Machines in the Garden

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WHAT DOES IT MEAN TO BE ALIVE AND CONSCIOUS: an aware, thinking creature? Using life-like machines to discuss animation and consciousness is a major cultural preoccupation of the early twenty-first century; but few realize that this practice stretches back to the middle of the seventeenth century, and that actual lifelike machines, which peopled the landscape of late medieval and early modern Europe, shaped this philosophical tradition from its inception. By the early 1630s, when René Descartes argued that animals and humans, apart from their capacity to reason, were automata, European towns and villages were positively humming with mechanical vitality, and mechanical images of living creatures had been ubiquitous for several centuries. Descartes and other seventeenth-century mechanists were therefore able to invoke a plethora of animal- and human-like machines. These machines fell into two main categories: the great many devices to be found in churches and cathedrals, and the automatic hydraulic amusements on the grounds of palaces and wealthy estates.

Neither category of contraptions signified, in the first instance, what machine metaphors for living creatures later came to signify: passivity, rigidity, regularity, constraint, rote behavior, soullessness. Rather, the machines that informed the emergence of the early modern notion of the human-machine held a strikingly unfamiliar array of cultural and philosophical implications, notably the tendencies to act unexpectedly, playfully, willfully, surprisingly, and responsively.

Moreover, neither the idea nor the ubiquitous images of human-machinery ran counter to Christian practice or doctrine. Quite the contrary: not only did automata appear first and most commonly in churches and cathedrals, the idea as well as the technology of human-machinery was indigenously Catholic. The church was a primary sponsor of the literature that accompanied

the technology of lifelike machines, and the body-machine was also a recurrent motif in Scholastic writing.[1]

Automata were therefore theologically and culturally familiar, things with which one could be on easy terms. They were funny, sometimes bawdy, and they were everywhere. To understand what Descartes and other seventeenth-century mechanists did with the idea of animal and human machinery, one needs to take into account its familiarity and pre-existing meanings. 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.

I. *DEUS QUA MACHINA*

A mechanical Christ on a crucifix, known as the Rood of Grace, drew great flocks of pilgrims to Boxley Abbey in Kent during the fifteenth century. This Jesus, which operated at Easter and the Ascension, "was made to move the eyes and lipps by stringes of haire."[2] Moreover, the Rood was able

> to bow down and lifte up it selfe, to shake and stirre the handes and feete, to nod the head, to rolle the eies, to wag the chaps, to bende the browes, and finally to represent to the eie, both the proper motion of each member of the body, and also a lively, expresse, and significant shew of a well contented or displeased minde: byting the lippe, and gathering a frowning, forward, and disdainful face, when it would pretend offence: and shewing a most milde, amiable, and smyling cheere and countenaunce, when it woulde seeme to be well pleased.[3]

Even before approaching the Rood for benediction, one had to undergo a test of purity administered by a remote-controlled saint:

> Sainct Rumwald was the picture of a pretie Boy sainct of stone . . . of it selfe short, and not seeming to be heavie: but for as much as it was wrought out of a great and weightie stone . . . it was hardly to be lifted by the handes of the strongest man. Neverthelesse (such was the conveighance) by the helpe of an engine fixed to the backe thereof, it was easily prised up with the foote of him that was the keeper, and therefore, of no moment at all in the handes of such as had offered frankly: and contrariwise, by the meane of a pinne, running into a

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[1] Aquinas himself proposed that animals might be regarded as machines some four centuries before Descartes and in strikingly similar terms. Thomas Aquinas, *Summa Theologica*, Prima Secundæ Partis, Qu. 13, Art II, Reply obj. 3.

[2] Charles Wriothesley, *A Chronicle of England During the Reign of the Tudors, 1485–1559*, ed. William Hamilton (London: Printed for the Camden Society, 1875), 1:74. On the Boxley Abbey Rood of Grace, see also Alfred Chapuis and Edouard Gélis, *Le Monde des Automates* (Paris, 1928), 1:95; and Michael Jones, "Theatrical History in the Croxton *Play of the Sacrament*," *ELH* 66, no. 2 (1999): 243–44.

