest shapes the plots of both the Friar's and the Summoner's tales: in both, the climax occurs when the curious poser of the question, the descendant of Bacon and Grosseteste in search of 'God's privities,' discovers the answer, and particularly one that depends on the senses rather than authority... the triumph of the demonstrated knowledge of science over mystery and irrationality." Chaucer is therefore satirizing what could today be termed scientism, but as regards automata, that Chaucer could construct jocular narratives around scientific inquiry, and that these plots were even conceivable, is consistent with the replacement of the proposed third and fourth currents of thought by the proposed fifth and sixth currents of thought. Rational methods of inquiry were beginning to overtake those which had no rational bases, even if Chaucer, per the Frankenstein Complex, finds the objective of scientific inquiry unseemly, too closely investigating the prerogatives of the Christian God.²⁶⁰ Similarly, the progression from the proposed third and fourth currents to the proposed fifth and sixth currents is shown, in a general sense, by a famed debate between representatives of the pre-Modern medical and legal professions, with "experimental science" beginning to replace pure logic as the basis of determining truth.²⁶¹

Of interest in this connection is the recurrence of the Augustinian theological framework which O'Brien has represented as most hostile to the nascent scientific and technological advances of the late Middle Ages, of which automata were, again, a part: "According to Salutati's [the representative of pre-Modern legal professions in the aforementioned debate] Augustinian principles, scientific demonstrations of the kind Bacon proposes are essentially 'ars-metrik,' excursions into God's privities."

measuring device." Elsewhere in his article, O'Brien draws the comparison between the summoner and a sufflator.

²⁶⁰ See O'Brien, "Ars-Metrik," page 12: "Although Chaucer uses the friar to expose the difference between the apostolic ideal of the friars and their selfish behavior, he also focuses his satire on the way they have turned their human, spiritual activity into systematic, mechanical gestures. Research into the friars' practices of composing sermons justifies this emphasis on the mechanical element in the friars' activity. As Joseph Mosher and D.L. d'Avray have shown, the friars constructed their sermons from immense 'exemplum books,' arranged under such categories as *gloria* and *gratia*, books that amounted to what d'Avray calls 'elaborate preaching machines' (74-75; Mosher 86-87). To the extent that they relied on this system, the friars resemble Chaucer's version of the scientist, as developed through the Friar's summoner and also, in more specific terms, through the lord and squire at the end of the *Summoner's Tale*. The scientific quest shapes the plots of both the Friar's and the Summoner's tales: in both, the climax occurs when the curious poser of the question, the descendant of Bacon and Grosseteste in search of 'God's privities,' discovers the answer, and particularly one that depends on the senses rather than authority. The *Summoner's Tale* resembles the *Friar's Tale*, then, in that it ironically describes the triumph of the demonstrated knowledge of science over mystery and irrationality."

²⁶¹ See O'Brien, "Ars-Metrik," page 17: "These closing sections of the *Summoner's Tale* point to a real matter of dispute in Chaucer's world concerning the value of experimental science. According to Geraldine Branca, Chaucer may have, in fact, been present in Florence to witness a famous dispute as to whether 'the doctor of medicine or the doctor of laws was the more scientific in his training and procedures' (65)."

This concern with transgressing the suitable bounds of human knowledge remains Asimov's Frankenstein Complex, and Chaucer may well have been influenced by it if O'Brien, following Branca, is correct, and Chaucer witnessed Salutati's oration while in Florence.²⁶² Regardless of whether Branca's attribution of Chaucer's attitudes to Salutati's participation in the Florentine debate is valid, it is clear, per O'Brien, that in *The Canterbury Tales*, Chaucer uses wordplay to emphasize the demonic nature of scientific investigation by emphasizing words with the "d-e" sound, as in "... 'demonstracioun' [demonstration] (2224), 'demonstratif' [demonstrative] (2272), 'demonyak' [demoniac] (2240), and perhaps even 'deemen' [deem] (2236)." This suggests Chaucer registered the third and fourth currents by this phonological technique, recalling, of course, that to a pre-Modern churchman, all magic was Satanic; and that Salutati, a contemporary intellectual, registered the fourth current by representing empiricism as contrary to respect for the divine.²⁶³

This analysis is repeated elsewhere in O'Brien's work, as when, for example, he characterizes a "culture in transition" amidst "...the giving way of the old, authoritative to the new, experimental method of arriving at solutions to problems in the physical world," as inasmuch as this relates to a progressive trajectory in the designs and technologies of automata, and to the cultural reception of the same in Western Europe, it represents movement from this thesis' proposed third and fourth, to proposed fifth and sixth, currents of thought.²⁶⁴ If this perhaps seems tenuous, the insightfulness of O'Brien's conclusion, and its applicableness to automata in the context of Chaucer's era, is evident in view of the changes in real-world automata, and to a lesser degree, the automata of fictitious works, which can be discerned over the course of the fifteenth, sixteenth, and early seventeenth centuries, that is, the centuries after Chaucer's death in the common year 1400. While there is still a well-attested case as late as the mid-fifteenth century, the triumphal automata built for

²⁶² *Ibidem*.

²⁶³ See O'Brien, "'Ars-Metrik,'" page 18: "According to Salutati's [the doctor of law's] Augustinian principles, scientific demonstrations of the kind Bacon proposes are essentially 'ars-metrik,' excursions into God's privities. Through word-play Chaucer emphasizes also the connection between scientific and demonic activities: he puns on 'demonstracioun' (2224), 'demonstratif' (2272), 'demonyak' (2240), and perhaps even 'deemen' (2236), as if to suggest that demonstrations, or at least the technicalities of academic investigation which that term implies, are demonic activities."

²⁶⁴ See O'Brien, "'Ars-Metrik,'" page 18: "These puns develop further the connections in the *Friar's Tale* between the scientific quest, the need for demonstration, and demonic power. They also point to a culture in transition and suggest Chaucer's skeptical, even derisive, attitude toward some of the elements in that transition. For instance, on the one hand, the lord [a fictitious character] quite clearly represents the *via rationis*, which depends on demonstration *secundum imaginationem* and adherence to authority; he complains that the problem which the friar has brought him has never been discussed before in any works of 'ars-metrik' (2220-23). The problem is 'devilish' precisely because it has not received the attention of the authorities. The squire, on the other hand, represents the *via experientiae*, depending on the kind of demonstration that Bacon describes as deriving its final authority from the senses. Thus, far from being simply a self-reflexive display of academic discourse or a development of dramatic tension between the pilgrims, these closing sections of the *Summoner's Tale* play out the conflict between these two academic procedures and moreover the giving way of the old, authoritative to the new, experimental method of arriving at solutions to problems in the physical world."

Count Borso d'Este to which this thesis often returns, of a component-for-component, design-for-design recreation of a Hellenistic automaton work, with only the figural subjects changed to reflect a pre-Modern Christian religious iconography, rather than that of Hellenistic Greece, the appearance of novel designs for automata, rather than exact reuses of ancient designs and methods, like the d'Este device, demonstrates that the same tendency toward experimentation, rather than a total reliance upon received authority, also applied to intellectual culture of automata. Heron, Ctesibios, and the other classical, and especially Hellenistic authors of automata represent such authority for this thesis' topic, just as Aristotle, as an example, represented such authority for many other intellectual fields of endeavor in the pre-Modern and Early Modern periods. Recall too that, in the early medieval romances, it is most usual for the automata represented therein to have more or less Heronic designs, and in some cases, like the case of the fictitious archer automaton in the tomb of the Amazon Camille to which this thesis also often returns, these fictitious automata were also component-for-component, design-for design recreations of classical examples.²⁶⁵ Thus, as non-Heronic automata appear, which would include any automaton design incorporating kinetic clockwork, these non-Heronic automata show the same recourse to contemporaneous experimentation, rather than dependence on ancient authorities.

Some labored feats of argumentation in opposition to Chaucer's attitude, the proposed fourth current of thought, which apply other currents proposed by this thesis are also mentioned by O'Brien, although they are difficult to interpret. One falls back to the proposed first current as a counterargument to the proposed fourth current by situating automata as permissible works on the ground of the divine agency controlling the builders of high technologies, including automata: "...who become lost in employing and creating mechanical devices, are themselves the *instruments* of the arts and figures of an ultimate scientist/mechanic – i.e., Chaucer with his unforgiving irony and God with his providence." Another rebuttal to the negative reaction to automata represented by the proposed fourth current does not position the creation of automata as simply another development in the divinely-ordained order of reality, but instead addresses the putatively demonological dimension of automata inveighed against by those espousing the proposed fourth current of thought. This is accomplished by again applying an argumentative stance drawn from the proposed first current of thought, that whereas "...the mathematical/scientific templates of the [fictitious] lord and his squire [are] as anal, mechanical and demonic, he [Chaucer] nevertheless suggests that these circumscribed approaches cannot but express a divine, geometrical, mechanical appropriateness behind them." Here, one can see an expression of the concept which informs the Christian practice of exorcism, namely that the Christian and Chaucerian idea of ultimate evil, Satan and his demons, must recognize the authority of ultimate good, for they too exist within the Christian God's creation; thus, demons are expelled by invoking the name of God.²⁶⁶ So, this second

²⁶⁵ For these and all other examples of pre-Modern and Early Modern automata identified by this thesis, see the fourth appendix.

²⁶⁶ See O'Brien, "Ars-Metrik," page 19: "Those who search into God's privities, who measure and demonstrate by arts and figures, and who become lost in employing and creating mechanical devices,

counterargument extends the first, which does not make provisions for the identification of automata as demonic, by seemingly suggesting that even if automata and high technologies are indeed “anal, mechanical and demonic,” they nevertheless exist within the divinely-ordained order of reality, meaning that the first argument’s holding should still apply. This second argument would seem to be a weaker response to an articulation of the proposed fourth current’s hostility, however, since it must implicitly agree that automata are, at base, demonic, which is a philosophical and metaphysical position. Of course, that there is a “...divine, geometrical, mechanical appropriateness” to automata might be statement delimited to the physical materiality of real-world automata, which could then be argued without considering the allegation that automata and other works of automata are demonic at all, at which point this second argument merely becomes a restatement of the first. As the thesis has elsewhere stated, it is not disposed to regard any pre-Modern automaton under any of Kang’s four categories as indisputably “magical” or “demonic” in the absence of evidence to positively suggest that it figured in an occultic or Satanic practice, such as the Ficinian “investiture” discussed at length by Lily V. Filson.²⁶⁷

With these swirling intellectual-cultural ramifications of the proposed fourth current of thought’s reactionary nature considered, O’Brien follows Lawn in identifying the popularization of the “scholastic exercise of *quaestiones et responsiones*” within secular and non-academic settings as one intellectual-cultural route by which this proposed fourth current was finally abandoned in the progressive trajectory to the proposed fifth current, and then to the proposed sixth current.²⁶⁸ It seems, on the whole, that O’Brien argues throughout his article, and at its conclusion, that despite Chaucer’s scientific erudition and intellect, and inclusion of exchanges in the mode of the *quaestiones et responsiones* in *The Summoner’s Tale*, Chaucer nevertheless asserts this thesis’ proposed fourth current of thought by making his parodies operate upon the pre-Modern “...linking of private curiosity and scientism, whether rational or experimental, with anal activity, mechanical devices and demonic

are themselves the *instruments* of the arts and figures of an ultimate scientist/mechanic – i.e., Chaucer with his unforgiving irony and God with his providence. This view of God as scientist follows Wisdom 11:7 – wherein He is seen as having created ‘all things in number, weight, and measure’ – and also Grosseteste, for instance, who in discussing the physical world according to Euclidean geometry, refers to God as a mathematician: ‘*mensurator primus et certissimus*’ (qtd. In McEvoy 175). Even though Chaucer exposes the mathematical/scientific templates of the lord and his squire as anal, mechanical and demonic, he nevertheless suggests that these circumscribed approaches cannot but express a divine, geometrical, mechanical appropriateness behind them.”

²⁶⁷ See Lily V. Filson’s cited doctoral dissertation.

²⁶⁸ See O’Brien, “‘Ars-Metrik,’” page 20: “The way in which the discourse of the new world frames problems eliminates the need for the discourse of morality and value upon which the old world is ostensibly built. That this change of discourse was in fact taking place is suggested by the fact that the scholastic exercise of *quaestiones et responsiones*, the paradigm for the discourse at the end of the *Summoner’s Tale*, was being used in the fourteenth century ‘not for purely didactic purposes in the classrooms, but also as the basis for polite conversation’ among men ‘of divers states and conditions’ – a form of informal converse which was to be of increasing importance in the 16th and 17th centuries for the discussion and propagation of scientific ideas’ (Lawn 105).” [Note that everything after “not for” is from Lawn.]

presence.”²⁶⁹ In presenting O’Brien’s conclusions, the thesis is inclined to agree that the association between automata and magic, and hence demonology, has broad applicability throughout the many Christian cultures of pre-Modern and Early Modern Europe. As delineated, his analysis does have relevance to a dissection of the intellectual culture which could condition negative responses to automata in circumstances prevalent at certain times in the thesis’ considered period, and principally, the objection to automata on religious grounds, which is a hallmark of the proposed fourth current of thought. This current was in evidence when automata began to proliferate in Europe in the late Middle Ages, thereabout Chaucer’s lifetime; whenever certain clerics, disposed to registration of the proposed fourth current of thought, were confronted by novel and spectacular automata; and during the Reformation, when the religious fervor introduced by a new multiplicity of theologies heightened the scrutiny of any cultural artifacts, such as automata, usually deemed suspicious by religious authorities, or at least, whenever such artifacts were not under the patronage and control of these same authorities.

An example of the early trend under the proposed fourth current, which situates automata as demonic without evidence of the associations between magic, demons, and automata being spurred by the particular case of a physical, materially-realized automaton, or by an automaton under any of Kang’s categories within the broader cultural context of the Reformation, is the first of the brazen-head legends, the one circulated about the supposed automaton-making activities of Gerbert of Aurillac, Pope Sylvester II. Notwithstanding the fourth current, which it does register, this legend is intelligible as a case of the proposed third current being drawn from the proposed second current, as Gerbert’s multicultural education in Spain, an area with access to the classical Hellenistic knowledge preserved and expanded under Islamic polities, was first understood as “magical,” and only as “scientific” once Europe had begun to reach the same secular mentality regarding automata, and more broadly, science and technology, which was represented, centuries prior, in West Asian societies by the proposed second current of thought. With these points established, the persecutorial fourth current is registered by Gerbert’s legendary brazen head for purposes of argument because, as discussed by Truitt, the legend of the same was originally defamatory in nature, and was intended to unfavorably portray Gerbert as a sorcerer by his political enemies within the cardinalate, who were chiefly represented by Cardinal Beno.²⁷⁰

²⁶⁹ See O’Brien, “‘Ars-Metrik,’” page 21: “His [Chaucer’s] means of containment is the value-laden associative pattern I have been examining, the linking of private curiosity and scientism, whether rational or experimental, with anal activity, mechanical devices and demonic presence. In other words, his [Chaucer’s] response to this individualism is traditional both in medieval terms and in the generic terms of satire: unfettered expressions of individualism, in a sense, activate necessity, mechanize humanity, and reduce its activity to a collection of physical dynamics.”

²⁷⁰ See Truitt, “Celestial Divination and Arabic Science,” page 217: “William [of Malmesbury] confirmed many prior accounts that mention Gerbert’s education in Spain and reiterated the claim that Gerbert was in league with the Devil, conjoining that with the story of the prophecy and the church where Gerbert fell ill. Although William repeated prior assertions that Gerbert trafficked with Devil, he did not present Gerbert’s oracular head as the product of demonic magic, as Beno had done, but rather

In the case of Gerbert's legendary brazen head, multiple currents proposed by this thesis are identifiable, and as noted elsewhere in the preceding sections, the sweep of this thesis' named currents through history can likewise be identified in Kang's book, where on its sixth page, in the third through second paragraphs, this thesis' progressive trajectory, from its third through sixth currents, is stated by Kang, although not in this thesis' terms, of course; the proposed fourth current is included in this trajectory.²⁷¹ Elsewhere in Kang, the proposed fourth current is notable when automaton-makers are presented as magicians, since the understanding of automata as "magical," and assumption that the builder of an automaton must therefore have truck with "magic" in its creation, is what gives rise to the fourth current, since all that is then needed to create a prevailing situation in which automaton-makers are subject to censure and persecution is hostility to "magic," as a power believed existent to the same degree as that of the Christian God, but not as a power originating with the Christian God, but instead, with the only other source of such power acknowledged by pre-Modern theology: the Christian God's spiritual enemy, Satan.²⁷² This hostility was pervasive in European societies throughout the pre-Modern and Early Modern eras and often colored the characterization and response to automata categorizable under Kang's typology. Kang notes that even upon the publication of his cited book, "...creators of artificial creatures, even in the modern period, are so often portrayed in the manner of magicians," but since the societal mores and norms of the present century vastly differ from those of pre-Modernity and the Early Modern period, this point no longer results in persecutions of "creators of artificial creatures," even if Kang's assessment that these people are "portrayed in the manner of magicians" is or was accurate, and not merely a rhetorical flourish.²⁷³

That the connection of the automaton-maker with the occultist is a very real and historical truth is unambiguous, and should be uncontroversial. This thesis, in offering its proposed fourth current of thought, is simply assigning a name to a perceptible historical phenomenon, so that the meanings and prevalence of this phenomenon in history can better and more easily be analyzed. Kang, in a sound exposition of three underlying bases for this connection, writes "...both fictional and actual automaton-makers were often regarded as sorcerers and necromancers." The cited passage which contains this exposition is highly relevant to this thesis' proposed third and fourth currents of thought. Further, it is of some interest that, according to Kang, "...advocates of natural magic themselves regarded mechanics as a type of neutral magic, closely related to or subsumed under the rubric of mathematics," since "Leo the Mathematician," the figure reputed by legend to have built the Throne of

as the product of astral science. Furthermore, he referred to specific authors and practices, revealing the extent to which Arabic scientific texts were known in England at that time [William's time]."

²⁷¹ See Kang, *Sublime Dreams of Living Machines*, page 6, paragraphs 2 – 3.

²⁷² See Kang, *Sublime Dreams of Living Machines*, page 36.

²⁷³ See Kang, *Sublime Dreams of Living Machines*, page 43: "This is why creators of artificial creatures, even in the modern period, are so often portrayed in the manner of magicians..."

Solomon and other Solomonic automata in Byzantium, was apparently a mathematician by vocation or avocation, at least in view of his epithet.²⁷⁴

Returning to this thesis' observation that its proposed fourth current of thought could be registered at any point in the pre-Modern and Early Modern periods when Christian clerics, from their religious zeal, equated automata with "magic," and thus in traffic with demons, but that this fourth current had some of its clearest expressions in the late Middle Ages, and thereafter, during the Reformation, Kang's discussion of Giovanni Fontana, who lived at what is considered the latest part of the international European Middle Ages by typical periodization schemes, but in what was already an Italian Renaissance setting, in this thesis' view, certainly warrants consideration, together with the scholarly source on Fontana cited by Kang. As regards Giovanni Fontana, Kang writes "Fontana had contempt for the fraudulent tricks of magicians and may have exposed the inner mechanical workings of the diabolical automata [Fontana's designs] in order to deflate stories of sorcery. But he also affirmed the reality of certain forms of natural magic, including theurgical operations." These two positions are facially contradictory, so in Kang's characterization, Fontana himself registers the proposed fourth current of thought, even as he is an excellent example of it as an actual maker of automata in a century when such activity could give rise to persecution.²⁷⁵

The second upswelling of the proposed fourth current, which was not a response to technology, as had occurred during the later Middle Ages and produced Giovanni Fontana, but instead a response to the cultural upheavals of the Reformation, also yielded a figure who can well be understood through the lens of this thesis' proposed fourth current: John Dee, an actual magus, and not an engineer, like Fontana.²⁷⁶ While Fontana's case has all the ambiguities which Kang ascribes to

²⁷⁴ See Kang, *Sublime Dreams of Living Machines*, page 60: "First, to return to Arthur C. Clarke's dictum, any machine whose operation or purpose was not apparent to the viewer was liable to be regarded as magical, especially for an object, like the automaton, that was evocative of theurgy. Consequently, both fictional and actual automaton-makers were often regarded as sorcerers and necromancers. Second, the advocates of natural magic themselves regarded mechanics as a type of neutral magic, closely related to or subsumed under the rubric of mathematics. During the Renaissance, people like Agrippa, Dee, and others explicitly pointed to the automaton as a type of marvel that could be achieved through the use of natural or mathematical magic. Third, for reasons detailed in the last chapter, the automaton was such a captivating but unstable object in terms of its conceptual significance that it was deployed in the ongoing debates on the nature and legitimacy of magic."

²⁷⁵ See Kang, *Sublime Dreams of Living Machines*, page 83: "For example, Anthony Grafton analyzes the works of the fifteenth-century engineer Giovanni Fontana, who had an interest in automata, illustrating in his treatises a flying bird, a fire-farting rabbit, and devils with mobile facial features, arms, and wings. In his exploration of Fontana's motivation in designing such works, especially the frightening devils, Grafton encounters the same complex attitude toward magic and mechanics found in the Middle Ages. Fontana had contempt for the fraudulent tricks of magicians and may have exposed the inner mechanical workings of the diabolical automata in order to deflate stories of sorcery. But he also affirmed the reality of certain forms of natural magic, including theurgical operations."