[3] William Lambarde, *A Perambulation of Kent: Conteining the Description, Hystorie, and Customes of that Shire. Written in the Yeere 1570. by William Lambarde of Lincolns Inne Gent.*, ed. Richard Church (Bath: Adams and Dart, 1970), 205–6. See also Wriothesley, *Chronicle of England*, 1:75; Edward, Lord Herbert of Cherbury, *Life and Reign of King Henry the Eighth, together with which is briefly represented A general History of the Times* (London: Mary Clark, 1683), 494. "The 24 of February being Sonday, the Rood of Boxeley in Kent, called the Rood of Grace, made with divers vices, to move the eyes and lips, was shewed at Pauls Crosse by the Preacher, which was the Bishop of Rochester, and there it was broken, and plucked in pieces." John Stow and Edmund Howes, *Annales, or, a generall chronicle of England. Begun by John Stow: continued and augmented with matters forraigne and domestique, ancient and moderne, unto the end of this present yeere, 1631* (London: [Printed by John Beale, Bernard Alsop, Thomas Fawcett, and Augustine Mathewes] impensis Richardi Meighen, 1632), 575.

post . . . it was, to such as offered faintly, so fast and unmoveable, that no force of hande might once stirre it.[4]

Having proven your "cleane life and innocencie" at the hands of the rigged Saint Rumwald, you could proceed to the mechanized Jesus. Automaton Christs—muttering, blinking, grimacing on the cross—were especially popular.[5] One, a sixteenth-century Breton Jesus, rolled his eyes and moved his lips while blood flowed from a wound in his side. At his feet, the Virgin and three attendant women gesticulated, while at the top of the Cross, a head symbolizing the Trinity glanced shiftily from side to side.[6]

Mechanical devils were also rife. Poised in sacristies, they made horrible faces, howled and stuck out their tongues to instill fear in the hearts of sinners. The Satan-machines rolled their eyes and flailed their arms and wings; some even had moveable horns and crowns.[7] A muscular, crank-operated devil with sharply pointed ears and wild eyes remains in residence at the Castello Sforzesco in Milan.[8]

There were also automaton angels. A host of these, in one Florentine festival, carried the soul of Saint Cecilia up to heaven.[9] For the feast of the Annunciation at San Felice, the fifteenth-century Florentine architect Filippo Brunelleschi sent the archangel Gabriel in the reverse direction in a mechanical "mandorla," an almond-shaped symbol in which two merging circles represent heaven and earth, matter and spirit. Brunelleschi, a master of holy mechanics (*ingegni*), mechanized heaven too. His mechanical paradise was "truly marvellous . . . for on high a Heaven full of living and moving figures could be seen as well as countless lights, flashing on and off like lightning."[10]

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[4] Lambarde, *Perambulation of Kent*, 209–10.

[5] Later examples of automaton Christs include an eighteenth-century one in Dachau, Germany, that has human hair. Hidden in its beard are strands that control the movements of the eyes, mouth, and head. Another, in Limpias, Spain, moves its lips, rolls its eyes, blinks, and grimaces. See Chapuis and Gélis, *Le Monde des Automates*, 2:95–96; 1:104. On mechanized Passions, see also Johannes Tripps, *Der Handelnde Bildwerk in der Gotik* (Berlin: Gebr. Mann, 1998), 159–73 and plates 10e and f, pp. 292–93; plates 42a and b, p. 325; plate 43a, p. 326.

[6] Chapuis and Edmond Droz, *Automata: A Historical and Technological Study*, trans. Alec Reid (Geneva: Editions du Griffon, 1958), 119–20.

[7] Some mechanical devils are depicted in drawings by the fifteenth-century engineer, Giovanni Fontana, Bayerische Staatsbibliothek Cod.icon. 242 (MSS. mixt. 90), 59vo—50ro; printed in Eugenio Battisti and Giuseppa Saccaro Battisti, *Le macchine cifrate di Giovanni Fontana* (Milan: Arcadia, 1984), 134–35. On Fontana's automaton devils, see especially Anthony Grafton, "The Devil as Automaton," in *Genesis Redux: Essays on the History and Philosophy of Artificial Life*, ed. Jessica Riskin (Chicago: University of Chicago Press, 2007), chap. 3. See also Chapuis and Gélis, *Le Monde des Automates*, 2:97–101.

[8] I am indebted to Paula Findlen for bringing this devil to my attention.

[9] Alessandro D'Ancona, *Origini del teatro in Italia* (Firenze: Successori le Monnier, 1877), 1:424; D'Ancona, *Sacre rappresentazioni dei secoli XIV, XV e XVI* (Firenze: Successori le Monnier, 1872), 2:321; Philippe Monnier, *Le Quattrocento, essai sur l'histoire littéraire du XVè siècle italien* (Paris: Perrin et Cie, 1908), 2:204.

[10] Giorgio Vasari, *Lives of the Most Eminent Painters, Sculptors & Architects*, trans. Gaston de Vere. (London: Philip Lee Warner, 1912–14), 2:229–32. On Brunelleschi's and other *ingegni*, see Frank D. Prager and Gustina Scaglia, *Brunelleschi: Studies of His Technology and Inventions* (Cambridge, MA: MIT Press, 1970); Paolo Galluzzi, *Gli ingegneri del Rinascimento da Brunelleschi a Leonardo da Vinci* (Bolognia: Istituto e Museo di storia della scienza, 1996); and Anthony Grafton, "From New Technologies to Fine Arts," in *Leon Battista Alberti: Master Builder of the Italian Renaissance* (Cambridge, MA: Harvard University Press, 2000), chap. 3. Jacob Burkhardt was scathing on the subject of the *ingegni*: the drama, he said, "suffered from this passion for display," in Burkhardt, *The Civilization of the Renaissance in Italy* (1860; London: Penguin, 1990), 260. The moving figures in heaven that Vasari mentions were in fact little boys; nevertheless he considers them as components in an overall work of "machinery." The paradise apparatus was so heavy that it pulled down the roof of the Carmine monastery where it was installed and necessitated

Brunelleschi was outdone in the second half of the century by Cecca (Francesco D'Angelo), who engineered Christ's Ascension at the Church of Santa Maria del Carmine. Here, where Christ was borne aloft on "a Mount very well made of wood" the "said Heaven was somewhat larger than that of S. Felice in Piazza." Moreover, the festival planners added a second heaven over the chief tribune, with "certain great wheels" that "moved in most beautiful order ten circles standing for the ten Heavens." These were filled with stars: little copper lamps suspended from pivots so that they would remain upright as the heavens turned. Two angels stood on a platform suspended from pulleys.

> These angels, when a little rope was unwound from the Heaven above, came down the two larger ropes . . . and announced to Christ that He was to ascend into Heaven, and performed their other functions. And since the iron to which they were bound by the girdle was fixed to the platform on which they stood, in such a way that they could turn round and round, they could make obeisance and turn about both when they had come forth and when they were returning . . . ; wherefore in reascending they turned towards the Heaven.[11]

The heavenly machinery was balanced beneath by engineered hells. The Passion play at Valenciennes in 1547 featured a hell with a "great mouth" specially rigged for "opening and closing when needed."[12] Another mechanical inferno's moving gates gaped ajar amid rumbling thunder and flashes of lightning to spew forth writhing automaton serpents and dragons.[13]

A menagerie of mechanical beasts played in religious theater, especially the mammoth mystery plays. A mechanical bear menaced David's sheep.[14] Daniel's lions gnashed their teeth,[15] and more lions knelt before Saint Denis.[16] Balaam's ass balked and swerved before the angel of the

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the monks' departure. See Vasari, *Lives of the Most Eminent Painters*, 2:229. On moving Annunciations, see also Tripps, *Der Handelnde Bildwerk*, 84–88.

[11] See Vasari, *Lives of the Most Eminent Painters*, 3:194–96.

[12] Bibliothèque nationale de France (hereafter cited as BNF), MS. Fr. 12536; Gustave Cohen, *Histoire de la mise en scène dans le théâtre religieux français du moyen âge* (Paris: Champion, 1926), 97; Chapuis and Droz, *Automata*, 356–57.

[13] D'Ancona, *Origini del teatro*, 1:424; D'Ancona, *Sacre rappresentazioni*, 2:135, 232; Monnier, *Le Quattrocento*, 2:204. These mechanized performances were elaborations of an older tradition of religious puppet shows, or "motions." An individual puppet might also be called a "motion," and the puppeteer was known as the "motion master." William Lambarde described a motion that took place in Witney, in Oxfordshire, in which the priests used articulated figures to enact the Resurrection. These puppets might have included some mechanized features. The figure of the waking watchman who saw Christ rise made a continuous clacking noise that earned him the nickname "Jack Snacker of Wytney." See Lambarde, *Dictionarium Angliæ topographicum & historicum. An alphabetical description of the chief places in England and Wales; with an account of the most memorable events which have distinguish'd them. By... William Lambarde... Now first publish'd from a manuscript under the author's own hand* (London: F. Gyles, 1730), 459; and William Hone, *The Every-Day Book and Table Book* (London: William Tegg, 1825–27), entry for September 5, 1825, entitled "Visit to Bartholomew Fair."