²⁷⁶ See Kang, *Sublime Dreams of Living Machines*, page 91: "This was a particular sore point with him [Dee], as he was suspected of sorcery throughout his career, first when he constructed a machine for a flying scarab in a theatrical production of Aristophanes's *Peace* [SIC] as a fellow at Cambridge and

the intellectual-historical concept of automatons itself, and rewards study, given the tensions and competing worldviews crystallized by Fontana's transitional moment at the close of what could be called the Middle Ages, Dee's case is another matter. If Fontana was a learned man who designed automatons and had an ambivalent view of "magic," Dee was a learned man who designed at least one automaton, "a machine for a flying scarab in a theatrical production," but who had a very different view of magic, and indeed, was partially responsible for establishing an entire branch of magical practice, Enochian magic, and the Enochian alphabetical system used for communication therein, which remains in use, advisedly, by latter-day practitioners of the occult.²⁷⁷ Yet, ironically, Dee resented the hostile reaction to his automaton, according to Kang; in this thesis' view, that was most likely because Dee was knowledgeable enough about magic to be aware of theurgical rituals, and possibly Ficinian "investiture," but likely did not "enchant" the stage machinery he had constructed, and was made incredulous, in what became, per Kang, a lifelong "sore point with him," when the scarab-automaton was nonetheless made the basis of prejudice against his interests, and on the ground of magical practice.²⁷⁸ Even so, it would seem that his contemporaries adjudged Dee's automaton as "magical" by consideration of its source, Dee himself. Perhaps, to close this very brief sketch of John Dee, a certain quote from Kang could be said to apply: "...one who creates wonders through the manipulation of worldly forces can justifiably be regarded as a wielder of supernatural powers." This line, and Kang's complete quote, as cited, are themselves registrations of this thesis' proposed fourth current of thought, and if injudiciously applied, would position every builder of automata, in any period, as a wizard, witch, or suchlike individual, an attributed status which could imperil one's life in the considered periods.²⁷⁹

Of the two lists assembled by Kang and referenced in the conclusion of the prior section for this thesis' proposed third current of thought, the first giving "negative" interpretations of automata, and the second "positive" interpretations of the same, the first of the "negative" interpretations registers this thesis' proposed third and fourth currents, and the second of the "negative" interpretations registers this thesis' proposed first and fourth currents. For the "positive" interpretations, the first registers this thesis' proposed third, fourth, and fifth currents. As before, "negative" and "positive" interpretations from these respective lists which only concern human beings, and their attitudes to automata, are omitted from the above reconciliation of these two lists of historical perspectives with this thesis' proposed model.²⁸⁰

later, more seriously, when he was arrested in 1555 after an accusation that he had cast spells against Queen Mary on behalf of Elizabeth. He was cleared of the charge, but the reputation stayed with him, prompting him toward the end of his life to make an appeal to the newly crowned James I to clear his name, which was rejected by the monarch[,] who was hostile to magical studies."

²⁷⁷ For Dee's automaton, see Kang, *ibidem*, and this thesis' fourth appendix.

²⁷⁸ See Kang, *ibidem*, and the surrounding passages.

²⁷⁹ See Kang, *Sublime Dreams of Living Machines*, page 198: "Since the supernatural (spirit) is at work in the natural (matter), one who creates wonders through the manipulation of worldly forces can justifiably be regarded as a wielder of supernatural powers."

²⁸⁰ See Kang, *Sublime Dreams of Living Machines*, page 305, *et seq.*

Kang's source on Fontana is Grafton, who notes that "...like [Roger] Bacon, the engineers took care to distinguish their practices from the evil (if effective) ones of diabolic magic." The construction of real automata at a time when the efficacy of magic was undisputed, and the resultant interplay between discourses of engineering and sorcery, denote the fourth current under this thesis' proposed model, especially since Fontana, per Grafton, "...was certainly conscious of these traditions when he designed the mechanical devils," and in this thesis' opinion, was knowingly playing upon the notion of the automaton-maker as occultist, even as Fontana sought to contest this same notion by exploding it through his publication of mundanely technological designs for "demonic" automata.²⁸¹ The interplay between the scientific and the demonological, which defines the fourth current under the proposed model, is also attested by Grafton's acknowledgment of the Hermetic theurgical tradition, although if this tradition had any influence on Fontana, such influence would not have been in Ficinian techniques of "investiture," themselves a recreation of Hermetic *telestike*, because Ficino's period of authorial activity postdates that of Fontana.²⁸²

Much of Grafton's analysis turns upon the seemingly contradictory nature of Fontana's beliefs, which are evident to a modern audience (if not to Fontana and his contemporaries), and some specific evidence is provided in further proof of this point: Fontana "acknowledged that men could obtain true knowledge by demonic or angelic inspiration;" "treated the *ars notoria*, astrology and talismanic magic, as valid;" "claimed to have spoken to a 'spiritual substance,'" and, most importantly for this thesis' purposes, per Grafton, "was more than aware of the older tradition that treated ensouled statues." Yet he also "...made fun of popular [magical] beliefs and practices," which, when taken together, lends the impression that his opinions on magic may have been influenced by his educational attainment, with more sophisticated and Latinate magic, including varieties of magic featuring contact with Christianity's preternatural beings, being favored by him over the beliefs of common, and presumably illiterate people. That Fontana himself accepted some forms of "magic," but knew that his own automata were not "magical," and that he intended to denude his automata of "magic" before their audience, while fashioning them as preternatural, demonic figures to heighten the irony knowingly introduced this

²⁸¹ See Grafton, "The Devil as Automaton," page 52: "Like [Roger] Bacon, the engineers took a special interest in devices that showed the human ability not just to emulate but to outdo nature: wagons that moved without draft animals, powerful weapons, and the like. And like Bacon, the engineers took care to distinguish their practices from the evil (if effective) ones of diabolic magic. Fontana – an educated man as well as an engineer – was certainly conscious of these traditions when he designed the mechanical devils."

²⁸² See Grafton, "The Devil as Automaton," page 52: "Yet the devilish appearance of Fontana's automata is as revealing as their mechanical interiors. For, in fifteenth-century Italy, the making of statues that moved could smack of more than technical ingenuity. From late antiquity onward, readers of the central Latin Hermetic text the *Asclepius* were astonished, horrified, and exalted by the text's claim that the ancient Egyptians 'discovered the art of making gods' – that is, they 'called up the souls of demons or angels and implanted them in likenesses through holy and divine mysteries, whence the idols could have the power to do good and evil.'"

particular contradiction, and all at his own, real risk, are each a registration of this thesis' proposed fourth current of thought.²⁸³

So far as it is possible to persuasively reconstruct the intentions of a historical figure, Grafton does write, unambiguously, that Fontana meant his automata to be "...as a deflation of the stories told by magi and theologians alike." How his automata would have been received, or were received, is another matter, but if Grafton is correct, the broader trend identified by this thesis is applicable here, the proposed fourth current of thought, for the intersection of magic as concept and practice with pre-Modern and Early Modern automata, and especially those of Kang's third type, registers it whenever the results are dangerous accusations, persecution, the grinding together of systems of technological knowledge and religious belief; and as Grafton shows, Fontana did have to contend with the inevitable reaction to his automata, despite his intentions.²⁸⁴ That this reaction can be said to have been inevitable is because, in what was surely reckless behavior, Fontana enjoyed exploiting the ontological, categorical ambiguity of automata discussed by Kang and Truitt, and treading the fine line between socially acceptable and unacceptable automaton-building activities, at least as perceived by his peers. In this, he was unlike Dee, a magus who happened to have built an automaton for purposes other than magic rituals, and was instead an engineer who built automata as exercises in intellectual provocation. Grafton writes "Necromancers raised the dead. A wooden skeleton linked by cords to a wheel and an escapement, Fontana explained, would appear to move its members," showing the degree to which, in designing such automata, Fontana exposed himself to moral reprimand, since necromancy was always regarded as a forbidden form of magic, and the degree to which Fontana was aware of the history of magic in relationship to automata, since necromantic magic, the animation of dead matter, was closely associated with automata in the pre-Modern period. While the topos of death registers this thesis' proposed seventh current of thought, as will be shown, Grafton's presentation of an automaton design from Fontana which registers this seventh current is included in a broader presentation of Fontana's participation in the discourse of the proposed fourth current as an automaton-maker.²⁸⁵

²⁸³ See Grafton, "The Devil as Automaton," page 53: "Fontana, moreover, took a serious interest in magical as well as mechanical contrivances. In his work on the art of memory, for example, he acknowledged that men could obtain true knowledge by demonic or angelic inspiration and by dreaming as well as by trial and error. He treated the *ars notoria*, astrology and talismanic magic, as valid, powerful disciplines. He himself claimed to have spoken to a 'spiritual substance,' from whom, or which, he received very useful information. And he was more than aware of the older tradition that treated ensouled statues as a preeminent work of demonic magic. [...] For the most part, however, Fontana treated magical traditions with scathing disdain. He made fun of popular beliefs and practices, and the supposedly wonderful objects that sustained them – like the stones with two horns that women thought could protect them against lightning."

²⁸⁴ See Grafton, "The Devil as Automaton," page 54: "The evidence suggests that Fontana meant his diabolic automata to be understood in a similar way – not only as evidence of his own powers of invention, but also as a deflation of the stories told by magi and theologians alike."

²⁸⁵ See Grafton, "The Devil as Automaton," pages 54 – 55: "Necromancers raised the dead. A wooden skeleton linked by cords to a wheel and an escapement, Fontana explained, would appear to move its members, 'just as the figures in mechanical clocks do.' Tongue firmly in cheek, he called this design,

Unsurprisingly, Fontana's activities, which self-reflexively registered this thesis' proposed fourth current of thought, produced the outcome which epitomizes it: allegations of sorcery, which were by no means brought by the ignorant, but instead, in accord with Fontana's own understanding of magic, by educated persons who shared his received knowledge of formal magical rituals (presumably from the pre-Ficinian Hermetic tradition), per Grafton's assertion that Fontana was aware of theurgical practices. Interestingly, these allegations were highly specific, indicating this correspondence between the knowledge shared by Fontana and his accusers. Grafton writes that "Certain men at Padua, though 'most learned,' falsely accused him [Fontana] of raising 'infernal spirits' from Tartarus to help him, using a pentacle of seals and secret seals. This was probably the very reaction that he hoped to provoke..."²⁸⁶ However, Grafton not only suggests that Fontana consciously participated in the clash of ideas which generates this thesis' proposed fourth current, but that Fontana deliberately tried to wield the social discord introduced by the proposed fourth current to elevate and advance his profession, and thus himself, to a kind of hierophantic or Brahmic status, and unlike Dee, all without resorting to the actual practice of magic, so far as is known.²⁸⁷ It was perhaps the recognition of this feat that led Ficino, the magus, to take inspiration from Fontana, the automaton-maker, per Grafton: Ficino "...drew on the engineers' ideas and their work, as well as that of their observers, when he set out to define a new sort of magical practice." The relationship between the work of Fontana and Ficino which is claimed by Grafton registers this thesis' proposed third current of thought, as it shows the interplay between concepts of "magic" and the pre-Modern or Early Modern automaton, even as this interplay led to Fontana's denouncement, which registers this thesis' proposed fourth current of thought.²⁸⁸

perhaps destined for a clock, 'resurrectio mortuorum artificiosa' – 'a crafty way to bring the dead back to life.'" See Kang's *Sublime Dreams of Living Machines* and Truitt's *Medieval Robots* for the difficulties in characterizing automata within ontological and epistemological frameworks, and especially *Medieval Robots* for a thorough discussion of mortuary science, necromancy, and automata, which is given in a chapter humorously titled "The Quick and the Dead."

²⁸⁶ See Grafton, "The Devil as Automaton," page 55: "There is every reason to think that Fontana meant not only to advance the claims of engineering, but also to deflate those of magic and its critics when he illustrated his designs. At times, he explicitly acknowledged that he had cast [pun intended?] his inventions in provocative forms. Certain men at Padua, though 'most learned,' falsely accused him of raising 'infernal spirits' from Tartarus to help him, using a pentacle of seals and secret seals. This was probably the very reaction that he hoped to provoke with his resurrection machines and fire-farting rockets in the shape[s] of rabbits and birds."

²⁸⁷ See Grafton, "The Devil as Automaton," page 56: "Again and again, Fontana wrapped his purely mechanical devices in frightening exteriors that recalled the other great set of fifteenth-century claims to human power over nature, those of the magicians. By doing so, he suggested that engineers could claim the same immense powers as magi. By the same token, and more radically, he mechanized the apparently preternatural or supernatural – and by showing that he could do so, he exalted his own craft [pun intended?] as no one before him had."

²⁸⁸ See Grafton, "The Devil as Automaton," page 59: "Even the most text-obsessed and speculative of the early magi, Marsilio Ficino, drew on the engineers' ideas and their work, as well as that of their observers, when he set out to define a new sort of magical practice and a new vision of the magus. And no wonder. The fifteenth-century engineer – as Fontana embodied and Alberti understood him – was

The impulse to realize ideas from fiction, as was done by the makers of automata in the centuries after medieval romance literature had its height of popularity, when they built devices that had previously only been imagined in these romances, was not limited to the pre-Modern and Early Modern periods. A quote from Marsh, writing about the twentieth-century automaton (and latter-day brazen android) Elektro the Moto-Man, on "...attempting to turn science fiction into reality," registers the relationship between the third and fourth currents in the proposed model, for this is a relationship wherein an idea, the automaton, for both pre-Modern and Early Modern European engineers (e.g., Giovanni Fontana), and for Mid-Century Modern American engineers, is encountered first in fiction, and then "made real," either by the recovery of ancient technology, in the cases of the Renaissance-era Europeans, or by the creation of new technologies, in the cases of the Mid-Century Modern Americans. Of course, as regards this thesis' periods of study, the "making real" of automata from works of pre-Modern fiction drew an association with the occult, as automata from these works were typically identified with magic in the same; and, inasmuch as magic was believed to be efficacious throughout the considered periods, this association led to persecution in the so-called "persecuting societies" of the late Middle Ages and Early Modern period, registering the proposed fourth current of thought. This development was not replicated in the Mid-Century Modern setting, both because the automata in the nascent genre of science fiction, which arose, in its form identifiable today, with Hugo Gernsback in the decade of the 1920s, did not have associations with magic, but rather with speculative technologies, understood as such, and because there was not a pervasive, sincere belief in the efficacy of magic during the Mid-Century Modern decades, certainly not to the same extent prevalent during the pre-Modern and Early Modern periods.²⁸⁹

Van Dyck, in his cited exhibition guide, writes "...the clock was able to symbolize a more general idea that encompassed all the human arts and technology as an imitation of natural processes created by God." If automata are construed as a development following from horological advancement (which need not be the case, but which will be assumed here for the sake of argument), and if religion, the impetus to mimetic emulation of a deity's ordering of the world's time, is the basis of horological advancement, then observance of religion indirectly led to the development of automata --- and indeed, automata originally had religious purposes under the proposed first current, although they were not necessarily related to timekeeping in the classical world (since, as with later automata, the motions of some

ready to play Frankenstein. He could already build a partial replica of a human being, and by doing so, he showed not only, as Archimedes had said in another context, that he could move the world, but also that he could disenchant it. The automaton was one of the strongest pieces of evidence that he could wield in support of this bold and influential claim."

²⁸⁹ See Marsh, "Elektro the Moto-Man," page 2 in the author's printed copy: "Elektro wowed audiences, first at the World's Fair and then on tour across the country, and it hawked appliances for Westinghouse. But you'd be wrong to dismiss it as simply a publicity stunt. The engineers who developed Elektro were pioneers, attempting to turn science fiction into reality by developing a voice-activated robot."

classical automata would always occur within a fixed interval of time, and could also be triggered to recur at a fixed interval of time, without the moving automaton itself being intended or received as a clock); but yes, some were true timekeepers, such as the Gaza clock. When applied to automata, this thought raises Asimov's Frankenstein complex, that the automaton *qua* concept is humankind's attempt to actualize the ultimate emulation of the divine, the creation of a new consciousness, which is invariably construed under the Frankenstein complex as an act of vain foolishness which must end in the failure, coded with moral righteousness, of the automaton-making project, the destruction of the automaton, and often, the punishment or demise of its maker; and these outcomes, in turn, register the proposed fourth current of thought as a narrative trope.²⁹⁰

²⁹⁰ See Van Dyck, "Under Time's Spell," page 73: "The clock has no input, such as the position of the sun, to transform into a measurement of time. All that could be said about it was that the virtually uniform movement of the cogwheels more or less imitated the rotation of the celestial sphere. It was the result of human inventiveness rather than of scientific insight. In this way, the clock was able to symbolize a more general idea that encompassed all the human arts and technology as an imitation of natural processes created by God." For the Gaza clock, see this thesis' fourth appendix.

THE FIFTH CURRENT OF THOUGHT.

Others did not view automata as works of magic, but the reasons underlying this more mundane conceptualization are ambiguous and perhaps only identifiable in the personal factors which inform individual minds. What is clear is that the views of those who (accurately) distinguished automata from “magical” bases of causation, and saw them as works of human material culture made functional by craftsmanship, science, and engineering, competed with those of individuals fearful of the occult power they believed to animate automata and to have been wielded by automaton-makers. In effect, those Europeans who did not perceive the automata in their midst as genuine gods or divine emanations, as did the ancients, or as works of magic in accord with the representation of automata, both classical and non-classical, in the romances authored in the Middle Ages, instead partook of the same worldview which informed the second current of thought in the Arab world, although its articulation differed in a European context. This is the fifth current of thought. Most especially, the fifth current of thought is the first to use clockwork gearing to transfer kinetic energy as the basis of actuation in automata.

It should be noted that the secularism of the fifth current, which did not admit of perceptions that automata were divine or magical, was a secularism which nevertheless arose within the cultural context of late medieval and Early Modern Europe, an area which had already formed aesthetic conventions for the “magical” automata it had imagined in its development of the third current of thought. As a result, some automata in the fifth current assumed the brazen idiom of automata in the third current. Notwithstanding the evocation of the third current by the material medium used to fashion automata, the imagery, animal subject matter, and coloration of automata in the third current, and therefore also in the fifth, were necessarily informed by the culture of the European Middle Ages in another sense: the fictive European automata of the third current and constructed European automata of the fifth show the aesthetic influence of European heraldry. Brass, of course, becomes the color *Or* in heraldic blazon, and the conceptual imagery of the various animals comprising the subject matter of pre-Modern and Early Modern biological automata with animal figures are perfectly transferable as animal representations to the two-dimensional medium of heraldic charges, and vice-versa. Most, if not all, humanoid, animaloid, etc. figures represented by the European automata of pre-Modern and Early Modern fiction, fact, and legend also feature as charges in the heraldry of the European cultural zone, including the British Isles.

The two best examples in proof of the relationship between automata and heraldry in the European context of the third and fifth currents are the lion created by Leonardo da Vinci and the stag created for Charles IV “The Beloved” of France. The latter, one of the few “false automata” identified by this thesis, contained a hidden human operator. However, its visual cues as a stag *Argent* collared with a crown are purely heraldic, and its appearance would have been recognizable as a (falsely) technological realization of an embodied heraldic charge. As Mark Elling Roshiem has discussed in *Leonardo’s Lost Robots*, da Vinci’s lion, in his interpretation, was

“rampant,” a term and posture derived from heraldry which indicate an upright stance with arms extended. Further, the lion’s chest was designed to pop open and reveal a heraldic achievement. Another lion which reused da Vinci’s design appeared many decades after the first, and while these lions may have been the same automaton, it is considered more probable that the second was a distinct machine built with the same design as the first. This stag *Argent* and these lions *Or* (or *Proper*), with the lions a clear conveyance for a heraldic displays, were thus assertions of power both as material-cultural objects featuring high technology and as presenters of gentles’ armorial bearings.

The common appearance of automata to Western Europe led to this bifurcation in currents of thought. In a new environment of more widespread automata in this region, its inhabitants articulated a modulation of the third current as the fourth current, as discussed above, and the second current as the fifth current, as discussed above. The prevalence of the second and third currents as the bases for the fifth and fourth currents, respectively, led to an incidental diminution of the first current. It is noteworthy that in Saint Mark’s clocktower in Venice, an example to which this thesis consistently returns, that the figures of the Magi are automata, whereas the figures of the Madonna and Child around which they process are not. While some late Renaissance-era automata retain the figure of Jesus Christ, this or any god-figure appears with reduced frequency by the Early Modern era in this thesis’ review, usually appearing in concert with other, non-divine figures when presented in later centuries.

This diminution was exacerbated by the technological secularism of the fifth current, which forced those persuaded of the scientific basis for motive force in automata to consider its ramifications for their assessment of the intention and purpose of devotional objects. Of course, to the later Protestants, preacher’s crosses like the Boxley Rood of Grace were simply deceptive ploys meant to dupe an ignorant audience already conditioned to accept the Babylonian superstitions of Catholicism. Over the centuries, the desacralization of the automaton in Western Europe caused the first current of thought, which envisioned automata as genuinely divine, and the third current of thought, which envisioned automata as “magical” in the twofold senses of magic, natural or demonic, to fall away, leaving only the fifth current of thought, which envisioned automata as secular constructs not intended for religious veneration as gods or monsters and not inherently “magical,” although nevertheless wonderful and wondrous.

EXAMPLES OF THE FIFTH CURRENT OF THOUGHT.

The secularism of the proposed fifth current, while still evident *ante* the common year 1650, becomes increasingly apparent, almost cartoonishly so, in the centuries succeeding this thesis' period of interest. In the case of the Russian brazen head-building competition, which has already been noted, the proposed third and fourth currents, signifying the concept of magic in relation to automata, and persecution of automaton-builders on that ground, were replaced by the proposed fifth and sixth currents, for the brazen head, which had formerly been one of the most common representations of the "magical" automaton, was given a wholly secular meaning in the case of that competition, devoid of any preternatural, supernatural, or "magical" dimensions, and was made the object of scientific study, experimentation, and scholarly interest, respective registrations of the proposed fifth and sixth currents, had they occurred in a prior century.²⁹¹ Indeed, automata of the eighteenth and early nineteenth centuries tended to combine historical discourses surrounding automata by playfully referencing the proposed third current in works actually registering the proposed fifth current, again, had the automata of those later centuries existed within this thesis' period of study, as in the example of Maillardet's "Magician," which is presented by Bedini.²⁹²

Within this thesis' period of study, the transition from the proposed fourth current of thought to the proposed fifth current of thought is identifiable in a comment by Braswell, who notes that "No doubt the [pre-Modern and Early Modern] audience[s] soon became acclimated to this kind of mechanical magic."²⁹³ Here, it would seem Braswell contributes to the same semantic ambiguity regarding the term "magic" which has haunted automata since time immemorial, but so far as the thesis recalls the intended meaning of that quote, "magic" is used in it to communicate the sense of "wonderment," one of the meanings established by this thesis. The parties responsible for the "acclimation" to automata, applying Braswell's term, were "tregetours," artificer-mechanicians, who would register the proposed fourth current whenever persecuted, but also, in what is perhaps the earliest transition between the

²⁹¹ See Bedini, "Role of Automata," page 38: "The next major advance in this field was made in about 1770 by Friedrich von Knauss of Vienna, who constructed not one but four speaking heads. That his project was not completely successful is attested to by the fact that in 1779 the Academy of Sciences in St. Petersburg used the production of a successful speaking head as the theme of a contest for mechanics and organ manufacturers, specifying that the machine be capable of speaking the five vowels. Three inventors produced results at about the same time: the Abbe Mical in 1778, the Baron von Kempelen and C.G. Kratzenstein, both in 1780. Numerous others constructed speaking heads within the next decades, but never with any marked degree of success."

²⁹² See Bedini, "Role of Automata," page 39: "Two other figures almost as notable are the Magician and the Draughtsman-Writer of Henri Maillardet (1745-?), a craftsman who had worked with the Jacquet-Droz. The Magician, seated upon a stage built over a clock music box, answers questions printed on oval cards inserted in a drawer on the stage. If the drawer is opened and closed without a question, the magician shakes his head. When a legitimate question is asked, he rises slowly, moving his head and eyes, and points to a small door behind him which opens to reveal the answer."

²⁹³ See Braswell, "The Magic of Machinery," page 104.

proposed fourth and fifth currents, the fifth current whenever they were not subjected to persecution, at least in Braswell's characterization.²⁹⁴ It is this same "acclimation" that forms the argumentative basis of Braswell's conjecture, which is, unfortunately, unsubstantiated, that "...*The Franklin's Tale* was actually enacted [with automata] to the delight of an audience knowledgeable of contemporary automata." If such were the case, the "knowledgeableness" prerequisite to a positive reception of such an automaton display would be the result of Braswell's "acclimation," and this, in turn, would have been accomplished, at least in part, by the work of the tregetours. Because the conjectural automata used to stage the scene in *The Franklin's Tale* per Braswell correspond to illusions conjured by magic, the instance of pre-Modern or Early Modern automata comprised of same would correspond to the proposed fifth current, by way of the proposed third, and likely fourth currents, at the early juncture of Chaucer's flourishing in the fourteenth century.²⁹⁵

This same trend of "acclimation" extended into the philosophical discourse of the final two centuries under consideration. Bedini writes that "...the steady advancement of technology and the increase in *familiarity with machines and their fundamental theory* [emphasis added] is usually cited as the decisive factor in the growth of mechanistic philosophy, especially toward the beginning of the instrument-dominated Scientific Revolution in the sixteenth and seventeenth centuries." For purposes of this thesis' proposed model, Bedini's observation indicates the transition from the proposed fifth current of thought to the proposed sixth current of thought, since the ubiquity of technologies in society, including automata, which registers the former, fifth current, causes these same technologies, including automata, to become the measure of progress and basis of philosophizing, which registers the latter, sixth current.²⁹⁶

It is of interest that the progression from the proposed fourth to the proposed fifth current, typically mediated by the activities of those professionals in society tasked with accomplishing early automata and other visual technologies intended for courtly display, the tregetours, could be bypassed altogether, with the proposed fourth current in its entirety, by the highest strata of the medieval Western European aristocracy, who were cognizant enough both of automata as a concept, and of novel technologies, not to necessarily associate real-world automata with sorcery and

²⁹⁴ See Braswell, "The Magic of Machinery," page 106.

²⁹⁵ See Braswell, "The Magic of Machinery," page 108: "It is tempting, therefore, to believe that before its incorporation into *The Canterbury Tales*, *The Franklin's Tale* was actually enacted to the delight of an audience knowledgeable of contemporary automata. In a world in which nominalism was beginning to gain ascendancy over symbol, in a society whose sophisticated members were insisting on verification through experience, it was not sufficient for the tricks of the Clerk of Orleans to be sheer illusion. For automates maneuvered by "viace," capston [SIC] winch, clock mechanism, whatever – these marvels were indeed the magic of the late Middle Ages."

²⁹⁶ See De Solla Price, "Automata and the Origins of Mechanism and Mechanistic Philosophy," page 9: "Indeed, the steady advancement of technology and the increase in familiarity with machines and their fundamental theory is usually cited as the decisive factor in the growth of mechanistic philosophy, especially toward the beginning of the instrument-dominated Scientific Revolution in the sixteenth and seventeenth centuries."

diabolism. This was due, no doubt, to the inescapable fact that pre-Modern and Early Modern nobles were the very individuals who patronized both the fictions featuring representations of imaginary or historical automata, and many new, material automatons built during these periods. Further, within the secular domain of rulership, these patrons were less susceptible to paranoid views of automata, the “religious exception,” which predominated amongst the lower clergy, who sincerely believed in preternatural powers, and for whom the existence of a physical automaton, in accord with these beliefs, must have represented a nightmarish manifestation of a perceived threat to the moral and metaphysical order of their worldviews. This is not to say that the nobles of the considered periods were not religious; on the contrary, many were devout, especially in the earlier Middle Ages, and were required to at least present themselves as pious, if only due to the imperative of maintaining useful appearances, as analyzed by Machiavelli.

Thus, for members of the high aristocracy, a bypass of the proposed fourth current, in which case the thesis’ model jumps directly from the “magical” automata of medieval European fiction, to secular automata, understood as were the automata of the proposed second current of thought, but within a Western European, rather than West Asian setting, is in evidence. It bears mentioning, too, that even when automata with religious subjects appeared in religious settings under the European cultural setting of the proposed fifth current of thought, they were understood in secular terms, that is, not considered gods, or conduits of preternatural power. It must be recalled, of course, that the same aristocrats able to bypass the proposed fourth current of thought also peopled the ranks of the pre-Modern and Early Modern Church’s upper echelons. In this, then, a distinction between the proposed second current of thought and proposed fifth current of thought can be seen: although they represent equivalent thoughts about the nature of automata, the automatons produced by the second current do not appear with religious figures, or in religious settings, whereas those of the proposed fifth current appear with both secular and religious figures, and in both secular and religious settings. For both the proposed second and fifth settings, automata are not perceived as gods, or meaningfully made the subjects or objects of liturgical ritual; and neither are they perceived as works of magic; and neither are the builders of automata held culpable for having done the magic entailed by the same perception, that automata bore magical properties. As has been shown, however, not all members of pre-Modern and Early Modern European societies, from the ignorant, to the intellectual class, could bypass the proposed fourth current of thought.

In Farmer’s short discussion of the famous pre-Modern automata at Hesdin, she writes “...[Count] Robert [II de Artois] may also have learned about the mechanically driven Islamic sculptures and sculpturally adorned water clocks that had belonged to King Roger II of Sicily and the Emperor Frederick II. And even if he did not learn about those mechanical devices, he would have become familiar with the idea of such wondrous artifacts through his reading of the *Cleomades*...” The proposed second current of thought is in play here, considering that the automaton clocks owned by Roger II and Frederick II had West Asian, Islamic origins; the

proposed third current, because the said Robert had almost certainly encountered fictitious automata in the *Cleomades*, a medieval romance which, to use a presentist analogy, was not unlike a science fiction serial, even if there is no direct evidence he saw the rare automata owned by the above-referenced kings; and the proposed fifth current, as Robert did proceed to include automata in the program of improvements he undertook at Hesdin, his estate. That it is highly probable Robert read the *Cleomades* is demonstrated by the *envoi* addressed to him by its author, Adenet le Roi. However, the proposed fourth current is not evident in the activities of Robert and his courtiers, and attitudes toward the resultant automata. This could be the case because Robert's automata were situated within a private estate, and were only seen by those granted access to the same, or because Robert's station positioned him, and his own craftsmen (and indeed, tregetours) above the reproaches of the zealous clerics susceptible to registrations of the proposed fourth current. What can be repeated is that, so far as this thesis is aware, the proposed fourth current was never registered by a reaction to Robert's automata.²⁹⁷

If one disregards the personal connection between Robert and the *Cleomades*, and instead emphasizes the possibility that Robert witnessed the presence of automaton-bearing Islamic clepsydrae at the courts of foreign kings in Southern Europe, an aristocratic bypass would then exist not only for the proposed fourth current of thought, but also the proposed third current of thought. As such, the person of Robert II, Count of Artois, would jump directly from the proposed second current to the proposed fifth current. However, this thesis is not of the opinion that such a leap is likely, and would instead posit that Robert's awareness of automata was at least influenced by the proposed third current of thought, and by the traditional, "magical" automata of European romances, including the *Cleomades*. Even so, there is no evidence that Robert II, or his court, presupposed actual magical efficacy on the parts of the automata he himself had patronized, unlike Francesco I de Medici, who may have believed his respective automata had magical power after acts of Neoplatonic Ficinian "investiture," given Lily V. Filson's analysis in the latter's doctoral dissertation.²⁹⁸

Insofar as Robert's automata as material-cultural constructions are concerned, per Farmer, "...the count, who had harnessed the manpower and talent to create the surrounding countryside, had also harnessed the manpower and ingenuity to create

²⁹⁷ See Farmer, "Aristocratic Power and the 'Natural' Landscape," pages 677 – 678: "During his sojourns in Sicily and southern Italy, Robert may also have learned about the mechanically driven Islamic sculptures and sculpturally adorned water clocks that had belonged to King Roger II of Sicily and the Emperor Frederick II. And even if he did not learn about those mechanical devices, he would have become familiar with the idea of such wondrous artifacts through his reading of the *Cleomades*, a French romance based on one of the tales of the Arabic *Thousand and One Nights*. Robert's contemporary Adenet Le Roi wrote the French tale, and several of the earliest manuscripts of the text, which include an illustrated *envoi* to Count Robert, suggest that Robert was familiar with the text."

²⁹⁸ See Farmer, "Aristocratic Power and the 'Natural' Landscape," page 679: "In one way or another – either through literature or direct experience – Robert's moving monkey statues and other mechanical devices were probably inspired by models coming from the Islamic world." See Filson's cited doctoral dissertation for the automata at Pratolino, and how they may have been "magicked."

the moving statues.” Here can be seen the concept of “ingenuity” as a thing-unto-itself, reified through the implementation of technology. Robert’s automata, in their historical context, only registered the proposed fifth current of thought as secular assertions of European courtly power, but they approach the basis for the proposed sixth current of thought as suggestions that automata could be considered “ingenious” objects, worthy of study in their own right.²⁹⁹ That these automata were intended to impress Robert’s guests, with the implicit ramification that they were worthy of attention, is both an intuitive conclusion, and one borne out by Farmer’s reconstruction of Robert’s intentions vis-à-vis the same.³⁰⁰

Generally, spectacle, monumentality, sumptuousness of materials, and suchlike considerations did contribute to the remarkableness of automata, regardless of scale. Fliegel, in his cited article, makes reference to a table fountain owned by Charles V, a more diminutive class of material culture, which is not included in the catalog of instances under this thesis’ fourth appendix, as there was insufficient information to even place it under Kang’s fourth type. Had it been entered in the fourth appendix, it would have registered at least the first and fifth currents of thought, as it had religious subjects, “...a figure of Our Lady and two “angeloz” surrounded by prophets,” but would have been contemporaneously classed and used as a secular object. If it could be established that this or any other table fountain bore automata, moving figural subjects, then it would be worthy of inclusion in the fourth appendix, and serious consideration, like Villard de Honnecourt’s design for a chantepleur.³⁰¹ However, Fliegel’s detailed description of The Cleveland Table Fountain, which he has frequently made the subject of his publications, establishes that it is not itself an automaton, or an automaton-bearing device, by this thesis’ definitions. Like automata, however, the two cases of Charles V’s mysterious table fountain, and The Cleveland Table fountain, demonstrate that material culture of the Renaissance, including automata which register the proposed fifth current of thought, could interchangeably have either secular or religious figural embellishments: “...the decoration of the Cleveland fountain is completely secular in spirit – drolleries,

²⁹⁹ See Farmer, “Aristocratic Power and the ‘Natural’ Landscape,” page 680: “The very purpose of Count Robert’s monkey statues was to give the viewer a first impression that the monkeys were real. To be sure, the ultimate pleasure, as far as Robert was concerned, was in his guests’ revelations that the monkeys were not real – and in their subsequent realization that the count, who had harnessed the manpower and talent to create the surrounding countryside, had also harnessed the manpower and ingenuity to create the moving statues.”

³⁰⁰ *Ibidem*.

³⁰¹ See Fliegel, “The Cleveland Table Fountain and Gothic Automata,” pages 17 – 18: “While the decoration of the Cleveland fountain is completely secular in spirit – drolleries, dragons, lions, musicians – Charles V’s second fountain is described as having a figure of Our Lady and two “angeloz” surrounded by prophets. Obviously sacred imagery was sometimes employed on table fountains.” While Fliegel’s article does not establish The Cleveland Table Fountain as an automaton-bearing device by this thesis’ definitions, it does contain an excellent technical diagram showing the design of Villard de Honnecourt’s chantepleur.

dragons, lions, musicians... [yet] sacred imagery was sometimes employed on table fountains.”³⁰²

The mixedness of the proposed fifth current’s figural subjects between religious and secular beings, and secular understanding of the same, even in religious settings, although any automaton with a religious figure is simultaneously reflective of the legacy of the proposed first current of thought, down through the ages, is a mixedness reflected by the pre-Modern or Early Modern automaton about which many articles have been written, the monk attributed to Gianello Turriano by Elizabeth King. Of this automaton, she writes that it “...walks a delicate line between church, theater, magic, science. He circulates among – murmurs about – all of them. He is a synapse, transmitting a host of simultaneous signals.” This line suggests the proposed first (“church”), third (“magic”), and either the fifth or sixth currents, or both of the latter (“theater” for the fifth, “science” for the sixth), could be registered by this automaton, but readers are referred to this thesis’ fourth appendix to see which were authoritatively assigned in the entry cataloged for this instance.³⁰³ Inasmuch as many proposed currents are identifiable in this specific line from King, and are likewise identifiable in the works of other authors, readers are again reminded that the virtue of this thesis is in the assignation of a nomenclature for these trends, which have been repeated and restated in many publications, and for many years.

For example, O’Brien’s article could be construed to endorse the conceptual reversal offered by De Solla Price in the latter’s cited article, and regardless of whether he is or is not doing so, O’Brien’s analysis situates philosophical mechanicism centuries before Descartes, which may indicate the proposed sixth current, as well as the pervasiveness of automata in Europe that registers the proposed fifth current.³⁰⁴ Specifically, O’Brien writes how the “...habit of seeing mechanisms in terms of the human body” can be inferred from certain sketches by da Vinci, which this thesis cannot positively identify as drawings of automata, but which advance O’Brien’s point; and this point is that, “...moreover, [these sketches] indicate the probability that such an association [between mechanisms and the human body] was

³⁰² *Ibidem*.

³⁰³ See King, “Clockwork Prayer,” page 18 in the author’s printed copy: “He [the automaton monk] walks a delicate line between church, theater, magic, science. He circulates among – murmurs about – all of them. He is a synapse, transmitting a host of simultaneous signals.” See this thesis’ fourth appendix for information regarding Turriano’s monk automaton.

³⁰⁴ See O’Brien, “Ars-Metrik,” pages 3 – 4: “Leonardo da Vinci has left two sketches of such a device in human form [not noted as instances under the fourth appendix, because other than this quote, they are not known to this thesis, given O’Brien’s description], as well as an extraordinary drawing – perhaps developed as a design for a festival costume – of a man resembling a bagpipe riding a horse (Reti 129). Produced a century after Chaucer designed his own ‘blower’ on a horse, these sketches nevertheless reflect this habit of seeing mechanisms in terms of the human body and, moreover, indicate the probability that such an association was part of the period’s ‘popular culture.’ The description of the Summoner in the *General Prologue* calls to mind such a device as the *sufflator*, but so do other parts of Chaucer’s portrayal of the Summoner: the episode in the *Summoner’s Tale* during which Thomas gives the friar his noxious gift and the one in the tale’s coda during which the squire proposes to have Thomas brought before the company to repeat the explosive act.”

part of the period's 'popular culture.'"³⁰⁵ In order for mechanicism or proto-mechanicism, which is what O'Brien seeks to establish in the fifteenth and sixteenth centuries, long before Descartes, to have appeared, the cultural connection would have to have been drawn between the moving human body and moving machinery, such as automata – and this cultural connection could not have been drawn unless moving machinery, and especially automata, which are simulacra of the human body, had come to be an accepted, common element of everyday life. This state of affairs is a registration of the proposed fifth current of thought, and once the mundane existence of automata, perceived neither as divine, nor magical, nor as an offense warranting punishment, gives way to the study of automata, and even the celebration of automata, these states of affairs register the proposed sixth current of thought.

The shift from the proposed third and fourth currents of thought to the proposed fifth and sixth currents of thought is suggested by O'Brien's broader analysis, in which he concludes that Chaucer "...ironically describes the triumph of the demonstrated knowledge of science over mystery and irrationality" in *The Summoner's Tale* and *The Friar's Tale*, which can show this shift was underway in Chaucer's lifetime, either because he, as author, set these tales in his contemporary time, or because he, as author, was influenced by the same. This thesis would dispute that O'Brien's "triumph" was a wholesale replacement and sea change in views of technology, and specifically automata, since, as has been discussed, cultural developments like the Reformation could reintroduce the phenomena of the third and fourth currents of thought.³⁰⁶ That the passage from the proposed third and fourth currents of thought to the proposed fifth and sixth currents of thought was underway in a general sense, with empiricism beginning to replace pure logic as the basis of inquiry, can be inferred from O'Brien's citation of Branca's presentation Salutati's debate, as has already been discussed.³⁰⁷

³⁰⁵ *Ibidem*.

³⁰⁶ See O'Brien, "Ars-Metrik," page 12: "Although Chaucer uses the friar to expose the difference between the apostolic ideal of the friars and their selfish behavior, he also focuses his satire on the way they have turned their human, spiritual activity into systematic, mechanical gestures. Research into the friars' practices of composing sermons justifies this emphasis on the mechanical element in the friars' activity. As Joseph Mosher and D.L. d'Avray have shown, the friars constructed their sermons from immense 'exemplum books,' arranged under such categories as *gloria* and *gratia*, books that amounted to what d'Avray calls 'elaborate preaching machines' (74-75; Mosher 86-87). To the extent that they relied on this system, the friars resemble Chaucer's version of the scientist, as developed through the Friar's summoner and also, in more specific terms, through the lord and squire at the end of the *Summoner's Tale*. The scientific quest shapes the plots of both the Friar's and the Summoner's tales: in both, the climax occurs when the curious poser of the question, the descendant of Bacon and Grosseteste in search of 'God's privities,' discovers the answer, and particularly one that depends on the senses rather than authority. The *Summoner's Tale* resembles the *Friar's Tale*, then, in that it ironically describes the triumph of the demonstrated knowledge of science over mystery and irrationality."

³⁰⁷ See O'Brien, "Ars-Metrik," page 17: "These closing sections of the *Summoner's Tale* point to a real matter of dispute in Chaucer's world concerning the value of experimental science. According to Geraldine Branca, Chaucer may have, in fact, been present in Florence to witness a famous dispute as

Similarly, the “transition,” O’Brien’s own term, from the proposed third and fourth currents of thought to the proposed fifth and sixth currents of thought is interpretable in “...the giving way of the old, authoritative to the new, experimental method of arriving at solutions to problems in the physical world,” with the latter of these two methods necessarily based in a secular view that itself admits of experimentation, since appeals to authority, whether Biblical, Aristotelian, Aquinian, Galenic, or indeed, Heronic, do not allow for the formation of competing hypotheses, and study based on the same. This secularism, applied to automata, registers the proposed fifth current of thought, and the experimentalism abetted by the same, applied to automata, registers the proposed sixth current of thought.³⁰⁸ So, for the proposed fifth current, the pursuit of knowledge using the *quaestiones et responsiones* template had continuing significance from the last years of the fourteenth century, in Chaucer’s lifetime, to the mid-seventeenth century, when this thesis’ period of interest concludes.³⁰⁹

However, the progression between the proposed currents is not always so uncomplicated and easily apprehensible. A variety of instances of pre-Modern and Early Modern automata in the romance tradition are discussed by Sherwood, and in one passage, Sherwood contrasts registrations of the proposed third and fifth currents in discussing these instances, skipping the proposed fourth current because works of fiction, and not real, material automata under Kang’s third type, are under consideration.³¹⁰ Simply put, when an automaton is fictitious, there is no one to

to whether ‘the doctor of medicine or the doctor of laws was the more scientific in his training and procedures’ (65).”

³⁰⁸ See O’Brien, “‘Ars-Metrik,’” page 18: “These puns develop further the connections in the *Friar’s Tale* between the scientific quest, the need for demonstration, and demonic power. They also point to a culture in transition and suggest Chaucer’s skeptical, even derisive, attitude toward some of the elements in that transition. For instance, on the one hand, the lord [a fictitious character] quite clearly represents the *via rationis*, which depends on demonstration *secundum imaginationem* and adherence to authority; he complains that the problem which the friar has brought him has never been discussed before in any works of ‘ars-metrik’ (2220-23). The problem is ‘devilish’ precisely because it has not received the attention of the authorities. The squire, on the other hand, represents the *via experientiae*, depending on the kind of demonstration that Bacon describes as deriving its final authority from the senses. Thus, far from being simply a self-reflexive display of academic discourse or a development of dramatic tension between the pilgrims, these closing sections of the *Summoner’s Tale* play out the conflict between these two academic procedures and moreover the giving way of the old, authoritative to the new, experimental method of arriving at solutions to problems in the physical world.”

³⁰⁹ See O’Brien, “‘Ars-Metrik,’” page 20: “The way in which the discourse of the new world frames problems eliminates the need for the discourse of morality and value upon which the old world is ostensibly built. That this change of discourse was in fact taking place is suggested by the fact that the scholastic exercise of *quaestiones et responsiones*, the paradigm for the discourse at the end of the *Summoner’s Tale*, was being used in the fourteenth century ‘not for purely didactic purposes in the classrooms, but also as the basis for polite conversation’ among men ‘of divers states and conditions’ – a form of informal converse which was to be of increasing importance in the 16th and 17th centuries for the discussion and propagation of scientific ideas’ (Lawn 105).” [Note that everything after “not for” is from Lawn.]