[14] *Le mistère du viel testament*, ed. James de Rothschild (Paris: Firmin-Didot, 1878–91), 4:112; Cohen, *Histoire de la mise en scène*, 147. *The Mystère du viel testament* was composed around 1450 by the brothers Arnoul et Simon Gréban and first performed in 1470.

[15] Edelestand Du Méril, *Origines latines du théâtre moderne* (Paris: Franck, 1849), 253; Cohen, *Histoire de la mise en scène*, 31.

[16] Arnoul and Simon Gréban, *Mystère des actes des apôtres, représenté à Bourges en avril 1536, publié depuis le manuscript original*, ed. Auguste-Théodore and Baron de Girardot (Paris: Didron, 1854), 27; Cohen, *Histoire de la mise en scène*, 147. The *Actes des Apôtres* was an assemblage of dramatizations of stories from the Old Testament collected around 1450 and staged in Paris at the beginning of the sixteenth century.

Lord.[17] The serpent twined itself round the trunk of the Tree of Knowledge to proffer its apple to Eve.[18] A wild boar tracked by hunters, a leopard that sniffed Saint André, a dromedary that wagged its head, moved its lips and stuck out its tongue, a host of dog- and wolf-shaped devils surging up from the underworld, and serpents and dragons spewing flames from their mouths, noses, eyes and ears rewarded the stunningly devoted spectators at the forty-day performance of the *Mystère des actes des apôtres* in Bourges in 1537.[19] The machines were commissioned from local artisans, usually clockmakers.[20]

Mechanical enactments of biblical events spread across the European landscape, reaching a crescendo during the late fifteenth and early sixteenth centuries.[21] Nor was the holy machinery the sole province of the cities. In May 1501, an engineer in the village of Rabastens, near Toulouse, was engaged to build an endless screw that could propel the Assumption of the Virgin. The following August, the Virgin rose heavenward, attended by rotating angels, and disappeared into paradise (its entrance hidden in clouds). Meanwhile a golden, flaming sun also rotated, carrying more angels on its rays.[22] Another mechanical Ascension of the Virgin took place annually in Toulouse, moving in alternate years between the Eglise Notre-Dame de la Daurade and the Eglise Saint-Etienne.[23] At home, in the region around Toulouse, children built small replicas of the Virgin-elevator for the Assumption in the same way that they arranged crèches at Christmas.[24]

Even the Eternal Father appeared in mechanical reenactments. In Dieppe, for example, he loomed at the top of the Eglise Saint-Jacques, a "venerable old man" astride a cloud in an azure, star-sprinkled canopy of heaven. Mechanical angels flew about him, flapping their wings and swinging their censers. Some played the "Ave Maria" in time to the organ on handbells and horns at the end of each office. After the service, the angels blew out the altar candles.[25] At the feast of

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[17] Armand Gasté, *Les drames liturgiques de la cathédrale de Rouen* (Evreux: Imprimerie de L'Eure, 1893), 75; Cohen, *Histoire de la mise en scène*, 31.

[18] Anonymous, *Jeu d'Adam* [ca. 1150], ed. Wolfgang van Emden (Edinburgh: British Rencensvals Publications, 1996) (original is in the Bibliothèque municipale de Tours, MS 927), 23 (l. 292); Cohen, *Histoire de la mise en scène*, 54.

[19] Gréban and Gréban, *Mystère des actes des apôtres*, livre IV, fol. 67 v°, livre III, fols. 21 r° and 23 r°, livre II, fol. 9 r°; Cohen, *Histoire de la mise en scène*, 147.

[20] Cohen, *Histoire de la mise en scène*, 143–44; Chapuis and Droz, *Automata*, 356–57.

[21] Vasari described the high point of Florentine festivals as having coincided with the career of the architect Francesco d'Angelo (known as Cecca), in the second half of the fifteenth century: Cecca "was much employed in such matters at that time, when the city was greatly given to holding festivals." These took place, according to Vasari, not only in churches "but also in the private houses of gentlemen." There were also four public spectacles, one for each quarter of the city. For example, the Carmine kept the feast of the Ascension of Our Lord and the Assumption of Our Lady. See Vasari, *Lives of the Most Eminent Painters*, 3:194.