³¹⁰ See Sherwood, “Magic and Mechanics,” page 569: “Occasionally, however, an attempt is made to explain the phenomena as produced by natural causes: by wind, in the case of the singing birds in the

persecute but its author, and this thesis is not aware that there were ever censorious efforts in pre-Modern and Early Modern Europe to destroy manuscripts, or to prosecute the many poets, jongleurs, and novelists who included automata in their works on the basis of that specific ground, or to otherwise obstruct the inclusion of automata from the fictions of these periods.

Sherwood proceeds to offer other instances, although early and fictive, which register the proposed fifth current, and bypass the proposed fourth current, due to their existence in works of fiction rather than reality, that is, under Kang's second type, not Kang's third type. To the degree that the third current could also be said to be registered by these instances, it is only in that they have the conventionalized, brazen coloration historically associated with "magical" automata, and the same could be said for the many actual, material automata of the Early Modern period which were fashioned from brass, copper, gold, or other yellowy metals, or even given these or similar colorations by different means.³¹¹ Yet another discrete example of this phenomenon, the bypass from the third to the fifth currents in medieval fiction, is offered by Sherwood, and the point seems proved that, while nobles were less prone to persecute automaton-makers than clerics, neither nobles nor clerics could persecute the author of a fictitious automaton, for the basis of such persecution lay in the magical processes thought necessary to construct automata, and no such construction could reasonably be alleged to have arisen from the circulation of a romance, for instance.³¹² Yet it is fascinating that the early, fictitious automata have

hall of the Emir of Babylon, in *Aymeri de Narbonne*, of hollow birds on a golden linden-tree, in *Wolfdietrich*, and of some of the examples mentioned above; by forced currents of air in other instances. In the *Roman d'Escanor*, Esclarmonde, a fairy whose master in magic was Virgil, made a small tree, which she placed at the head of the bed. It appeared to bear both flowers and fruit continuously, and on every branch were birds which seemed alive and which sang sweetly. A golden pipe was set up inside the tree, on the top of which was an angel holding a trumpet to its mouth. The angel was on a pivot enabling it to turn in any direction. Apparently, when the angel was in position, a pipe inside it connected with the large pipe in the tree. Presumably, also, there were similar pipes inside the birds. The blowing of the trumpet was the signal for the birds to begin to sing. The movements of the angel are not very fully described. It is stated, however, that if the angel turned ever so little to one side all the sounds ceased, which would seem to mean that this movement shut off the vent of air from the main pipe. If the angel turned back 'towards' the pipe – that is, moved directly over it – the birds began to sing. If it removed the trumpet from its lips the birds stopped singing, but when it held it again to its mouth, the melody broke forth once more. Difficult as the interpretation of this passage is – nor am I entirely satisfied with my reading of it –, enough of it is clear to establish the fact that the author of *Escanor* had in mind an actual machine which he had seen or heard of."

³¹¹ See Sherwood, "Magic and Mechanics," page 570: "In the *Eneas*, we read of an artificial grapevine in the branches of which are ten thousand golden birds. The vine is 'hollow and flames are underneath. When there is wind, it makes all the birds sing and flutter.' This would seem to mean that the current created by hot air rising caused the mechanism to operate. [New Paragraph] In Candace's palace, according to Lamprecht's *Alexanderlied*, there was a golden stag with 1000 horns, on each of which was perched a bird. On the stag sat a man leading two dogs and holding a horn to his lips. Underneath were 24 bellows with 12 strong men manning each. When the latter worked the bellows, all the figures became vocal."

³¹² See Sherwood, "Magic and Mechanics," page 570: "In his *Troyanerkrieg*, Konrad von Wurzburg tells us that was before Priam's palace a tree with roots and trunk of silver, branches of gold, leaves of

exaggerated but plausible designs, sometimes with clear references to Heronic devices, and this thesis is disposed to suggest that this point is nothing more or less than the pre-Modern mind striving towards that which it could envision, but not realize, just as pains are usually taken in the romances to detail the voluptuous sumptuousness of precious materials, the finery of fabrics and apparel, and the impressiveness of architecture, even as medieval European societies lacked the magnitude of these luxuries.

That medieval fiction was primarily patronized and consumed by secular, educated nobles may mean that the secularism of the fifth current may be based, to some degree, in the romances, as has been mentioned. The meanings of automata in the romances can be encapsulated by Sherwood's line "...the ultimate source of the magic 'machines' of fiction is in many cases an ancient myth which was 'modernized' to suit the contemporary [medieval] taste for mechanical toys," although mechanical toys in the High Middle Ages, if they existed, could not be located in the course of research. For purposes of this thesis' model, that quote shows the influence of the first current, either by way of the second current, or through the bypass of the second current which is seen in certain cases of fictitious automata under Kang's first and second types; recall that in some romances, automata with historical precedents in the Heronic tradition are described, independently of any known textual transmission from the Hellenistic world, or via the West Asian cultures, in a development which cannot be explained by the instant thesis, or by any other work, except through the speculation which is offered by this thesis, namely that an oral tradition, or an undocumented corpus of Hellenistic technical treatises (almost certainly in a language other than the original Greek) persisted in Europe. In this respect, it is clear that fictitious automata can skip the second current, just as they can skip the fourth current; but, far from weakening the proposed model, this only demonstrates the distinction between fantasies and reality, even as the fictitious automata of Kang's first and second types, and the legendary automata of his fourth type, remain intelligible under this thesis' unifying model.³¹³

Even when fictitious species of material culture which are not themselves automata, but adjacent to those bearing automata (in this case, vessels for liquids) are considered, the relationship between classical and medieval culture modeled by a bypass of the proposed second current can be observed. Direct progression from the proposed first to third currents, bypassing the second, which may (or may not) be present in works of fiction, is seen in the case of a Tantalus cup, something close to

emeralds and rubies and, on its boughs, birds which were made of precious stones of all colors and which sang summer and winter. Such a tree is represented in a miniature from Sanct-Blasien, with the caption: 'The tree of cast metal of which the Geste of Alexander speaks: when air is pumped from below, sweet and diverse voices issue from the mouths of the birds.'

³¹³ See Sherwood, "Magic and Mechanics," page 574, the second of Sherwood's qualifications: "In the second place, the ultimate source of the magic 'machines' of fiction is in many cases an ancient myth which was 'modernized' to suit the contemporary [medieval] taste for mechanical toys." For Kang's typology, see *Sublime Dreams of Living Machines*, and the many prior citations corresponding to its system for categorization of pre-Modern and Early Modern automata.

Villard de Honnecourt's chantepleure. Here, as when fictive automata are concerned, educated persons reading the romance *Huon de Bordeaux* were presented with a "magical" cup they, according to Sherwood, may have been able to recognize as real, non-magical and non-preternatural technology, presaging the appearance of the fifth current's secularism.³¹⁴

Again and again, the cited authors present historical developments that are comprehensible under this thesis' proposed model, including its fifth current of thought. In a fitting quotation which concerns real-world automata, those under Kang's third type, and not Kang's first or second types (the subjects of Sherwood's article), Sherwood writes "The achievements of the Ancients in the field of mechanical science were preserved to a great extent by the Arabs and transmitted largely through Spain to the Western world. This work of transmission was accomplished by the close of the 13th century [at least, in Spain – the thesis' comment]." Following this quote, Sherwood proceeds to offer some disputable remarks which show a certain biased, midcentury exuberance for "Western" triumphalism; for example, this thesis is not aware of any attested, specific, and complete European translations of the Hellenistic technical treatises prior to the fifteenth century, or at least, any which sparked the automaton-building trend visible in the later Renaissance. As regards such translations, it should be acknowledged that Spain was not the only conduit wherein West Asian copies of Heron and other Hellenistic and/or classical authors, technical and non-technical, returned to Europe, but that these works also reappeared in Western Europe after the city of Constantinople finally fell to conquest in the common year 1453, at which time displaced intellectuals fled Constantinople, the former capitol of the Byzantine Empire, in a pattern of emigration which constituted a major cause of the general, international European Renaissance. Returning to the quote by Sherwood under present discussion, it establishes the relationship between this thesis' proposed first, second, and fifth currents, and in this thesis' contention, for real-world automata, it ought to also have included the proposed third and fourth currents, although these are omitted by Sherwood, presumably upon the reasonable ground that Sherwood's article is primarily concerned with fictitious automata, and instead provides cited evidence of bypasses in the progressive, linear trajectory of this thesis' model which are generally, and observably, most applicable to the imaginary automata of Kang's first and second types.³¹⁵

³¹⁴ See Sherwood, "Magic and Mechanics," page 574, where the presentation of an episode from *Huon de Bordeaux* ends: "In the incident described here he is the victim of a practical joke which, to those among the author's public familiar with the 'tantalus cup' – and they were probably many – had an added piquancy. The ancient legend of the testing-cup was thus brought up to date. It is not the motif but its modernization that has its source in the 'engien d'esbattement.'"

³¹⁵ See Sherwood, "Magic and Mechanics," page 576: "The achievements of the Ancients in the field of mechanical science were preserved to a great extent by the Arabs and transmitted largely through Spain to the Western world. This work of transmission was accomplished by the close of the 13th century [at least, in Spain – the thesis' comment]. But there were also translations made directly from the Greek. It was, however, the fact that Western researchers made important additions, through

Kang, too, in *Sublime Dreams of Living Machines*, shows the progression from the proposed third current to the proposed sixth current on page 6, at paragraphs 2 – 3, as has been noted, including the fifth current.³¹⁶ Because semantics are an important factor in understanding the history of automata, another individual remark by Kang is of interest, as many of this thesis’ proposed currents can be extricated from it. Kang writes “The modern usage of the meaning [of ‘automata’] that refers exclusively to the mechanical, [is] a definition that arose in the seventeenth century in the context of the scientific revolution, when the word was established in direct opposition to the magical and the preternatural.” In this thesis’ interpretation, the first clause, about the “scientific revolution,” describes the proposed sixth current of thought by way of the proposed fifth current of thought, since the fifth current of thought was operative by the early seventeenth century, and within the European context, is prerequisite to the sixth current of thought (just as, in West Asian societies, the second current of thought is prerequisite to the sixth current of thought). Moreover, the word “magical” in this quote signifies the proposed third current of thought, whereas the word “preternatural” signifies the proposed first current of thought.³¹⁷ Kang, like many other cited authors, does not discuss the contributions under this thesis’ proposed second current because his work is concerned with the intellectual history of European cultures, and the scope of his focus is a legitimate reason not to have done so.

Responding to John Cohen, Kang also writes “...what is behind the robot fantasy is the desire to heal the apparent rift between the two worldviews [the scientific worldview and magical worldview, this thesis’ clarification of this line in its context].” This, Kang’s “deduction” from Cohen, imputes the appearance of the automaton concept to the divergence of this thesis’ proposed fifth current from proposed third current, and an *ex post facto* (post-fifth current) “desire” to reconcile the two; this may seem Eurocentric, as it disregards the second current, but as already stated, Kang, in his book, is exclusively writing about Europe. A second part of this passage, in which Kang mentions the “...divine power [and not magical power] of bringing life to the lifeless” that would accrue to whomever could achieve said reconciliation, is a return to the proposed first current, and Kang therefore suggests Cohen’s message is that to merge the proposed fifth current with the proposed third current (science with magic), and thus gain a “true understanding of the nature of life” (esotericism?) would result in divine power, the first current. Here, one does not see Asimov’s Frankenstein Complex, but rather Shelley’s Victor Frankenstein writ

discoveries of their own, to the lore inherited from their Greek predecessors, that constituted the real revolution in science in the 13th century.”

³¹⁶ See Kang, *Sublime Dreams of Living Machines*, page 6, paragraphs 2 – 3.

³¹⁷ See Kang, *Sublime Dreams of Living Machines*, page 19: “The modern usage of the meaning [of ‘automata’] that refers exclusively to the mechanical, [is] a definition that arose in the seventeenth century in the context of the scientific revolution, when the word was established in direct opposition to the magical and the preternatural.”

large – an admixture of the occult with science in an attempt to animate the inanimate, and thus become a god.³¹⁸

The proposed fifth current is registered by Kang’s citation of Pamela Long, whom he writes “...has shown that a number of new works on mechanics appeared in Germany and Italy in the fifteenth and sixteenth centuries – by such figures as Conrad Kyeser and Giovanni Fontana – that built on ancient knowledge with designs for original devices of mainly military purpose.” Of course, the proposed fifth current is a secularization of the first current, which also appears in the quoted phrase “ancient knowledge,” but Long’s identification of military technologies unrelated to automata in the outputs of these authors is noteworthy.³¹⁹ To this thesis’ knowledge, Kyeser did not design, build, or otherwise engage with the concept of automata, unlike Fontana, a key figure as regards the study of pre-Modern and Early Modern automata who was located in the course of this thesis’ research. Fontana’s automata were not intended for military applications, but it is interesting that others of his designs were for weaponry, or could be weaponized, just as was the case with da Vinci. This bespeaks the warlike nature of cultures in pre-Modern and Early Modern Europe, which was beset by a state of almost constant warfare throughout much of the considered periods. The tendency of engineers who coincidentally designed or built automata in these periods to have also produced designs for use in the prosecution of war is not a characteristic shared, at least to the same degree, by the automaton-makers associated with proposed currents beyond pre-Modern and Early Modern Europe, such as the stable, Hellenistic world of Roman Alexandria which produced Heron, or the stable, Islamic world of West Asia which produced al-Jazari. This is not a racial comment, but a pragmatic assessment. Of the major Islamic authors on automata, those known to this thesis (pseudo-Archimedes, the Banu Musa, al-Muradi, al-Jazari, and Ridwan) are, mostly, wholly unconcerned with weapons; only al-Muradi included weapon designs in his treatise. Hill noted Taqi al-Din as another Islamic builder of automata, but unfortunately, this thesis is insufficiently aware of al-Din to make any statement respective to his work. To this thesis’ knowledge, the extrapolation that automaton designers and builders at distinct times, and in distinct cultures, shared the noted tendency of the pre-Modern and Early Modern Europeans engaged in these activities to also function as military engineers is not accurate, strictly speaking.

The specific conditions of Western Europe during the pre-Modern and Early Modern periods could occasionally yield individuals who, in their particular circumstances, were positioned to bypass certain of the currents of thought proposed

³¹⁸ See Kang, *Sublime Dreams of Living Machines*, pages 24 – 25. In response to John Cohen’s work, Kang “deduces” as follows: “...what is behind the robot fantasy is the desire to heal the apparent rift between the two worldviews [scientific and magical]. This could be achieved by gaining a true understanding of the nature of life, which would allow us to obtain mastery over the environment and transcend to a higher realm of existence through the divine power of bringing life to the lifeless.”

³¹⁹ See Kang, *Sublime Dreams of Living Machines*, page 80: “And the historian of technology Pamela Long has shown that a number of new works on mechanics appeared in Germany and Italy in the fifteenth and sixteenth centuries – by such figures as Conrad Kyeser and Giovanni Fontana – that built on ancient knowledge with designs for original devices of mainly military purpose.”

under this thesis' progressive trajectory, like the person of Count Robert II of Artois, as has been described, but this does not undermine the validity or utility of this thesis' model as an instrument in furtherance of a cohesive and coherent understanding of the lengthy historical narrative for pre-Modern and Early Modern automata. On the contrary, because the currents function like tags, it is possible to apply them, without contradiction, to the works of idiosyncratic authors, like Albertus Magnus, the great saint, polymath, and Doctor of the Universal Church. Approximately two centuries before the conventionally-periodized general Renaissance of the mid-fifteenth century, Albertus' description the aeolipiles, a secular (and occasionally vulgar) device which meets this thesis' definition of an automaton whenever so constructed as to expel steam from the mouth or nose of a humanoid face in figural effigy, must register this thesis' proposed first and fifth currents of thought.

Kang unambiguously writes that the aeolipiles "originally [appeared] in works of ancient engineers like Hero[n] and Vitruvius," registering the proposed first current of thought. However, because the aeolipiles' technology is not more sophisticated than that of a tea kettle, requiring only a sound metallurgical construction, it apparently persisted in Europe from the classical through Early Modern periods with only aesthetic changes, thus bypassing the proposed second current because it was neither lost in Europe, nor apparently given serious attention by the West Asian engineers, like more challenging automata designs; and bypassed both the proposed third and fourth currents for the same reason, that its manufacture never abated in Europe, meaning that it was never unfamiliar, and hence "magical." Albertus, who had truly encyclopedic intellectual knowledge of his time, is the only source known to this thesis to have discussed these devices in the Middle Ages, meaning that the only other proofs of their existence are extant material-cultural recoveries: per Kang, "As verified by modern archaeologists through their findings in England, Germany, and other places, Albertus claimed that they were often made in the shape of a man, with the steam and water spraying out of its mouth or genitals." As regards legends of brazen heads, and Albertus' brazen automata, Kang presents Lynn White's theory that the description of the aeolipiles in Albertus' treatise *De Meteoris* is what gave rise to the "thing of brass" trope in the intellectual history of pre-Modern automata, but this thesis endorses Kang's view in this matter, that White's theory is unsatisfactory, and that Albertus' discussion of the aeolipiles was independent of the popular "things of brass."³²⁰

³²⁰ See Kang, *Sublime Dreams of Living Machines*, page 322, endnote 71: "Lynn White has presented an interesting theory that the source of the talking head legends may be the description in Albertus's *De Meteoris* of a device called an aeolipiles or fire-blower. Originally appearing in works of ancient engineers like Hero[n] and Vitruvius, it was a hollow metal vessel that was filled with water and heated. A blowing device then sent steam and water out of it through a hole and onto a fire, making the flames flare up. As verified by modern archaeologists through their findings in England, Germany, and other places, Albertus claimed that they were often made in the shape of a man, with the steam and water spraying out of its mouth or genitals. This report may have contributed to the legends, especially in connection with Albertus, but it is unlikely to be the source since the story attached to Gerbert is earlier and there are other more plausible origins of the talking head image. See White, *Medieval*

The emergence of the proposed fifth current of thought is usually placed much later than Albertus' lifetime in the European context to which it applies. Kang writes that "...in the late sixteenth and throughout the seventeenth century a process was under way of naturalizing the preternatural, of providing mundane explanations for marvels without any references to otherworldly beings or forces." This statement accords with the proposed fifth current to the degree that it suggests a secular view of automata had come to prevail at the indicated times, "without any references to otherworldly beings or forces," in response to the observable action of an automaton in operation, and also accords with the proposed sixth current to the degree it supplies the basis of this shift in mentalities, of "naturalizing the preternatural, of providing mundane explanations," in using automata as the basis for formal scientific, medical, and philosophical investigations.³²¹ This thesis' proposed fifth current is resonant in Kang's continued argument that "...the automaton was likewise systematically deprived of its magical nature [at the given times] and completely rehabilitated as a product of human mechanics that promised the technology necessary for the control of nature," with the latter part of this quote, on the "control of nature," also veering towards the proposed sixth current.³²²

Of the proposed currents, the fifth and sixth have a close spatiotemporal connection, as do the third and fourth, for the third and fourth exclusively, or almost exclusively, apply to Europe, as does the fifth, although the sixth, while a natural and rapid development from the fifth in the European context, was reached independently in the late Islamic Golden Age, when (for instance) the output of Ridwan, medical doctor, mirrored that of Conrad Dasypodius, professor of sciences, as both completed and published written documentations of the major restorations each undertook for preexisting automaton clocks in their respective societies. Kang, in a cited passage, writes "While the objects [automata] retained their wondrous aura, they represented the marvels of the machine in the everyday world, devoid of preternatural magic and supernatural entities." The first half of this statement, to "world," registers the proposed sixth current of thought, and the second half, ending in "entities" registers the proposed fifth current.

However, the thesis is not disposed to agree with the entirety of this line's passage, and especially the preceding line, "...Renaissance engineers built their automata to look like devils, pagan gods, and monsters to enhance their magical effect, Enlightenment mechanics like Vaucanson and the Jaquet-Droz made them in the shapes of ordinary animals and people engaged in the everyday tasks of writing,

Technology and Social Change, 90 – 91. For more on aeolipiles including archaeological findings, see W.L. Hildburgh, 'Aeolipiles as Fire-Blowers,' *Archaeologia* 94 (1951): 27 – 55."

³²¹ See Kang, *Sublime Dreams of Living Machines*, page 114: "Already in the late sixteenth and throughout the seventeenth century a process was under way of naturalizing the preternatural, of providing mundane explanations for marvels without any references to otherworldly beings or forces."

³²² See Kang, *Sublime Dreams of Living Machines*, pages 114 – 115: "As the mechanistic model of the world was being established and the preternatural was being naturalized, the automaton was likewise systematically deprived of its magical nature and completely rehabilitated as a product of human mechanics that promised the technology necessary for the control of nature." These kinds of arguments recall those of Alfred W. Crosby's well-known book *The Measure of Reality*.

drawing, and playing musical instruments.” Figural automata with secular subjects in Europe long predate Kang’s chronological outline, as in the case of Jack Blandifers at Wells Cathedral; and, of course, very many of al-Jazari’s automata appear to play musical instruments; and appear to write; and are all unequivocally secular in creative intention and audience reception, meaning that it is misleading to exclusively associate the secularism of the second and fifth currents with the era of the European Enlightenment, which falls outside this thesis’ scope. Further, it is not accurate to opine that the figural subject matter of Renaissance-era automata was chosen “to enhance their magical effect,” since on the contrary, the case of Fontana shows that at least one prominent engineer created automaton devils to *reduce* the “magical” perception of automata. Non-religious Renaissance-era automaton figures generally match the overall, classicizing program of secular humanism, which could include “magic” as an element of Neoplatonism, and the broader concern with study of the ancients, but there is only one case known to this thesis where the “magical effect” of automaton figures was given serious consideration as a sincere, Neoplatonic theurgical exercise, that of the automata at Pratolino.³²³ Having made these points, to conclude this thesis’ responses to Kang in its section on the proposed fifth current, it returns to the list of positive and negative views of automata presented near the end of Kang’s book, and again notes that the first of the “positive” views in these lists registers a sweep of this thesis’ proposed third, fourth, and fifth currents of thought, omitting certain of Kang’s “positive” perspectives which were not applicable to this thesis’ bounds, and/or which only concerned human beings.³²⁴

Religious automaton figures in the Renaissance are the other major case, aside from the aeolipiles, where a jump from the proposed first current directly to the proposed fifth current is reliably seen, and this development is also explicable due to a specific cause. While the presence of automaton figures which depict religious subjects or beings must register the proposed first current, even when removed from ritual practices, Hellenistic automata were driven hydraulically and/or pneumatically, and never kinetically, because clockwork technology was simply nonexistent in Hellenistic antiquity. When kinetic clockwork did appear in Europe, it was possible to create monumental clocks with religious figures, but using technology that neither originated with Heron and the other Hellenistic authors, nor with the West Asian civilizations that had preserved and advanced the design and construction of automata in the Hellenistic style. As such, these automata were not freighted with the

³²³ See Kang, *Sublime Dreams of Living Machines*, page 121: “And while the Renaissance engineers built their automata to look like devils, pagan gods, and monsters to enhance their magical effect, Enlightenment mechanics like Vaucanson and the Jaquet-Drozs made them in the shapes of ordinary animals and people engaged in the everyday tasks of writing, drawing, and playing musical instruments. While the objects retained their wondrous aura, they represented the marvels of the machine in the everyday world, devoid of preternatural magic and supernatural entities.” See this thesis’ fourth appendix for Jack Blandifers and all the secular automata known to this thesis under its proposed second current of thought, many of which do the very things, ca. the common years 1000 – 1250, which Kang situates as conceits of Enlightenment-era European automata. For the automata at Pratolino, see Lily V. Filson’s doctoral dissertation.

³²⁴ See Kang, *Sublime Dreams of Living Machines*, page 305 *et seq.*

connotation of “magic” which arose from prior European awareness, and fear, of ill-understood Hellenistic automata in West Asia, and as has been discussed, were probably not subject to the degree of suspicion entailed by registrations of this thesis’ proposed fourth current because they were constructed for monumental cathedral clocks under the direct patronage and supervision of the Church. Due to the Western European (Catholic) Church’s theological position on representational images, it was possible for these automata to appear in sacred spaces, and even to depict sacred or otherworldly figures in those spaces, without being the subjects of direct worship (even now, the misconception that Catholics consider religious paintings and statuary as divinities is an anti-Catholic canard). Thus, it is possible for an automaton-bearing clockwork mechanism in a European religious space, or with religious figures, to register the proposed first current, but not the second current, which is wholly secular, being removed from religious spaces and subjects, and denotes implementations of distinct technologies; nor the third current, as nothing about such a device would be considered “magical” to anyone but the ignorant; nor the fourth current, for without the semblance of “magic,” no allegation of sorcery can arise in connection with it.

These are the reasons that Riskin writes “...automaton Christs, angels, devils, and Virgins prepared the ground for mechanical animals of every variety and clockwork models of the cosmos itself. The Catholic Church was the cradle of the clockwork universe and its mechanical inhabitants... the church also promulgated, in association with clock-work, the plurality of early modern mechanical images of people and animals.” This quote illustrates the trajectory from exclusively sacred subject matter in sacred settings under the proposed model’s first current to a mixture of secular and sacred subjects in sacred settings, and in various other settings, under the proposed fifth current.³²⁵ The intuitive reason for the deployment of the early, massive astronomical clocks in cathedrals and religious settings is stated by Riskin, who writes in the same passage that such was done “in the interest of calendar reform and of accurate predictions of feast days.”³²⁶ Essentially, the automata of the pre-Modern and Early Modern European worlds are mostly permutations of non-Hellenistic technology, and based in clockwork, or of Hellenistic technology, and based in hydraulic-pneumatic flow systems. The latter, Hellenistic technology does not re-emerge in Europe until the Alexandrine technical corpus reappears, either by way of Spain, Southern Europe, or Eastern Europe. This is why, apart from automata (unless included at the level of systems design), Riskin also writes “late medieval and early modern palace waterworks were informed by translations of ancient texts,

³²⁵ See Riskin, “Machines in the Garden,” page 26: “Later, automaton Christs, angels, devils, and Virgins prepared the ground for mechanical animals of every variety and clockwork models of the cosmos itself. The Catholic Church was the cradle of the clockwork universe and its mechanical inhabitants. In the interest of calendar reform and of accurate predictions of feast days, the church sponsored both the astronomy and the technology of timekeeping. And the church also promulgated, in association with clock-work, the plurality of early modern mechanical images of people and animals.”

³²⁶ *Ibidem*.

notably the works of Hero[n] of Alexandria, and made virtually no changes to the ancient mechanisms.”³²⁷

While a waterworks itself registers neither the proposed first nor proposed fifth current, not being an automaton by this thesis’ definitions, the given trend is the same applicable to automata, that ancient technologies were recovered, after the elapse of centuries, and applied in Renaissance-era Europe, after translation out of Greek. The first and fifth currents are equally indicated by Riskin’s lines “A burgeoning literature on automatic machinery informed and accompanied installations such as the Palatine gardens waterworks. This literature began, as we have seen, with a series of ancient texts on mechanical and hydraulic automata, principally, in addition to Vitruvius’s *Ten Books*, the treatises of Hero[n] of Alexandria...” The Palatine Gardens did contain automata by this thesis’ definitions, and inasmuch as this was the case, these classical sources were used to create the same, since an automaton’s motive power supply is integral in its design. The first current is thereby registered, as is the fifth current, the rediscovery (Renaissance) of the first current’s technology in contexts that could be either sacred or secular, rather than exclusively sacred – and which, in this case, were secular, the private gardens of a reigning monarch.³²⁸

That the automata of the first, and therefore the second, currents did not incorporate clockwork, or an extensive use of gears as a transfer system for kinetic energies, is corroborated by de Solla Price, who writes “The Islamic tradition of water clocks did not involve the use of gears, though very occasionally a pair is used to turn power through an angle when this is dictated by the use of a water wheel in the automata. In the main, everything is worked by floats and strings or by hydraulic or pneumatic forces, as in Hero[n]’s devices.” Yet, as this thesis has explicated, despite the foundationally equivalent technologies of the proposed first and second currents, they are differentiated by cultural considerations, which determine everything from purpose, to selected figures, to venue. Both the proposed first and second currents are distinguishable from the fifth current, as described; the first was sacred, the second secular, and the fifth, either sacred or secular, or by circumstance, arguably both. Of course, once the classical technical corpus was rediscovered and translated in the European Renaissance, it was given almost exactly the same application in Europe as in West Asia, hundreds of years earlier, which was namely the design and

³²⁷ See Riskin, “Machines in the Garden,” page 31, footnote 83: “Late medieval and early modern palace waterworks were informed by translations of ancient texts, notably the works of Hero[n] of Alexandria, and made virtually no changes to the ancient mechanisms.”

³²⁸ See Riskin, “Machines in the Garden,” page 39: “A burgeoning literature on automatic machinery informed and accompanied installations such as the Palatine gardens waterworks. This literature began, as we have seen, with a series of ancient texts on mechanical and hydraulic automata, principally, in addition to Vitruvius’s *Ten Books*, the treatises of Hero[n] of Alexandria, which were repeatedly translated and printed over the course of the sixteenth century. In turn, these inspired modern works that borrowed extensively from the classical ones.” For the automata at the Palatine Gardens, see this thesis’ fourth appendix.

construction of pleasure-gardens for secular rulers, as evidenced by the above-mentioned case of the Palatine Gardens.³²⁹

A similar corroboration of another assertion presented by this thesis, that the reemergence of Hellenistic technological knowledge in Western Europe was, in part, caused by the flight of Byzantine intellectuals from the Ottoman conquest of Constantinople, is afforded by Moran, who writes “Leonardo [da Vinci] cultivated an early appreciation of classical knowledge and benefitted directly from the flow of newly reintroduced Greek science and philosophy from the fall of Byzantium (1453).” The relationship between this thesis’ proposed first and fifth currents of thought is borne out by this quote, which demonstrates that fifteenth and early sixteenth-century Europe then became the recipient of the valuable Alexandrine technical achievement, just as the Byzantine (that is, Eastern Roman) and Islamic societies of West Asia had, ironically, been its recipient centuries, and nearly a millennium earlier, after the fall of the Western Roman Empire.³³⁰ While da Vinci’s motivations cannot be known with certitude at a personal level, the relationship between the first and fifth currents is again discernible in Moran’s ascription of da Vinci’s inspiration for the self-propelled cart, one of da Vinci’s more famous designs. Moran argues that da Vinci designed this device to imitate the tripods built by the god Hephaestus in Greek mythology, divine automata which are frequently mentioned in historical and contemporary discussions of ancient technology, and specifically “automata,” things which move by themselves. da Vinci’s “mobile cart,” if Rosheim’s interpretation is followed, was actually a component of, and therefore one and the same with, a famous and well-documented figural automaton known to have been built by da Vinci, a lion, making it a germane instance of pre-Modern and Early Modern automata per this thesis’ definitions for the same.³³¹

³²⁹ See De Solla Price, “On the Origin of Clockwork,” page 26 in the author’s printed copy: “The Islamic tradition of water clocks did not involve the use of gears, though very occasionally a pair is used to turn power through an angle when this is dictated by the use of a water wheel in the automata. In the main, everything is worked by floats and strings or by hydraulic or pneumatic forces, as in Hero[n]’s devices. The automata are very elaborate, with figures of men, monkeys, peacocks, etc., symbolizing the passage of hours.”

³³⁰ See Moran, “The da Vinci Robot,” page 987: “Leonardo cultivated an early appreciation of classical knowledge and benefitted directly from the flow of newly reintroduced Greek science and philosophy from the fall of Byzantium (1453).”

³³¹ See Moran, “The da Vinci Robot,” page 987: “It was during this [Florentine] period that he [da Vinci] may have designed for Lorenzo Medici his first programmable, mechanical computer-controlled automaton. It is known that he was reading classic Greek texts and had a keen desire to reproduce the science of these masters and perhaps to outdo them. In 1478, his automaton was a three-wheeled mobile cart. It is almost a design to prove that he could create mechanical devices that might rival the Greek god, Haephestus. ‘... since he [Hephaestus] was working on twenty tripods which were to stand against the wall [of] his strong-founded dwelling. And he had set golden wheels underneath the base of each one so that of their own motion they could wheel into the immortal gathering, and return to his house: a wonder to look at.’” For Rosheim’s postulate, that da Vinci’s self-propelled cart is one and the same with the latter’s famous lion automaton, see *Leonardo’s Lost Robots*. If Rosheim’s reconstruction of the cart as the base and motive power of the lion automaton is followed, it should be acknowledged that the cart/lion was not truly programmable, but could be “preprogrammed” to move along defined pathways with different shapes by interchanging certain physical components with others.

Similarly, while there is no hard evidence on offer to suggest that da Vinci was directly inspired by Pindar in designing a hydraulic Jacquemart, Moran's proposal regarding the relationship between da Vinci's bell-ringer, which is described by Rosheim, and the automaton-building culture of Greek antiquity accords with registrations of this thesis' first and fifth currents of thought. Pindar's mention of "magic" in the passage cited by Moran is interesting, as it would register the proposed third current of thought if endorsed, and not rejected, by Pindar; but on the whole, as in Pindar, there is little to suggest that the ancients found automata "magical" in the senses of the later usage of that term in the Middle Ages and Renaissance, although they certainly viewed automata through the lens of religion – but there is, and was, a meaningful distinction between supernatural "magic" and the preternatural.³³² If any ancient Greeks truly believed, as a religious tenet, and not an apprehension of "magic," that automata contained the essential energies of a major or minor deity from their pantheon, and this same sort of belief persisted in the Middle Ages, in such likely cases as the Boxley Rood of Grace and *Virgen de los Reyes*, when figures of Jesus Christ and the Virgin Mary, respectively, replaced those of the classical gods, then Riskin's remark that "...human agency was gradually replacing divinity as the source of the spiritual or lively presence within [automata]," in the era of the Renaissance, is accurate, and can be construed to represent the shift from the conceptualization of automata under the "sacred" first current of thought, as proposed, to the "secular" fifth current of thought, as proposed, and thence to the "scientific" sixth current of thought, as proposed, in which "human agency" would come to be celebrated. Of course, this trajectory is appropriate because European automata are mainly discussed by both Riskin and Kang, whereas if those of Asia were substituted, the proposed second current of thought would replace the proposed fifth current of thought in its progression.³³³

During the Renaissance, the construction of secular automata became another expression of renewed interest in the achievements of the classical world, independently of whether ancient hydraulic technologies were reused, or extrapolations from classical technologies, like those devised by da Vinci for his

³³² See Moran, "The da Vinci Robot," page 988: "Leonardo continued and advanced his fascination with ancient Greek science by developing fully animated automata, and by the age of 56, he designed a water-powered bell ringer using 12 interconnected chambers of actuate[d] float valves. His inspiration here was Pindar's Seventh Olympic Ode (c. 520 B.C.) ... 'And their ways teemed with sculptured forms like to beings that live and talk: and high waxed their renown. But in the man who has the craft-lore even the greater skill putteth itself forth without the guide of magic.'" Note that like all public ceremonies, the Greek Olympic games had religious elements; and that, at a juncture more than 500 years removed from Heron's time, "magic" is discounted in relation to automata per the work of an extant classical author. Another interesting point is that, despite the availability of clockwork, da Vinci seems to have designed his Jacquemart with a hydraulic source of motive power as a tribute to the Heronic tradition, which is observed by Rosheim in *Leonardo's Lost Robots*.

³³³ See Riskin, "Introduction: The Sistine Gap," page 24: "At the same time, King writes, the monk [by Turriano] exemplified a shift in the way such images were seen – the same shift chronicled in Grafton's story of the automaton devils of Giovanni Fontana – in which human agency was gradually replacing divinity as the source of the spiritual or lively presence within [automata]." See this thesis' fourth appendix for the Boxley Rood of Grace and *Virgen de los Reyes*.

jacquemart, were formulated, or clockwork technologies were applied. This trend exists quite apart from theurgical considerations, whether in ancient ritual, Neoplatonic magic, or the corresponding revival of Neoplatonic magic effectuated by Ficino, in his Renaissance-era system of magic, and was an expression of intellectualism. For instance, de Morales explicitly writes that Juanelo [Gianello] Turriano was inspired by the technology of ancient Greece, and that by building an automaton, he sought to imitate and revive the same.³³⁴ This rationale probably informed the proliferation of automata in the sixteenth century, like the one described by de Morales. Among these automata, the “animated figures of pagan myth (and often the figures of play: Diana, Cupid, or Bacchus)” and “pieces representing biblical figures and Christian themes” both register the proposed first current of thought, in addition to the proposed fifth current of thought, and potentially two others, the proposed sixth current of thought or proposed fourth current of thought, depending upon the context and historical circumstances surrounding a given instance of Early Modern automata, with a delimitation to that period made necessary by specific review of “the sixteenth century” (and, of course, delimitation to the proposed fifth current, since European automata are being discussed).³³⁵

Surprisingly, there is some relevance to the proposed fifth current in certain lines from the scholarly apparatuses included with the cited editions of Islamic technical treatises, at least as regards passage through the proposed second current, the Islamic preservation and elaboration of classical automaton technologies, as an antecedent to the later currents of thought, including the European fifth current. Lynn White, Jr.’s foreword to Hill’s edition of al-Jazari’s treatise references “... Muslim transmission of Hellenistic, Far Eastern, and indeed Muslim inventions to the West.” The narrative progression from the first current, the Hellenistic world, to the second current, in this case, the Islamic world, and thence to the fifth current, the Europe of the Renaissance, sometimes at earlier, medieval dates, or in later, Reformation dates, by way of the proposed third and fourth currents, (“magic” in fiction and myth, and later persecution of the technologist on the ground of “magic”), is clear.³³⁶

³³⁴ See King, “Perpetual Devotion,” page 272. The following is King’s translation of Ambrosio de Morales’ Old Spanish passage regarding this instance of Early Modern automata in the latter’s work, *Las antigüedades de las ciudades de Espana* (1575): “Juanelo as a diversion also wanted to create anew the ancient statues which moved and, on that account, were called automata by the Greeks. He made a lady more than one *tercia* high [about one foot tall] who, placed on a table, dances all over it to the sound of a drum which she meanwhile beats herself, and goes round in circles, returning to where she started. Though it is a toy and fit for mirth, it is nevertheless a great proof of his high intelligence.”

³³⁵ See King, “Perpetual Devotion,” page 288, endnote 18: “We continually remap the border between useful things and frivolous ones, regardless of the complexity of the objects themselves. Among classes of automata unique to the sixteenth century [in the thesis’ opinion, this dimension of ‘uniqueness’ is ill-conceived, and probably erroneous] – figure clocks, musical tableaux, dancing animals, animated figures of pagan myth (and often the figures of play: Diana, Cupid, or Bacchus) – one finds a considerably less ludic subgroup of pieces representing biblical figures and Christian themes.”

³³⁶ See al-Jazari, *Book of Knowledge*, page XIII (13), in Lynn White, Jr.’s “Foreword:” “These examples, [‘conical valves,’ ‘segmental gears,’ and ‘metal casting in closed mould (SIC) - boxes with

Medieval Islamic West Asian hydraulic automata and medieval Christian European kinetic automata, when they appear at different times in these two settings, are “very similar,” per Hill, because both varieties of clocks reuse the conception of automata from the classical authors (Philon, Heron, and Ctesibius), even if they do not reuse classical technologies, either exactly, or at all (although, in some cases, like that of the automaton Saint Propser of Reggio to which this thesis frequently returns, these classical technologies were reused component-for-component), and even if they do not feature the same automaton figures.³³⁷ Through the thesis’ model, it is possible to explain this “similarity:” the proposed third and fourth currents take inspiration from the proposed first and second currents by way of fictionalizations and tales, that is, both the first and second currents were fictionalized, and made the subjects of tales, but finally arrived at cultures with like access to the textual works of the classical authors when Europe eventually reached the historical point described by this thesis’ proposed fifth current; and generally, by the historical points described by this thesis’ proposed fourth and fifth currents, kinetic energy had replaced hydraulic energy as the driver of timekeeping devices in Europe.

Thus, European cultures, during the centuries in which the proposed third and fourth currents predominated, retained access to the *concept* of automata, through their own half-remembrances in stories like the romances, and through the tales of travelers to Islamic automaton-building cultures (Hill calls the latter “travellers’ reports”); this is a very different statement, and stance to argue, than to simply assert, as does Hill, that “...most of the ideas that were to be important for the development of European technology came from the mainstream of Islamic engineering,” which would include European automaton-building.³³⁸ Cases in which obviously Heronic designs inexplicably appear in the romances, such as the episode in the tomb of Diana the Huntress, for example, demonstrate awareness of classical automata, perhaps preserved by word-of-mouth, like the ancient myths. Yet, because knowledge of how these machines functioned (their internals) was lost, kinetic technologies developed by Europeans, in the meantime, filled the gap left by the missing ancient texts, so that by the time these ancient texts were restored, around the fifteenth century, European automata were not hydraulic. Even so, da Vinci’s jacquemart automaton suggests that there may have been a historical moment, after kinetic automata were predominant, but also after the classical corpus was recovered, when building hydraulic automata after the ancient fashion, but with *de novo* designs, was contemplated, with this thought being a means to emphasize mastery of the classical engineering tradition, in the true spirit of the Renaissance.

green sand’] and others, suggest Muslim transmission of Hellenistic, Far Eastern, and indeed Muslim inventions to the West.”

³³⁷ See The Banu Musa, *Book of Ingenious Devices*, page 23, in Hill’s “Historical Context of The Book of Ingenious Devices: “Nor can the influence of Islamic water-clocks upon the development of the mechanical clock be discounted. In both machines the automata are very similar and it is not implausible to compare the controlled descent of a heavy float with the escapement-controlled descent of a weight.”

³³⁸ *Ibidem*.

THE SIXTH CURRENT OF THOUGHT.

Coupled with the nascent awareness of Heronic mechanisms, the automaton therefore became a secular object understood to demonstrate its movement through applications of the science, engineering, and craft knowledge applied in the second current, although in a Western European rather than Islamic cultural context. The bifurcation of currents of thought which led to the dominance of the second current via the fifth current in turn led to a new, sixth current of thought via the fifth, and the thesis would contend this sixth current is still effective in Western European-derived cultures. Now, into the late Renaissance and/or early Baroque period of the early seventeenth century and beyond, the automaton was construed as an accomplishment of skilled craftsmanship and design, and inasmuch as it was an accomplishment, also as an index of society's progress respective to science and technology. This view of the automaton is the sixth current of thought, and it is still operative in the contemporary world.

Consider Elektro and Sparko, two "robots" presented at the 1939-1940 World's Fair which are contended to have been heavily influenced by pre-Modern and Early Modern automata. While constructed with aluminum bodies, they had a golden or brazen coloration, as do an overwhelming majority of fictitious automata corresponding to the third current of thought and some pre-Modern and Early Modern automata built in emulation of these fictitious automata. Neither presented nor understood by their audience to be gods, neither the anthropoid automaton Elektro nor canine automaton Sparko register in the first current of thought. They were presented as novel, certainly, but not as clever novelties, and while perhaps not very grave as objects, they are distinguishable as works which partake of the sixth current of thought because they emblemize the equation of "progress" with technological advancement.

As the thesis has attempted to demonstrate, this sixth current is traceable to the fifth current, the realization of automata as secular technology in Western Europe, and then to the second current, the realization of automata as secular technology in the Arab world. Here must the attempt at tracing the lineage of Elektro and Sparko stop, for while the second current was only made possible by the Arabic preservation and digestion of the classical Greco-Roman corpus of technological knowledge, a corpus also responsible for the classical automata which engendered the first current of thought, Elektro and Sparko would only be classifiable in accords with this first current if they were announced to their audience as gods or divine manifestations and then worshiped, feared, or revered as such by that audience; or if Elektro and Sparko were to demonstrate true supernatural power, or "magic," in a work of fiction rather than in the reality of their existence.