[22] See M. Vidal, "Notre-Dame du Montement à Rabastens," in *Bulletin historique et philologique du Comité des travaux historiques et scientifiques* (Paris, 1908), 415ff; Chapuis and Gélis, *Le Monde des Automates*, 1:102.

[23] See Alphonse Auguste, "Gabriel de Ciron et Madame de Mondonville," in *Revue historique de Toulouse* 2 (1915–19): 26; Chapuis and Gélis, *Le Monde des Automates*, 1:103.

[24] This practice was thriving in the mid-seventeenth century, when Madame de Mondonville (Anne-Jeanne Cassanea de Mondonville) recalls in her memoirs having built a Virgin-ascender with her brothers. She used her precious, glittering bits of quartz crystal to carve the Virgin. See Auguste, "Gabriel de Ciron et Madame de Mondonville," 26; Chapuis and Gélis, *Le Monde des Automates*, 1:103. On mechanical Assumptions, see also Tripps, *Der Handelnde Bildwerk*, 174–90.

[25] The Dieppe mechanical figures were built for a local festival of the Virgin, celebrated on the day of the Assumption and the following day, called the "mitouries de la mi-Août." See Jean-Antoine Samson Desmarquets, *Mémoire chronologique pour servir à l'histoire de Dieppe* (Paris: Desauges, 1785), 1:36; Ernest Maindron, *Marionnettes et guignols*

Whitsuntide, the Holy Ghost, in the form of a white dove, flew down from the main vault of Saint Paul's Cathedral in London, breathing a "most pleasant Perfume" over the congregation.[26]

Most early modern mechanical figures were found in cathedrals and exhibited religious themes. Many were connected with clocks, outgrowths of the church's drive to improve time-keeping for the better prediction of feast days,[27] or with organs. A mechanical man gripping a mallet to ring the hour became a familiar sight on clocktowers across Europe in the mid-fourteenth century. He went by the name "Jack" in England; in Flanders, he was "Jean"; in France, "Jaquemart"; and Germany, "Hans."[28] Over the next century, Jack-Jean-Jaquemart-Hans acquired crowds of company. On the clock in the Piazza San Marco in Venice, beginning in 1499, two giant shepherds struck the hour while an angel playing a horn emerged, followed by the three Magi. The Magi bowed before the Virgin and Child and removed the crowns from their heads with one hand while using the other to extend their gifts. They then stood, replaced their crowns, and exited through a door that opened automatically.[29] The scene of the Magi was a common motif on church clocks, which also often included calendars indicating feast days; the positions, oppositions, and conjunctions of the stars; the signs of the zodiac; the phases of the moon; and, as in the San Marco clock, astronomical models of a Ptolemaic cosmos.[30]

There were also roosters: mechanical cocks crowed and flapped their wings on clocks across Europe from about the mid-fourteenth century.[31] Perhaps the earliest, built around 1340, performed on the hour at Cluny Abbey, near Macon. Meanwhile an angel opened a door to bow before the Virgin, a white dove representing the Holy Spirit flew down from above and was blessed by the Eternal Father, and fantastic creatures emerged to stick out their tongues and roll their eyes before retreating inside the clock.[32] Another rooster did its flapping and crowing on the town clock in Niort from about 1570. This bird presided over three separate scenes involving some forty figures. Care appeared in a window to exhort Servitude to come out and strike the hour. An automaton Gabriel enacted the Annunciation with a mechanical Mary, Holy Ghost, and Eternal Father. Finally, a mechanical choir of angels sang in time to their conductor's baton, while Saint Peter appeared from behind a door, looked about, opened another door, and, at the admonition of two children, disappeared back into his own chamber to make way for the twelve

([S.l.], 1897), 99–102; Ludovic Vitet, *Histoire de Dieppe* (Paris: Ch. Gosselin, 1844), 45; Chapuis and Gélis, *Le Monde des Automates*, 1:103. This performance, like the others discussed here, combined living and mechanical actors.

[26] Lambarde, *Dictionarium Angliæ topographicum*, 459; Hone, *The Every-Day Book*, entry for September 5, 1825; Chapuis and Gélis, *Le Monde des Automates*, 1:104.