Of course, if the pair was perceived by its audience as a work of sorcery, and that audience then proceeded to destroy the android and his dog and persecute their foremost creators, J.M. Barnett, Jack Weeks Sr., and Harold Gorsuch, these automata and their audience, but not the trio of electrical engineers, would have participated in the fourth current of thought. Were Messrs. Barnett, Weeks, and Gorsuch to have

characterized themselves as warlocks, enchanters, etc. before, during, or after completing their automata, they too would have participated in that current. In accordance with this example, the fourth current of thought is distinguished as the sole current that is typically destructive in objective terms, although certain forms of religious expression might also render the first current of thought dangerous.

While this thesis is concerned with historical analysis, it has considered works of pre-Modern and Early Modern fiction to mount its lines of argumentation, and this is broadly appropriate for a work concerned with cultural and intellectual history. Taking this same approach with modern works of fiction can also be useful in corroborating paradigmatic validity for “currents of thought.” Many works of contemporary speculative fiction featuring automata, or “robots,” are in greater harmony with very, very old, and indeed pre-Modern, currents of thought than is likely realized by their consumers.

As Bur has established, the automata of the classical world were believed to possess actual supernatural power by dint of their likenesses of, or association with, the gods and goddesses of the classical pantheon. By contrast, while the automata of the third current of thought are crafted using magical means, as in Kang’s second type, and are able to perform magical deeds, their essence is still worldly rather than otherworldly; they exist in fictive realities which allow the operation of magic, but this magic is ultimately enacted in a temporal setting, even if it sometimes entails the involvement of otherworldly actors, such as demons, and the transmigration of such actors into fictionalized representations of reality. The involvement of inhuman actors (angels, demons, etc.) is thus indirect in the third current of thought, with these actors being one step removed from automata, even if their energies are temporarily harnessed to animate inanimate matter for the purpose of crafting an automaton. Indeed, as Truitt has extensively discussed, the magic used in medieval legend and fiction need not even to have necessarily involved inhuman actors, as the “natural magic” of *cumpas*, the antecedent of many natural sciences, could be sufficient to “magically” create an automaton without recourse to the power of supernatural, inhuman intelligences.

In the first current of thought, this single degree of separation is removed, and the automaton is itself a direct manifestation of supernatural power able to wield an unadulterated form of this power which is not contingent upon the intermediary action of a sorcerer or saint at the levels of fabrication or actuation. An automaton in the first current of thought is believed to gain and use its powers independently of human action, which is an important distinction. Accordingly, automata which are or are not built in the image of a deity or devil may gain the powers of these superhuman entities if “possessed” by the same, and it is just this “possession” which renders the automaton’s power authentic for purposes of automata in first current of thought. Unlike the third current, the nature of this operation means that automata actually constructed in the classical and medieval worlds could reflect the first current in accordance with the pre-Modern *weltanschauung*. While belief in the supernatural power of an automaton is a religious question, such a belief can exist with or without the condition of supernatural power truly being present and operative in lived reality

in the opinion of this thesis or the empiricist consensus of Modern, post-Modern, and even post-post-Modern science. Allowance for the mediated involvement (and therefore reality) of disembodied, supernatural intelligences, of course, is also an essential philosophical predicate and antecedent for the reaction to actually-built automata seen in the fourth current of thought.

This is an important point. As the thesis has already established, “currents of thought” can identifiably exist simultaneously at a given historic time. For example, the *Virgen de los Reyes*, which participates in the first current of thought, can be contemporaneous with the secular technology of the Arab world, the second current. While the currents are cumulative and roughly correspond to the historic progression of automata as a species of technology, they are not exclusive, much as different levels or types of technology can simultaneously exist in different geospatial and cultural zones. These currents of thought are also non-exclusive at the level of an individual automaton; a confluence of multiple currents may exist in a single automaton.

Christopher Swift’s conception of the “robot saint,” of which the *Virgen de los Reyes* is his prime example, demonstrates how distinct currents may mix to produce many permutations. While the *Virgen de los Reyes* is comprised of the Madonna and Child, thus being a physical representation of Christ and very directly indicative of the first current, other examples of the “robot saint” more clearly contain multiple currents of thought in single instantiations of the pre-Modern and Early Modern automaton. For instance, at St. Mark’s Clocktower in Venice, the automaton figures of Balthazar, Caspar, and Melchior, the three wise men who are all saints in the tradition of Christianity which informed the Renaissance-era construction of this astronomical clock, are essentially religious. However, they are not intended for reverence in the same sense as the *Virgen de los Reyes*, and their programmed action, sequentially doffing their crowns in a semicircular procession before a non-automated statue of the Madonna and Child, is almost jocular, an entertaining spectacle. There is something of the first current in the “robot saint,” but also something of the fifth and sixth current. The moderated role of the first current could indeed be considered a re-inscription of the Roman Catholic distinction between God and members of the communion of saints as the subject to whom worship is addressed.

“Robot saints” have a religious subject, a residue of the first current; they are secular in the sense of not being a not a god or monster, a residue of the second current via the fifth current; and by the era of their commoner appearance in the later Middle Ages and Renaissance, they are at least partially intended or understood as indications of civilizational progress by means of sophisticated technological expression, the sixth current of thought. Many “robot saints” exist other than the *Virgen de los Reyes* and the Magi of Saint Mark’s clocktower; some examples include the autonomous automaton figure of Saint Diego Alcala discussed by Elizabeth King; and the figure of Saint George in “The Iorge” at Saint Botolph’s Church, Billingsgate, discussed by Philip Butterworth. Each of these automata fully merits and has received attention as an individual work, and much discussion could be offered as to variations in currents of thought which is presented by each.

However, the thesis will next turn to another such current which, like that of the equation of automata (understood as a term analogous to “robots”) and comparable works of high technology with societal progress, survives and is operative in the contemporary world.

EXAMPLES OF THE SIXTH CURRENT OF THOUGHT.

Automata have been the harbinger of scientific progress in the European cultures since the early Renaissance, although the most famous automata date from the eighteenth century, in what was an extension of a preexisting trend, the proposed sixth current of thought. For example, Vaucanson's "digesting duck" is beyond the scope of this thesis' considered period, but is illustrative of how automata, as an exercise in the advancement of technology, could give rise to new technologies: Bedini relates how Vaucanson, in creating it, also created "...the first flexible tube of India rubber (caoutchouc), which was to have a variety of applications in many fields in the future."³³⁹ As has already been mentioned, in the eighteenth century, construction of a working, technologically-based brazen head had become the basis for a scientific competition, for by that time, this thesis' proposed third and fourth currents had long since been replaced by its proposed fifth and sixth currents.³⁴⁰ Friedrich von Knauss, who had created four brazen head devices years before that competition, and had also built four writing-machines, is credited by Bedini with the invention of typewriters, which demonstrates the same relationship between the construction of automata and the emergence of new technologies seen in Vaucanson's above case, and which is a trend registering the proposed sixth current of thought whenever noted in this thesis' period of interest.³⁴¹

Bedini corroborates this understanding of the relationship between automata technologies and general technology, writing "...basic inventions produced for these attempts to imitate life by mechanical means led to significant developments culminating in modern automation [not automata, but automated systems] and cybernetics." This line is one representation of the proposed sixth current of thought, which positions automata as the basis of study, and a factor in the furtherance of general science and engineering.³⁴² Bedini later reiterates this argument, more

³³⁹ See Bedini, "Role of Automata," page 37: "It was inevitable that, in the course of devising these complicated automata, Vaucanson should invent several devices which subsequently achieved technological importance. One was the first flexible tube of India rubber (caoutchouc), which was to have a variety of applications in many fields in the future and which Vaucanson devised for the purpose of simulating the intestines in the 'moving anatomy' of his duck."

³⁴⁰ See Bedini, "Role of Automata," page 38: "The next major advance in this field was made in about 1770 by Friedrich von Knauss of Vienna, who constructed not one but four speaking heads. That his project was not completely successful is attested to by the fact that in 1779 the Academy of Sciences in St. Petersburg used the production of a successful speaking head as the theme of a contest for mechanics and organ manufacturers, specifying that the machine be capable of speaking the five vowels. Three inventors produced results at about the same time: the Abbe Mical in 1778, the Baron von Kempelen and C.G. Kratzenstein, both in 1780. Numerous others constructed speaking heads within the next decades, but never with any marked degree of success."

³⁴¹ See Bedini, "Role of Automata," page 39: "It is of particular interest to the history of technology that Knauss [the same Knauss], the inventor of these four machines [automaton writers, not talking heads], was subsequently the inventor of the first typewriter."

³⁴² See Bedini, "Role of Automata," page 41: "A study of the history of automata clearly reveals that several of the basic inventions produced for these attempts to imitate life by mechanical means led to significant developments culminating in modern automation and cybernetics."

forcefully, which is also an articulation of the proposed sixth current of thought as regards automata.³⁴³ De Solla Price, writing in the same publication, extends the significance of automata in intellectual history not only to the aggrandizement of the STEM fields, but also to philosophy, delivering the intuitive observation that “...increase in familiarity with machines and their fundamental theory is usually cited as the decisive factor in the growth of mechanistic philosophy,” with this type of philosophizing associated with the dualistic theories of Descartes, and the intellectual movement which made these theories, amongst other things, the basis for medical practice. This point also shows the progression from the proposed fifth current to the proposed sixth current, as technology became the measure of progress and basis of the above-mentioned philosophizing.³⁴⁴

This thesis is not inclined to agree with De Solla Price’s overall argumentation in the cited article, as it seems to indulge in contrarianism for its own sake. However, there are still some points in it which relate to this thesis’ proposed sixth current of thought, as when De Solla Price notes “In these special mechanisms [automata] are seen the progenitors of the Industrial Revolution... from automata has evolved much of our technology, particularly the part embracing fine mechanism and scientific instrumentation.”³⁴⁵ This concept, the prominence of automata in technical developments, is not only a registration of the proposed sixth current of thought, but is also useful as a rebuttal to dismissals of pre-Modern and Early Modern automata as mere toys.³⁴⁶ It could conceivably be inferred that the positioning of automata as essential to the development of high technology is an exaggeration offered the authors who published on this topic, and had an intrinsic bias towards it, but when taken at

³⁴³ See Bedini, “Role of Automata,” page 42: “However, the stage for the machine era may be said to have been set centuries earlier with the development of the mill and the clock... The role of automata in the progress of technology is therefore of considerable importance. Efforts to imitate life by mechanical means, for whatever purpose, resulted in the development of mechanical principles and led to the production of complex mechanisms which have fulfilled technology’s original aims – the reduction or simplification of physical labor.”

³⁴⁴ See De Solla Price, “Automata and the Origins of Mechanism and Mechanistic Philosophy,” page 9: “Indeed, the steady advancement of technology and the increase in familiarity with machines and their fundamental theory is usually cited as the decisive factor in the growth of mechanistic philosophy, especially toward the beginning of the instrument-dominated Scientific Revolution in the sixteenth and seventeenth centuries.”

³⁴⁵ See De Solla Price, “Automata and the Origins of Mechanism and Mechanistic Philosophy,” pages 9, 10: “We suggest that some strong innate urge toward mechanistic explanation led to the making of automata, and that from automata has evolved much of our technology, particularly the part embracing fine mechanism and scientific instrumentation.” The latter clause of this quote regarding technology and automata is another registration of this thesis’ proposed sixth current, but the first clauses are the reversal from De Solla Price that this thesis finds contrarian, as the opposite, that automata led to mechanismism, and not that mechanismism led to automata, is what is broadly accepted.

³⁴⁶ See De Solla Price, “Automata and the Origins of Mechanism and Mechanistic Philosophy,” page 15: “Amongst historians of technology there always seems always to have been private, somewhat peevish discontent because the most ingenious mechanical devices of antiquity were not useful machines but trivial toys. Only slowly do the machines of everyday life take up the scientific advances and basic principles used long before in the despicable playthings and overly-ingenuous, impracticable scientific models and instruments.”

face value, the opinion offered both by Bedini, and De Solla Price, is a clear affirmation of this essentiality, as when the latter wrote “the techniques used are found at first only in them [‘astronomical clockwork and biological automata’], seeping slowly, and much later on, into other instruments and machines; ...throughout the entire medieval, Renaissance, and even modern evolution of fine mechanism a central role is played by great astronomical clocks whose principal characteristic is the combination of astronomical showpiece with the automatic jackwork.” Many of these clocks, including al-Jazari’s castle clock, that of Su Sung, and European examples, are cataloged in this thesis’ fourth appendix.³⁴⁷ In these cases, but also more generally, automata and automata-bearing devices are the driver of technical advancement, a statement which registers this thesis’ proposed sixth current of thought.³⁴⁸

De Solla Price’s observation is borne out by the case of a mechanical trap for otters at Hesdin, as presented by Farmer, which represents expanding, practical mechanization at an early site of automata, and is therefore indicative of the proposed sixth current. Automata are usually a spur to other technologies, and to mechanization, so De Solla Price is correct in making this argument, which can exist independently, and which is close to this thesis’ proposed sixth current.³⁴⁹ The unique appeal of automata, which Fliegel remarks “...fed the medieval love of ostentation, allegory, and ingenuity,” prefigures the proposed sixth current of thought at some junctures which long antedate the Scientific Revolution, like Villard de Honnecourt’s lifetime, for eventually, the love of ingenious things must give way to study of the same.³⁵⁰ It was in the fifteenth, sixteenth and early seventeenth centuries when this shift generally occurred, although not in a dramatic sea change, but a in a *mélange* of intermeshing and sometimes competing ideas. It was in these centuries when a device such as Turriano’s famed monk could be said to suggest “science” by King, yet also a variety of other significations at one and the same time, as noted, and register several currents proposed by this thesis.³⁵¹

³⁴⁷ See the fourth appendix.

³⁴⁸ See De Solla Price, “Automata and the Origins of Mechanism and Mechanistic Philosophy,” page 15: “In support of the thesis that astronomical clockwork and biological automata are complementary to each other, the following evidence is submitted: (a) both types of simulacra see their first extensive development at the same time; (b) the techniques used are found at first only in them, seeping slowly, and much later on, into other instruments and machines; and (c) throughout the entire medieval, Renaissance, and even modern evolution of fine mechanism a central role is played by great astronomical clocks whose principal characteristic is the combination of astronomical showpiece with the automatic jackwork of imitation animals and human beings.”

³⁴⁹ See Farmer, “Aristocratic Power and the ‘Natural’ Landscape,” page 662: “We learn from the time of Mahaut, moreover, that the countess owned some kind of mechanized trap that was used to capture otters.”

³⁵⁰ See Fliegel, “The Cleveland Table Fountain and Gothic Automata,” page 27: “However, like Villard’s *cantepleure*, we must not lose sight of the fact that such objects fed the medieval love of ostentation, allegory, and ingenuity.”

³⁵¹ See King, “Clockwork Prayer,” page 18, in the author’s printed copy: “He [the automaton monk] walks a delicate line between church, theater, magic, science. He circulates among – murmurs about – all of them. He is a synapse, transmitting a host of simultaneous signals.”

The lead-up for the early Renaissance corresponds to Chaucer's later years, and it is in that context that his work could be said to show "...satiric participation in the dominant scientific discourse," since such a "discourse" by then existed, and was recognizable to educated persons in secular spheres beyond, for instance, the walls of monasteries.³⁵² Although in a satirical, and not celebratory context, Chaucer's description of the Summoner is contended by O'Brien to deliberately evoke sufflators, which are elsewhere called aeolipiles in this thesis' text (the terms are synonymous), one of the simplest types of pre-Modern and Early Modern automata known to this thesis, and one so simple that it survived the fall of the Western Roman Empire, whereas the Heronic corpus was lost. Chaucer, following O'Brien's interpretation, likens the fictive Summoner to a sufflator, as well as Thomas, a character in the Summoner's tale, showing a connection between the behavior of an automaton and the human body.³⁵³ As such, O'Brien may endorse De Solla Price's reversal, that mechanismism led to automata, and not the opposite sequence of causality. Regardless, by astutely noting that the Summoner is characterized by Chaucer as the personification of an aeolipiles, a sufflator, O'Brien situates philosophical mechanismism centuries before Descartes, possibly registering the proposed sixth current, as well as the pervasiveness of automata, and in this case, sufflators, that registers the proposed fifth current.³⁵⁴ This accords with the thesis' interpretation of the line "...the triumph of the demonstrated knowledge of science over mystery and irrationality," which is shown by both *The Summoner's Tale* and *The Friar's Tale*, per O'Brien, and which suggests the replacement of the proposed third and fourth currents of thought by the proposed fifth and sixth currents of thought.³⁵⁵

³⁵² See O'Brien, "Ars-Metrik," page 1: "What has been ignored is the tale's [*The Summoner's Tale*] dependence for effect on certain medieval attitudes concerning mechanical devices and in particular its satiric participation in the dominant scientific discourse of Chaucer's age."

³⁵³ See O'Brien, "Ars-Metrik," page 3: "This dominant metaphor can account for much of Chaucer's portrayal of the Summoner, whether it is his steaming face or the exploding hind end of Thomas, his alter ego. Chaucer, however, was not just *following* the language and details of the medical theories of his time but rather was *developing*, for specific satiric purposes, a comparison between the Summoner and mechanical devices."

³⁵⁴ See O'Brien, "Ars-Metrik," pages 3 – 4: "Leonardo da Vinci has left two sketches of such a device in human form [not noted as instances, because other than this quote, I have not seen them], as well as an extraordinary drawing – perhaps developed as a design for a festival costume – of a man resembling a bagpipe riding a horse (Reti 129). Produced a century after Chaucer designed his own 'blower' on a horse, these sketches nevertheless reflect this habit of seeing mechanisms in terms of the human body and, moreover, indicate the probability that such an association was part of the period's 'popular culture.' The description of the Summoner in the *General Prologue* calls to mind such a device as the *sufflator*, but so do other parts of Chaucer's portrayal of the Summoner: the episode in the *Summoner's Tale* during which Thomas gives the friar his noxious gift and the one in the tale's coda during which the squire proposes to have Thomas brought before the company to repeat the explosive act."

³⁵⁵ See O'Brien, "Ars-Metrik," page 12: "Although Chaucer uses the friar to expose the difference between the apostolic ideal of the friars and their selfish behavior, he also focuses his satire on the way they have turned their human, spiritual activity into systematic, mechanical gestures. Research into the friars' practices of composing sermons justifies this emphasis on the mechanical element in the friars'

The emergence of the sixth current of thought, scientific empiricism, in contradistinction to the thought patterns of the Middle Ages, which were based (near-exclusively) on formal logic, is attested by the change in scholarly method "...from the discipline of logic to that of natural philosophy."³⁵⁶ Even during this change, the epistemological method, *sophismata*, originated with logic, but per O'Brien, was applied to subjects of inquiry beyond those of the logicians.³⁵⁷ Interestingly, *gedankenexperimente* appear to have been another approach during this period, although neither O'Brien, in describing it, nor the late medieval scholars themselves are known to have used that term.³⁵⁸ For reasons already discussed, O'Brien's analysis of competing intellectual paradigms in Chaucer's time shows the "transition," O'Brien's own term, from the proposed third and fourth to the proposed

activity. As Joseph Mosher and D.L. d'Avray have shown, the friars constructed their sermons from immense 'exemplum books,' arranged under such categories as *gloria* and *gratia*, books that amounted to what d'Avray calls 'elaborate preaching machines' (74-75; Mosher 86-87). To the extent that they relied on this system, the friars resemble Chaucer's version of the scientist, as developed through the Friar's summoner and also, in more specific terms, through the lord and squire at the end of the *Summoner's Tale*. The scientific quest shapes the plots of both the Friar's and the Summoner's tales: in both, the climax occurs when the curious poser of the question, the descendant of Bacon and Grosseteste in search of 'God's privities,' discovers the answer, and particularly one that depends on the senses rather than authority. The *Summoner's Tale* resembles the *Friar's Tale*, then, in that it ironically describes the triumph of the demonstrated knowledge of science over mystery and irrationality."

³⁵⁶ See O'Brien, "Ars-Metrik," pages 13 – 14: "Importantly, Grennen's discussion illustrates that Chaucer was not simply aware of scholastic terms as they had been used for the previous two centuries in writings on logic and grammar, but furthermore that he knew of the alteration in those terms in the logical disputes that were occurring at Oxford. This alteration amounted to a transfer of the scholastic process of solving puzzling problems in terms of strict logical and grammatical rules from the discipline of logic to that of natural philosophy. According to Murdoch and Sylla, then, this scholastic process was often centered upon a physical problem, such as motion, and the rules for solving the problem were physical as well as logical ones (234). In turn this process led to the Mertonians' [Oxfordians'] practice of applying quantitative, physical rules to qualitative, moral problems."

³⁵⁷ See O'Brien, "Ars-Metrik," page 14: "The key word in this passage [*The Clerk's Prologue*], of course, is 'sophyme,' a technical term referring to the scholastic *sophismata*. These were ingenious problems designed for the purpose of testing a scholar's knowledge in a particular subject – logic in the thirteenth century but physical laws as often as logical ones in the fourteenth century at Oxford. Solutions to such problems at Oxford during this period, moreover, often depended on arithmetical and geometrical demonstrations. The prevalence of the *sophismata* as a pedagogical tool is indicated by the importance of Heytesbury's *Regule solvendi sophismata*, which, according to Curtis Wilson, 'were widely known and frequently made the subject of commentary during a period of a century and a half after they were composed at Merton College [Oxford] in 1335 (3)."

³⁵⁸ See O'Brien, "Ars-Metrik," page 16: "The criticism of this Mertonian science, or what Grennen calls its 'petti-fogging imitators' (85), appears even more specific as we look at the issues inherent in the two other academic terms in this passage, 'yimaginacioun' and 'demonstracioun.' The first term appears most often in the phrase *secundum imaginationem*, which describes the process of proving a solution *via rationis*, that is, according to a consistent line of logic without regard for the observable world (Wilson 25). These 'thought experiments' involved *sophismata* or *impossibile* [that which is impossible]. Though this *via rationis* led to such interesting and influential ideas as the impetus theory, it also encouraged a disregard for emotion and spirit and thereby a tendency to explain moral virtue in terms of theories about the physical world developed *secundum imaginationem* (Grennen 85)."

fifth and sixth currents of thought.³⁵⁹ He highlights the *quaestiones et responsiones*, which, as discussed in other sections, exemplify the shift from the proposed fourth current, through the fifth current, to the sixth current.³⁶⁰

As is always the case with speculative fiction, of any era, or whenever its elements appear in works of other fictional genres, or works which antedate the concept of genre fiction (such as, for example, Lucian of Samosata's *True History*), real-life trends and technologies can be envisioned long before they materialize, which has at least been an observable phenomenon in comparing fictive works and the history of technology in the nineteenth, twentieth, and twenty-first century. So, moving from the fiction of *The Canterbury Tales*, which, in O'Brien's analysis, is useful in defining the scientific developments relevant to the emergence of the proposed sixth current of thought, the thesis will now momentarily return to *Le Roman de Troie*, another work containing pre-Modern representations of imaginary automatons. In this romance, an automaton is called "...a sign of great nobility: they say that it is a very great treasure; a work of such mastery was never created or heard of before." This line either prefigures or is a statement of the sixth current, the conceptualization of automata as an index of "progress" or societal achievement.³⁶¹

As has been noted, Kang, in an early passage from *Sublime Dreams of Living Machines*, gives the progression from the proposed third through sixth currents.³⁶² In prior sections, this thesis has also identified that Kang, when referring to the "scientific revolution," is noting this thesis' proposed sixth current by way of its fifth

³⁵⁹ See O'Brien, "Ars-Metrik," page 18: "These puns develop further the connections in the *Friar's Tale* between the scientific quest, the need for demonstration, and demonic power. They also point to a culture in transition and suggest Chaucer's skeptical, even derisive, attitude toward some of the elements in that transition. For instance, on the one hand, the lord [a fictitious character] quite clearly represents the *via rationis*, which depends on demonstration *secundum imaginationem* and adherence to authority; he complains that the problem which the friar has brought him has never been discussed before in any works of 'ars-metrik' (2220-23). The problem is 'devilish' precisely because it has not received the attention of the authorities. The squire, on the other hand, represents the *via experientiae*, depending on the kind of demonstration that Bacon describes as deriving its final authority from the senses. Thus, far from being simply a self-reflexive display of academic discourse or a development of dramatic tension between the pilgrims, these closing sections of the *Summoner's Tale* play out the conflict between these two academic procedures and moreover the giving way of the old, authoritative to the new, experimental method of arriving at solutions to problems in the physical world."

³⁶⁰ See O'Brien, "Ars-Metrik," page 20: "The way in which the discourse of the new world frames problems eliminates the need for the discourse of morality and value upon which the old world is ostensibly built. That this change of discourse was in fact taking place is suggested by the fact that the scholastic exercise of *quaestiones et responsiones*, the paradigm for the discourse at the end of the *Summoner's Tale*, was being used in the fourteenth century 'not for purely didactic purposes in the classrooms, but also as the basis for polite conversation' among men 'of divers states and conditions' – a form of informal converse which was to be of increasing importance in the 16th and 17th centuries for the discussion and propagation of scientific ideas' (Lawn 105)." [Note that everything after "not for" is from Lawn.]

³⁶¹ See Sullivan, "Medieval Automata," page 16: "In the opinion of the Trojans, the figure [an automaton] and its flowers are a sign of great nobility: they say that it is a very great treasure; a work of such mastery was never created or heard of before. (14862)"

³⁶² See Kang, *Sublime Dreams of Living Machines*, page 6, paragraphs 2 – 3.

current, just as his use of the term “magical” signifies the proposed third current, and “preternatural,” the proposed first current.³⁶³ While this thesis would debate Kang’s contention that a “golden age” of automata postdates its own period of interest, in the rest of the passage containing this “golden age” verbiage, Kang does describe this thesis’ proposed sixth current of thought as it existed in its progression from the proposed fifth current in Europe (Kang’s book concerns European history). However, the Islamic world also reached the proposed sixth current in the early thirteenth century, as evidenced by the work of Ridwan, which documents the restoration of an existing monumental automaton clock; and, of course, the early thirteenth century, when both al-Jazari and Ridwan’s respective manuscripts first came into circulation, represents the end of a true “golden age,” that widely acknowledged for the high medieval Islamic civilizations.³⁶⁴

A clear statement of the proposed sixth current in Kang, and one which is not based in semantic interpretation, is afforded by his line that European automata were “...a source of the good kind of wonder that inspired a decorous desire for the discovery and understanding of the worldly order.” This is, essentially, one articulation of the proposed sixth current of thought, and is offered by Kang as a partial restatement of another publication by Daston and Park, for Kang, in mentioning a “good kind of wonder,” references a dichotomy between “good” and “bad” wonder separately established by Daston and Park, and which he had presented in *Sublime Dreams of Living Machines*.³⁶⁵ Following this quote, another is presented, that “While the objects [automata] retained their wondrous aura, they represented the marvels of the machine in the everyday world, devoid of preternatural magic and supernatural entities;” the first half of this statement, to “world,” registers the proposed sixth current, while the second half, ending in “entities,” registers the proposed fifth current. As elsewhere noted, the thesis disagrees with Kang’s chronological placement of this last quote in its broader passage, for while it does apply to the proposed fifth and sixth currents of thought, Kang made it with respect to automata of the eighteenth century. However, as demonstrated by this thesis, figural automata with secular subjects long predate Kang’s timeline, as in the case of Jack Blandifers at Wells Cathedral; and, of course, very many of al-Jazari’s automata play

³⁶³ See Kang, *Sublime Dreams of Living Machines*, page 19: “...the modern usage of the meaning [of ‘automata’] that refers exclusively to the mechanical, a definition that arose in the seventeenth century in the context of the scientific revolution, when the word was established in direct opposition to the magical and the preternatural.”

³⁶⁴ See Kang, *Sublime Dreams of Living Machines*, page 102: “Once denuded of its magical aura, the automaton was then elevated as the single most important emblem of the emerging worldview that envisioned the world, the state, and the body in mechanical terms. So rich and varied as the roles the automaton played in the intellectual and imaginative writings of the Middle Ages and Renaissance, it entered the true golden age of its celebration, popularity, and significant use as both an actual and conceptual object in the following period.”

³⁶⁵ See Kang, *Sublime Dreams of Living Machines*, page 115: “And once deprived of its magic, it [the automaton] became a source of the good kind of wonder that inspired a decorous desire for the discovery and understanding of the worldly order.” For Kang’s presentation of Daston and Park’s work on dichotomous senses of “wonderment,” see *Sublime Dreams of Living Machines*, page 114.

musical instruments, and are all unequivocally secular in creative intention and audience reception, although Kang, whose cited book examines European history, mostly ignores al-Jazari, like many English-language publications on the history of pre-Modern and Early Modern automata.³⁶⁶

There are a variety of other remarks in Kang's book which register this thesis' proposed sixth current of thought. In a later section on a historical era which postdates that of interest to this thesis, automata are positioned as inspirations for technology, which is consistent with how the attitudinal ramifications of the proposed sixth current tend to abet and produce carryover of technology from automata to other material-cultural objects.³⁶⁷ Similarly, the proposed sixth current is identifiable in the introductory scenes of Romain Rolland's "The Revolt of the Machines," while the proposed seventh current is present in its subsequent plot, as summarized by Kang, although as a twentieth-century work, it falls beyond this thesis' bounds.³⁶⁸ As regards Kang's lists of "positive" and "negative" perspectives on automata, the fourth such "positive" perspective possibly registers this thesis' proposed sixth current, and if this interpretation holds, then the fifth such "positive" perspective also registers the proposed sixth current on the same ground. Next, the sixth such "positive" perspective also possibly registers the proposed sixth current, but only in the pre-industrial context with which this thesis concerns itself, not the industrial Victorian and later contexts. In attempting to reconcile Kang's "positive" list with the proposed sixth current of thought, certain of Kang's "positive" perspectives which were not applicable, and/or which only concerned human beings, were omitted.³⁶⁹ Further, of these "positive" perspectives, the eighth and ninth, which Kang consistently represents as the "human transcendence of limits imposed by nature," weakly register the proposed sixth current for automata, but not necessarily for the "biomechanical superman" or "biodigital cyborg," the respective referents of these perspectives, which are not automata by this thesis' definitions. However, the tenth of these perspectives, that automata are "a general symbol of human curiosity, the drive toward knowledge, and mastery over the self as well as the natural environment," strongly registers this thesis' proposed sixth current of thought.³⁷⁰

Kang is not alone in offering an assessment of the attitude, that is, the way of thinking, about automata which is defined by this thesis' proposed sixth current of thought. Grafton writes that "the automaton, like the other dazzling products of fifteenth-century engineering – Brunelleschi's dome, for example, and the new

³⁶⁶ See Kang, *Sublime Dreams of Living Machines*, page 121: "And while the Renaissance engineers built their automata to look like devils, pagan gods, and monsters to enhance their magical effect, Enlightenment mechanics like Vaucanson and the Jaquet-Drozs made them in the shapes of ordinary animals and people engaged in the everyday tasks of writing, drawing, and playing musical instruments. While the objects retained their wondrous aura, they represented the marvels of the machine in the everyday world, devoid of preternatural magic and supernatural entities."

³⁶⁷ See Kang, *Sublime Dreams of Living Machines*, pages 226 – 229.

³⁶⁸ See Kang, *Sublime Dreams of Living Machines*, pages 283 – 286.

³⁶⁹ See Kang, *Sublime Dreams of Living Machines*, page 305, *et seq.*

³⁷⁰ See Kang, *Sublime Dreams of Living Machines*, page 305, *et seq.* The listing of "positive" perspectives is on page 306.

machines he used to construct it – offered a new kind of testimony to the powers of the human intellect,” and this is a profound and incisive statement of the proposed sixth current’s crux under this thesis’ model.³⁷¹ One can construe another remark in Grafton’s article as a similar confirmation of the celebratory attitude towards technology, and specifically automata, which is the hallmark of the sixth current under the proposed model: in discussing the Renaissance humanists Manetti and Alberti, Grafton writes that they “...made clear that machines embodied the creative energy of the human mind at its highest.”³⁷²

Van Dyck, too, in his exhibition guide, delivered assessments of automaton technologies which are consistent with the proposed sixth current of thought. The recognition and valuation of technology, and specifically the horological automaton technology of the Immser clock, as a thing that is itself deserving of admiration, inasmuch as it is “...meant to display the fundamental inventiveness of the human mind,” is a formulation of the proposed sixth current of thought.³⁷³ A feedback loop between the construction of automata and the advancement of science and technology, typically horological technology, also registers the proposed sixth current of thought, a scientific mentality valuing such things as automata because, apart from the status of these objects as testaments to human ingenuity, they usually also represent advancements in practical technology which, in turn, invite still further refinements.³⁷⁴ In this exhibition guide, mention of “scientific and social progress” as intertwined concepts is indicative of the proposed sixth current of thought, but for its continuing applicability to technology as a domain, and not necessarily automaton technology specifically, in the eras succeeding this thesis’ period of study. That point

³⁷¹ See Grafton, “The Devil as Automaton,” page 50: “The terms that Niccolò [di Antonio degli Agli] used here were freighted with meaning. Renaissance engineers insisted that their craft had a powerful intellectual discipline at its core. Their very title, *ingegneri* or *ingeniatores*, designated them as men of the intellect, *ingenium*, as well as creators of clever new devices, *ingenia*. These were the terms that Antonio Manetti, Lorenzo Valla, and other humanists consciously echoed in the praise of human inventiveness that became a motif in the public conversation of the Italian republic of letters from the 1430s onward, a moveable feast of words that changed places and participants more than once. As Niccolò described Constanzo’s feats for Federigo, that great patron of both architecture and engineering, he constructed the lord of Pesaro as an engineer in his own right, a techie Prospero who not only paid for but staged his own masques. By doing so he made clear how brightly the arts of the engineer now glowed in the eyes of patrons and humanists. The automaton, like the other dazzling products of fifteenth-century engineering – Brunelleschi’s dome, for example, and the new machines he used to construct it – offered a new kind of testimony to the powers of the human intellect.”

³⁷² See Grafton, “The Devil as Automaton,” page 59: “And both men [‘Manetti and Alberti’] made clear that machines embodied the creative energy of the human mind at its highest. The chief lesson that the humanists drew from the work of the engineers was clear: the advancing edge of human effort had transformed and was continuing to transform the natural world, both as it was and as it was perceived.”

³⁷³ See Van Dyck, “Under Time’s Spell,” page 76: “An ornamental clock like this [the Immser clock] not only showed every aspect of time, but was above all meant to display the fundamental inventiveness of the human mind.” For the Immser clock, see this thesis’ fourth appendix.

³⁷⁴ See Van Dyck, “Under Time’s Spell,” page 76: “The quest for ways of optimizing these complex mechanisms [including automata] produced, as a by-product, a great increase in the accuracy of clocks.”

bears mentioning because Huygens' pendulum clock, which is the subject of Van Dyck's related discussion, definitely postdates January 1, 1651, although not by very many years. Indeed, the closeness of the juncture between the termination of this thesis' timescale and the development of pendulum clocks (given by Van Dyck as December 1656) suggests the appropriateness of this thesis' cutoff date.³⁷⁵

The last authors included in this section are Riskin and Hill. As has previously been noted, the former remarked, when discussing one of King's cited articles regarding Turriano's automaton monk, that "...human agency was gradually replacing divinity as the source of the spiritual or lively presence within [automata]," a trend also discernible by the years when Giovanni Fontana flourished, as treated by Grafton. As before, this quote can be construed to represent the shift from the conceptualization of automata under the "sacred" first current, as proposed, to the "secular" fifth current, as proposed, and thence to the sixth current, as proposed, in which, under this lattermost current, "human agency" would come to be celebrated in humanistic terms. Of course, this trajectory is appropriate because European automaton instances and history are discussed by Riskin, King, and Grafton, whereas if Asian automata were to be substituted, the second current, as proposed, would replace the fifth current, as proposed, in this trajectory.³⁷⁶ Indeed, as has been noted, automata of the second current did independently reach the sixth current, as exemplified by the work of Ridwan. Hill, whose translations of the Banu Musa and al-Jazari were consulted by this thesis, was quite aware of Ridwan; yet the proposed sixth current is identifiable in the scholarly apparatus for his translation of the Banu Musa's treatise, in which is found the line "...the representation of moving biological and astronomical phenomena had a profound effect upon European scientific thinking, since it led men towards a mechanistic interpretation of the universe." That line of argumentation is immediately identifiable as that advanced in De Solla Price's famous 1964 paper, which is cited by this thesis. While Hill thus offers an excellent precis for De Solla Price, this line is also relevant to this thesis' proposed sixth current of thought, since, as in De Solla Price, a direct connection is made between the appearance of automata and advances in scientific theorization.³⁷⁷

³⁷⁵ See Van Dyck, "Under Time's Spell," page 121: "The measurements of time that were made with the pendulum clocks represented a new ideal image of scientific and social progress. Just as in the Christian salvation history, the future already revealed itself in the present. However, it did this in a fundamentally new way: as a result of continuous human effort. The experience of historical time that underlay [this] no longer attached itself to the model of the sphere, but to the arrow of absolute time." Van Dyck gives the juncture of pendulum clocks' invention, December 1656, on page 111.

³⁷⁶ See Riskin, "Introduction: The Sistine Gap," page 24: "At the same time, King writes, the monk exemplified a shift in the way such images were seen – the same shift chronicled in Grafton's story of the automaton devils of Giovanni Fontana – in which human agency was gradually replacing divinity as the source of the spiritual or lively presence within [automata]." For Fontana's automaton devils, and Turriano's monk automaton, see this thesis' fourth appendix.

³⁷⁷ See The Banu Musa, *Book of Ingenious Devices*, page 23, in Hill's "Historical Context of The Book of Ingenious Devices:" "Equally important, the representation of moving biological and astronomical phenomena had a profound effect upon European scientific thinking, since it led men towards a mechanistic interpretation of the universe." Hill cites De Solla Price in the matching note on page 36 of Hill's published translation of the Banu Musa's treatise.

THE SEVENTH CURRENT OF THOUGHT.

The conjoined development of automata with timekeeping devices, whether clepsydra in the second current of clockwork in the fifth, led to an association with the inevitable outcome of time's measured passage: death. In the fourth chapter of her work *Medieval Robots*, E.R. Truitt discusses how fictitious depictions of medieval technology were deployed to provide the semblance of life to corpses, how magical automata of the third current were emplaced in texts as guardians of crypts to suggest, in at least one instance, a sort of suspended animation for Camille, an entombed Amazon, and how still other fictitious tombs contained magical automata of a more ornamental character. Truitt presents these examples as part of a larger argument which positions the automaton as a liminal entity. Further, as she mentions in her sixth chapter, the figure Death appears in the second astronomical clock of Strasbourg Cathedral; Philip Immser's celebrated astronomical table clock, which is discussed by Silvio Bedini and prominent in Maarten Van Dyck's exhibition guide *Under Time's Spell*, also features the figure of Death. These latter two examples are alike in that they include both Death and other figural automata as representations of *The Ages of Man*, with Immser's clock showing an automaton Death as the marker for the last quarter of each hour, after first showing three phases of man's life for its prior quarters, and with the second Strasbourg Cathedral clock showing both the four phases of man's life every three hours and Jesus Christ combatting Death at the close of each hour.

After the close of the Middle Ages, the continuing use of Death as the metaphoric subject of figural automata on large-scale public clocks and table clocks reinforced an inherent association between all automata and death as a concept, not merely as the black-robed, skeletal character Death, *Der Schnitter Tod*, and this is the seventh current of thought. Much of the "liminality" discussed by Truitt stems from the categorical ambiguity of a convincing automaton as inanimate matter perceived to be living, dead, or neither living nor dead. All of these categories are actually applicable only to matter that is or was at one time alive, even in the last case of the unholy reanimation exemplified by various interpretations of undead beings in works of fiction. The distinguishable artificiality of figural automata constructed as humanoids has continued to unsettle some people in contemporary times, for rather than apprehending the automaton as an exemplification of technological achievement, and therefore as a gauge of societal process per the sixth current, those troubled by the seventh current of thought find automata deathly, frightening, and implicitly threatening.

Such fear is ontological, resting with the disjoint introduced by the very nature of figural (biological) automata as constructs suggestive of living things and, by extension, with sacrilegious and ill-conceived imitation of the divine on the part of the automaton-maker. Masahiro Mori's concept of the "Uncanny Valley," which objectively considers the thresholds for human acceptance of artificial humanoids, demonstrates that robots, or automata for purposes of this paper, arouse the least unease in human viewers when their appearances are obviously artificial or

completely indistinguishable as artificial. When a robot is designed with a humanoid appearance, but its realism is unconvincing, an “uncanny valley” emerges. Mori’s paper thus demonstrates that the anxiety experienced by some people in response to some automata is sufficiently consistent and pervasive as to be an identifiable phenomenon. This fear is relevant to discussion of the seventh current of thought inasmuch as it is similar to the fear of the dead; the “uncanny” automaton is so designated because it suggests a being reminiscent of the human but lacking the characteristics of full life, thereby becoming an effectively dead or quasi-dead construct that nevertheless demonstrates independent motion.

The fourth current of thought reverberates in the seventh, for while Mori’s postulate can explain the revulsion that can be experienced upon encountering some automata, it is more concerned with the offending automaton than the automaton-maker. Yet the automaton-maker is also horrifying in the seventh current of thought, as he (and this figure is invariably male), like the later Romantic character Victor Frankenstein, is believed to have brought forth the automaton, a fearful abomination, as a direct result of his hubristic application or perversion of abstruse knowledge. Of course, in the fourth current of thought, such knowledge is truly arcane, being magical, and the fourth current positions the automaton-maker as a sorcerer.

The fear of automaton-makers and their creations runs thence from Victor Frankenstein, the fictional character, to Isaac Asimov’s articulation of a “Frankenstein Complex” to describe this phenomenon. The fourth current of thought relates to the seventh, and by extension both to Mori’s “Uncanny Valley” and to Asimov’s “Frankenstein Complex,” because the magic associated with automaton-makers by that fourth current is usually “necromancy,” the branch of magic involving the dead. While the conflation of automata with death is certainly comprehensible as an extension of the lifelessness of automata in the biological sense of cellular respiration, this connection is argued to have a deeper basis than this superficial explanation, a basis in automaton figures of Death on timekeeping pieces as a visual representation of human mortality.

EXAMPLES OF THE SEVENTH CURRENT OF THOUGHT.

In the late Middle Ages, as has already been noted, "...hell is a realm of the technological grotesque," at least under O'Brien's analysis. The passage in which this statement was made suggests this thesis' proposed third and fourth currents, as well as the proposed seventh current, for it relates to the possible afterlife of hell, a metaphysical realm only encountered in its horrific fullness after one's death as an unrepentant sinner.³⁷⁸ A possible contributing factor to the emergence of the specific association between biological automata and death, rather than between technology and hell as respective concepts, is what Swift, referencing the work of Masahiro Mori, calls the "nebulous perceptual realm between life and death, animation and stillness."³⁷⁹ Swift's article concerns "robot saints," and as regards that phrase, and another, "sacred robots," Swift's interest corresponds with this thesis' proposed first current of thought. However, his argumentation is interesting, as it also relates to the proposed seventh current of thought. A corollary to Swift's argument, which he gives in reverse, is that as "scientific or ontological certitude" respective to automata increased in accordance with the scientific advancements achieved by the early to mid-seventeenth century, Mori's "nebulousness" began to emerge, heightening the apprehension of the proposed seventh current, a visceral sense of unease and dread, that is, the fear of death, when confronted with an automaton.³⁸⁰ Thus, automata only become "creepy," Kang's term, when understood as works of technology existent beyond any connection with sacred ritual and the preternatural world, whether with forces of preternatural good or evil.³⁸¹ In this interpretation, which is an attempt to resolve the conflict between O'Brien and Swift's arguments, it would seem that an automaton believed to have been animated by a demon, or a hellscape filled with works of technology, could perhaps be fearsome, but not frightening in the way proposed by Mori; for, after all, the pre-Modern and Early Modern mind could well comprehend these ideas, but per Swift, this mentality would probably find a living, sentient consciousness defined by artificiality, and which was neither an angel, nor demon, nor mortal, truly horrifying due to its incomprehensibility, in a kind of cosmic, Lovecraftian sense.

A statement of the proposed seventh current of thought is seen in Kang, who wrote "...if one grants life, even a semblance of it, to what began as a lifeless thing,

³⁷⁸ See O'Brien, "Ars-Metrik," page 6: "In both Limbourg's and Brueghel's pictures hell is a realm of the technological grotesque."

³⁷⁹ See Swift, "Robot Saints," page 53: "'Autonomous' androids – robots – occupy a nebulous perceptual realm between life and death, animation and stillness: Japanese roboticist Masahiro Mori called this between space the 'uncanny valley' that conditions our responses especially to anthropomorphic automata."

³⁸⁰ See Swift, "Robot Saints," page 54: "If we frame the sacred robots within the specific devotional experience of materiality in late medieval Europe, a different interpretation emerges: due to the absence of scientific or ontological certitude about technological and biological differences in the medieval period, beholders may not have perceived the moving statues as in any way uncanny [contra Mori]."

³⁸¹ See Kang, *Sublime Dreams of Living Machines*, page 2.

there is always a possibility that it will go beyond one's control, to flee or to revolt," which articulates the conceit of the proposed seventh current, that the automaton, as a dead ("lifeless") thing brought to life, will become the bringer of death ("lifelessness") to the living, which accords with Asimov's Frankenstein Complex.³⁸² Additional information consistent with the proposed seventh current thought is provided elsewhere in Kang.³⁸³ For example, he presents a quote from Gaby Wood in which the automaton is presented as a "memento mori."³⁸⁴ In referencing both Wood and Victor Turner, the automaton concept is made analogous to that of the "zombie, living mummy, or vampire," an observation based in the liminal nature of automata.³⁸⁵

That the type of magic most associated with automata in the pre-Modern context was necromancy is noted by Truitt in her publications, especially *Medieval Robots*, but also by Kang, who, when discussing fictive automata, such as those in the *Perlesvaus* (surely some of the deadliest and most violent automata in the European romance tradition), writes that "...automata also appear as the products of diabolical magic practiced by evil witches and warlocks, especially in the form of 'necromancy,' a condemned form of magic associated with the raising of the dead and the summoning of demons." For the specific automata in the *Perlesvaus*, and pre-Modern and Early Modern automata generally, the proposed third current is indicated by the consideration of magic as a concept intersecting this thesis' topic, and the proposed seventh current by the like consideration of death.³⁸⁶ This latter association

³⁸² See Kang, *Sublime Dreams of Living Machines*, page 21: "...a perennial theme in the ancient and modern works... if one grants life, even a semblance of it, to what began as a lifeless thing, there is always a possibility that it will go beyond one's control, to flee or to revolt."

³⁸³ See Kang, *Sublime Dreams of Living Machines*, pages 51 – 52: "In addition to these authors' [Mori, and MacDorman and Ishiguro] empirical study of this issue, one can find many literary instances of this link between automata and death. In E.T.A. Hoffman's story 'The Automaton' (1814) the character Ludwig, shaken by viewing an uncanny automaton, decries such objects as those of 'living death or inanimate life;' and in William Saroyan's novel *The Human Comedy* (1943) a little boy is entranced by an automaton named Mr. Mechano at a shop window, until night falls and he suddenly takes fright at the object: 'He looked around, feeling a deep silent steady horror about all things – the horror of Mr. Mechano – Death!'" Citations for these works are provided by Kang in his eighty-first endnote.

³⁸⁴ See Kang, *Sublime Dreams of Living Machines*, page 52. The key line from Wood's passage, provided by Kang as a block quote and cited by him in his eighty-second endnote, is the last one, containing the "memento mori" phrase: "Rather than being copies of people, androids are more like memento mori, reminders that, unlike us, they are forever unliving, and yet never dead."

³⁸⁵ See Kang, *Sublime Dreams of Living Machines*, page 52: "The uncanny automaton is more akin to a zombie, a living mummy, or a vampire, as it crosses the categories of animate/inanimate, living/dead (as intimated in the passage from Wood above) and so threatens our reality schema in a particularly frightening way. So when a person finds an automaton particularly eerie, it is often expressed in terms of how one might feel if faced with an undead creature. The connection in this case is their common status as liminal entities, which as Victor Turner pointed out are often likened to the dead and the monstrous."

³⁸⁶ See Kang, *Sublime Dreams of Living Machines*, pages 64 – 65: "Second, in contrast to those positive depictions, automata also appear as the products of diabolical magic practiced by evil witches and warlocks, especially in the form of 'necromancy,' a condemned form of magic associated with the

between death and automata as concepts has persisted to the present day of this thesis' publication, but unlike many cases, where such an observation is merely rhetorical, or a case of presentism, evidence is seen in the centuries succeeding this thesis' period of interest that demonstrates, unambiguously, how the same identification of automata with death has stubbornly endured. For example, Kang quotes lines from Ludwig Archim von Arnim's Romantic novel *The Poverty, Wealth, Guilt and Atonement of Countess Dolores*, published 1810, which contains an episode with fictionalized versions of real-world automata, just like the medieval romances; and these lines show the fear of automata, ultimately a fear of death, which is in agreement with this thesis' proposed seventh current of thought.³⁸⁷

This fear of death can extend beyond the personal level and become applicable to communities of any scale, including the entire globe, in which case the proposed seventh current of thought is evident in the latter-day dystopian science fiction stories based in an imagined "robot apocalypse," which have existed in some form since at least the twentieth century, and which remain present in contemporary speculative fiction as a recognizable trope. However, as Kang notes, fears of a personal or civilizational death orchestrated by robots, which are the modern successors of automata, and which are usually an interchangeable, equivalent concept in Kang's analyses of works by Romain Rolland and Karel Capek, is little more than a form of projection, in which all things consistently understood as evil by humankind are imputed by humankind to any material being and consciousness of humankind's own technological creation, despite the realization of robots, as they exist in science fiction, remaining to be seen; recent advances in robotics and artificial intelligence make the imminent appearance of such robots a likelier proposition, however, than was even the case at the turn of this present century.³⁸⁸ It is likely for this reason, a tendency of human psychology, that the proposed seventh current persists and remains readily observable in popular culture.³⁸⁹

raising of the dead and the summoning of demons." For Truitt, see her section "The Quick and the Dead" in *Medieval Robots*.

³⁸⁷ See Kang, *Sublime Dreams of Living Machines*, page 216. Kang quotes the following lines from von Arnim's novel, citing them in his eighty-fifth endnote: "...of being entirely strange and alone under the power of unfeeling machines [fictitious representations of Vaucanson's biological automata, the famous duck and humanoid flautist], which, created by man, could easily get the upper hand over him."

³⁸⁸ See Kang, *Sublime Dreams of Living Machines*, page 285 – 286: "Modern technology is problematic in its capacity to multiply our power, but the root of its destructive force lies in ourselves, and its danger will continue as long as we are unable to control our own violent impulses... ..in Capek's and Rolland's narratives, their [robots'] behavior is linked directly to human nature, their rebellion and will to power [a Nietzschean term] reflecting their creators' inner desires."

³⁸⁹ See Kang, *Sublime Dreams of Living Machines*, page 297. The fictive robot Bender, from the animated television series *Futurama*, is quoted by Kang: "I came here with a simple dream. A dream of killing all humans." Bender's frequent utterance of the phrase "kill all humans" is a satirical acknowledgement of the proposed seventh current's pervasiveness in depictions of humanoid automata and robots, even in a time far removed from pre-Modernity and Early Modernity, the twenty-first century. As demonstrated by the instances in this thesis' fourth appendix, the seventh current has had

Kang himself participates in the idea of the proposed seventh current of thought, which extends onward from the medieval romances into the present, by postulating one possible outcome which could occur after the emergence of a true artificial intelligence, “inevitable confrontation,” but in his own contemporary times (2011, when his cited book was published), not the Middle Ages or Renaissance.³⁹⁰ As regards the lists of positive and negative views of automata which conclude *Sublime Dreams of Living Machines*, and to which this thesis has returned in its several presentations of the proposals comprising elements of its own model, the “negative” listing is applicable to the proposed seventh current of thought. In it, the first “negative” perspective relates to this thesis’ proposed third, fourth, and seventh currents; the sixth “negative” perspective relates to this thesis’ proposed third and seventh currents; the seventh “negative” perspective coincidentally relates to this thesis’ proposed seventh current; and the tenth “negative” perspective also relates to this thesis’ proposed seventh current. Certain of Kang’s “negative” perspectives which only concern human beings are omitted from these identifications.³⁹¹ For the first of these “negative” perspectives, Grafton’s presentation of Fontana’s skeleton automaton is an apt example. The topos of death signified by skeletal remains registers the proposed seventh current of thought, but this presentation of an automaton from Fontana is included in a broader presentation of Fontana’s participation under the proposed fourth current as an automaton-maker.³⁹²

One of the foremost authors to discuss the relationship between the concepts of death and automata, or robots, is Masahiro Mori, whose work is cited by Kang. Mori’s thesis associates automata with death because, as he describes, an artificial humanoid figure which is realistic, but not perfectly realistic (something yet to be achieved, at least as regards automata and robotics), will tend to disturb people, for the imperfection of its attempt to simulate the human person is treated by the human

incredible longevity as a durable association, doubtless due to the unchanged perceptual and psychological phenomena which underlie it in the human population.

³⁹⁰ See Kang, *Sublime Dreams of Living Machines*, page 300: “In our time, there are three contending views on the fate of humanity in the age of digital technology in which the robot is often used for conceptual and imaginative purposes. I will call these notions the theories of inevitable confrontation, of equivalence through sentience, and of cybernetic emergence.”

³⁹¹ See Kang, *Sublime Dreams of Living Machines*, page 305 *et seq.* Unlike the other sections, these “negative” perspectives will be quoted verbatim, as they are very useful in understanding this thesis’ proposed seventh current of thought. The first of Kang’s “negative” perspectives holds the automaton as “a diabolical idol of demonic possession or necromantic knowledge,” with the necessary connection between necromancy and death registering the proposed seventh current; the sixth “negative” perspective holds the automaton as “an uncanny object that may be animated by a supernatural force that could endanger the sanity of an individual and the stability of a society;” the seventh “negative” perspective holds the automaton as “a destructive and frightening monster of superhuman power and irrational will;”

³⁹² See Grafton, “The Devil as Automaton,” pages 54 – 55: “Necromancers raised the dead. A wooden skeleton linked by cords to a wheel and an escapement, Fontana explained, would appear to move its members, ‘just as the figures in mechanical clocks do.’ Tongue firmly in cheek, he called this design, perhaps destined for a clock, ‘resurrectio mortuorum artificisosa’ – ‘a crafty way to bring the dead back to life.’”

mind, upon apprehension through its sensory apparatus, as someone who is diseased, or actually a corpse. This point triggers the association between death and automata that defines the seventh current under this thesis' proposed model.³⁹³ The term "Death" is present in "Figure 2," a diagram showing Mori's "Uncanny Valley" model in an authoritative translation of his original publication, and the facing text for this diagram reads as follows: "Figure 2. The presence of movement steepens the slopes of the uncanny valley. The arrow's path in the figure represents the sudden death of a healthy person."³⁹⁴ The continuation of this same passage, still describing the diagram, reads "Therefore, our death can be regarded as a movement from the second peak (moving) to the bottom of the uncanny valley (still), as indicated by the arrow's path in Figure 2. We might be glad this arrow leads down into the still valley of the corpse and not the valley animated by the living dead!" Of course, there is no such thing as the "living dead" in point of fact, but therein lies one basis of the association of automata with death, and therefore, one basis of the seventh current under the proposed model, which is namely that automata are inanimate objects that move, and, as such, have an incongruous semblance of life (or "quickness"), which is discussed at length by Truitt in *Medieval Robots*.³⁹⁵

Another basis of the association between automata and death, as a concept, was the emergent aesthetic of Death, as a figural subject, in automata relating to timekeeping, where allegorical Grim Reapers and suchlike representations accentuated the relationship between the passage of time and the fact of human mortality; but this thesis would argue that a broader association formed, regardless of the allegorical identity and/or costuming of any given automaton figure, between the action of a horological automaton, its marking of time's endless march, and one's unavoidable death, which would surely cast a pall over all automata designed to sound or otherwise denote the hours, even the cheerful automata of this thesis' proposed second current. Van Dyck offers a remark on the connection between timekeeping and the concept of human mortality, which would, in turn, inform the figural trend towards morbid subjects and imagery in automata, and especially horological automata, by this thesis' interpretation, whereas these figures, in pre-Modernity and some portion of Early Modernity, had originally tended to be harmless, and even happy, depictions of people and animals: "There was however an inescapable limit to the mathematical mastery of time by astronomy. It was impossible to calculate the moment of everybody's inevitable death."³⁹⁶

³⁹³ See Mori, "The Uncanny Valley," page 1 in the author's printed copy.

³⁹⁴ See Mori, "The Uncanny Valley," page 4 in the author's printed copy. The translators made the following interpolation: "[Translators' note: *Noh* is a traditional Japanese form of musical theater dating from the 14th century in which actors commonly wear masks. The *yase otoko* mask bears the face of an emaciated man and represents a ghost from hell. The *okina* mask represents an old man.]"

³⁹⁵ See Mori, "The Uncanny Valley," page 7 in the author's copy, and Truitt's *Medieval Robots*, especially that section in *Medieval Robots* called "The Quick and the Dead."

³⁹⁶ See Van Dyck, "Under Time's Spell," page 35: "There was however an inescapable limit to the mathematical mastery of time by astronomy. It was impossible to calculate the moment of everybody's inevitable death. The possibility of abandoning the human perspective always came up against this

While scientific instrumentation is a distinct class of material culture which does not include automata by this thesis' definitions, unless, by chance, an instrument bears an automaton that accords with these same definitions, Van Dyck presents both an automaton clock, and a variety of scientific instruments, in his exhibition guide, for automata and fine instrumentation were conceptually and practically related in the pre-Modern and Early Modern periods, which is uncontroversial. Among the non-automaton instruments in Van Dyck's guide is an armillary sphere inscribed with the Latin phrase *mors vivet*, "death lives," bespeaking the morbid concern with death which came to accompany the scientific quest for knowledge, humbling the scientist, his goals, and his methods.³⁹⁷ It is this same expression of transience which Van Dyck presents in "...the destroyed clock, evidence of the vanity of the human ambition to master time." Such a clock emblemizes the transition from this thesis' proposed sixth current to its proposed seventh current, the grim knowledge that, despite the celebration and appreciation of technology, all things other than time itself are finite, and have their end; for the march of history is rarely an unbroken progression, but is more often divided by the rises and falls of civilizations, and correspondingly, by the rises and falls of the technologies associated with these civilizations.³⁹⁸

The "destructive shadowy side" of time, a phrase from Van Dyck, is nothing more or less than death, the proposed seventh current of thought as regards automata, whether the biological death of human mortality, or the conceptual conclusion attending all things, whether animate or inanimate, which are brought into existence. Because human life is finite, coming into and out of existence for an interval that is unknowable, except by demographic and statistical methods, the measurement of time can be morbid, since the passage of time is inexorable. As discussed in this thesis, the measurement of time usually led to the development of automaton technologies, causing figural automata to commonly become horological features; and, given that timekeeping, morbidly, observes the proverbial march to the grave, both for individuals and civilizations, it is unsurprising that automata were sometimes made with the imagery of death, especially during the early seventeenth century, the final decades under consideration by this thesis, which, apart from the two world wars, were some of the bloodiest in human history.³⁹⁹

limitation. This drawing by the young Rubens, after a print from Hans Holbein's *Dance of Death*, warned the astronomer that he should always be aware of this."

³⁹⁷ See Van Dyck, "Under Time's Spell," page 36: "The two armillary spheres from the Renaissance [at the Austrian Museum of Applied Arts/Contemporary Art, and at the Galerie Delalande, Paris], which we have already seen, bore a similar message. One of them was carried by the winged personification of time with a scythe in its hand. The other wore a medallion with the inscription *mors vivet*, 'death lives.' Everyone who looked at an armillary sphere became aware of his finitude." For Wood, as presented in Kang, see prior footnote no. 385.

³⁹⁸ See Van Dyck, "Under Time's Spell," page 86: "Time was not only a symbol of a dazzling order, but also had a destructive shadowy side. Nothing expresses this better than the destroyed clock, evidence of the vanity of the human ambition to master time."

³⁹⁹ See Van Dyck, "Under Time's Spell," page 86: "Time was not only a symbol of a dazzling order, but also had a destructive shadowy side. Nothing expresses this better than the destroyed clock, evidence of the vanity of the human ambition to master time." Consider the Thirty Years' War.

CONCLUSION.

The Clock of the Nations, when it opened to the public in 1962, is a monumental clock, replete with automata, that would have been recognizable to all the builders of pre-Modern and Early Modern automata, and to their audiences, as an entry in the same tradition of material culture which both these builders and audiences knew and admired. Were every engineer, every craftsman, every artist, every mechanic, and every patron who contributed to the grand automata tradition, which spanned the Old World in the pre-Modern and Early Modern eras, spontaneously resurrected, each in their prime, and simultaneously gathered at the Clock of the Nations' premiere, it would not be an alien object to any of these individuals, but rather an article of wonderment comprehensible in its spectacle of grandeur and display of skill. And, so far as this thesis is concerned, every representative of the many "nations" corresponding to the automaton-building civilizations documented under the appendices would not, hopefully, squabble amongst themselves when confronted, together, by The Clock of the Nations, but would rather, provided with the mutual intelligibility of tongues, work in concert to study its appearance, analyze its design and workings, and come to an appreciation of the device, even with a view to its reproduction. They would surely, immediately understand the sight before their eyes; and if transposed into even the decades of the middle twentieth century, such a convocation could surely achieve stupendous feats, inspired by The Clock of the Nations in the fullness of its first operation.

The proposed model is intended to describe pre-Modern and Early Modern automata, and is not necessarily extensible to the automata of other periods, or to other varieties of high technology. However, since it is the contention of this thesis that there is continuity between the Clock of the Nations and the pre-Modern and Early Modern clocks of the Old World, it is possible to describe the Clock of the Nations in this model's terms. While any such attempt must be subject to much interpretative subjectivity, and not least because the Clock of the Nations is itself not a work of pre-Modern or Early Modern technology, it can at least be said that, with an evident degree of intentionality on the parts of its designers, its motif of tilework, and situation in close proximity to a public, well-defined leisure space which also incorporated fountains, recalls this thesis' postulated second current of thought, with the Midtown Mall then also reminiscent of the pleasure pavilions which accompanied sites of Islamic culture during its Golden Age; that, as a work of a Midcentury Modern American culture still very much informed by Transatlantic cultural identifications, it registers this thesis' postulated fifth current of thought, having a basis in one polity to ultimately emerge from European settlement in the final decades of scholarly interest to this publication; and that, as an object found marvelous by contemporary audiences as an achievement of technology, both in the general and horological senses, and which was deemed worthy of conservation and restoration in the century succeeding that of its first appearance, The Clock of the Nations also registers this thesis' postulated sixth current of thought. In analyzing its presentation and function, there is no meaningful and reasonable case to be made in argument for the

Clock of the Nations' registration of the thesis' postulated seventh current of thought, and neither may intuitive cases be advanced for registrations of the postulated first, third, or fourth currents in the case of this device.

It is hoped that this thesis' work is of use in forming an understanding of the little-known history of the pre-Modern and Early automaton, which, for much of its existence, was a species of pneumatic and hydraulic technology, although after European advances in clockwork which occurred during this thesis' periods of interest, it remains most strongly associated with kinetic technologies. The understanding formed through this thesis' narrative model encompasses many different cultures and times, and is a synthesis of the ideas associated with automata which was created by analyzing the trends which surrounding the same over a long span of years, as well as the material culture represented by automata and automaton-bearing devices. In the unity formed by this thesis' model, and the appellations to visible trends which it applies, it is thought that future scholars may see some benefit from the expenditure of effort devoted to this work.

Christopher P. Pursel

Le Roy, New York, United States of America

Common Year 2025



VITA.

Christopher Patrick Pursel was born in Rochester, New York and has lived most of his life in Le Roy, New York, where he graduated from Le Roy Junior/Senior High School in the year 2008, earning an Advanced Regents Diploma with Honors. He attended the State University of New York College at Geneseo from the years 2008 to 2012, earning a Bachelor of Arts degree in History with documented English, Medieval Studies, and Philosophy minors in the year 2012. From the years 2013 to 2015, he completed coursework for a dual matriculation in the combined Master of Science in Information Science and Master of Arts in History program offered by the University at Albany, State University of New York, earning the former degree in the year 2015, with an Information Systems and Technology Concentration, after interning at the Rochester, New York offices of Paychex, Inc. He resumed work on his Master of Arts degree at the State University of New York College at Brockport in the year 2018, completing a second internship at the Western Monroe Historical Society's interpretative site, the Morgan-Manning House, in the year 2020. He is an Eagle Scout, a Roman Catholic, and enjoys musical and visual culture. As of February 2024, he is the IT Supervisor at Six Flags Darien Lake, the sole full-time member of staff for his department.

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ADDENDUM: STATEMENTS DELIVERED AT PUBLICATION, 2026.

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On submission for grading, the author's primary and secondary readers found that two of four hundred footnotes in the thesis document were blank. This copy expurgates one of these two blank footnotes and completes the other.

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THE APPENDICES:

This thesis contained four appendices, which together comprised more than one thousand pages of additional textual sections, diagrams, and charts, besides a further four hundred and nine footnotes in the fourth appendix. Despite references to these appendices in the thesis' argumentation, SUNY is only publishing the thesis' main text, which is the first of its three volumes. By arrangement, the four appendices, which comprise the second and third volumes, are freely available on the author's private website, <https://www.christopherppursel.com/index.html>.

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