[27] See J. L. Heilbron, *The Sun in the Church: Cathedrals as Astronomical Observatories* (Cambridge, MA: Harvard University Press, 1999); and David Landes, *A Revolution in Time: Clocks and the Making of the Modern World* (Cambridge, MA: Belknap, 2000), especially chap. 3.

[28] Chapuis and Gélis, *Le Monde des Automates*, 1:114; Chapuis and Droz, *Automata*, 53. The name may have come from St. John the Baptist. See Alphonse Wins, *L'Horloge à travers les âges* (Mons: Léon Dequesne, 1924).

[29] The current clock in the Piazza San Marco is the result of many modifications that have taken place over the centuries, but these central elements have remained. On the history of the clock, see *Relazione storico-critica della Torre dell' Orologio di S. Marco in Venezia* (Venice, 1860); Chapuis and Gélis, *Le Monde des Automates*, 1:118; and Renato and Franco Zamberlan, "The St. Mark's Clock, Venice," *Horological Journal* (January 2001): 11–14.

[30] For other examples, see Chapuis and Gélis, *Le Monde des Automates*, vol. 1, chap. 7.

[31] "Le coq, qui aux temps les plus reculés était déjà symbole de fierté et vigilance, est sans contredit l'animal que les constructeurs de machines horaires à sujets animés, ont mis le plus souvent à contribution." Chapuis and Gélis, *Le Monde des Automates*, 1:172–73.

[32] Chapuis and Gélis, *Le Monde des Automates*, 1:120. Cluny Abbey was the biggest church in Europe before Saint Peter's Basilica in Rome; it was almost entirely destroyed in 1790 during the French Revolution.

apostles. These arrived holding hammers with which they rang the hour while the children nodded their heads in time. The clock had a false door with two automaton Hercules on either side, ready to drop their clubs on anyone who tried to enter; above them, Vulcan with his hammer also stood guard.[33]

The Cluny, Niort, and other roosters were outdone by one unrivaled among mechanical fowl, the renowned rooster of Strasbourg Cathedral. For nearly five centuries, the Strasbourg rooster cocked its head, flapped its wings, and crowed on the hour atop the Clock of the Three Kings, originally built between 1352 and 1354, and refurbished by the clockmaker brothers Isaac and Josias Habrecht between 1540 and 1574. Beneath the rooster, the astrolabe turned and the Magi scene played out its familiar sequence. In the Habrecht version, the rooster, Magi, Virgin, and Child were joined by a host of other automata: a rotation of Roman gods who indicated the day of the week; an angel who raised her wand as the hour was rung, and another who turned her hourglass on the quarter-hour; a baby, a youth, a soldier, and an old man representing the four stages of life, who rang the quarter-hours; and above them, a timid, mechanical Christ, who came forth after the old man finished ringing the final quarter-hour, but then retreated in haste to make way for Death to strike the hour with a bone.[34] In a similarly dark scene at the Frauenkirche in Munich, from 1514, a vengeful God brandished a sword hourly over fallen mankind; Christ and Mary, begging for clemency, made him lower it to the crowing of the ever-present rooster.[35]

Apart from church clocks, the other prime spot for mechanical figures was church organs.[36] Organ-driven mechanical angels came in whole choirs of bustling figures, including the conductor waving a baton, sometimes accompanied by flocks of singing birds. Automaton angels lifted horns to their mouths and played drums and carillons.[37] At the cathedral in Beauvais, Saint Peter towered atop an organ of the late fourteenth or early fifteenth century and blessed the congregation on his feast day by nodding his head and moving his eyes.[38] Strasbourg Cathedral was hectic with mechanical activity, having automata connected with its organ as well as its clock. Three moving figures, known as *Rohraffen*, were attached to the strings of the organ in the late fifteenth century (where they remain): Samson boldly opening and closing the jaws of a lion; the Héraut de la ville, lifting his trumpet to his lips; and the Bretzelmann in a red and black cape.

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[33] "Description d'une horloge merveilleuse," par "Jean BOUHIN," BNF, fonds français, MS no. 1744, published by Edmond Duret as "L'horloge historique de Nyort en Poitou, fabriquée on 1570 par Jean Bouhin," *Revue Poitevine et Saintongeaise* 6 (1889): 432–34.

[34] Chapuis and Gélis, *Le Monde des Automates*, 1:120–27; Derek J. De Solla Price, "Automata and the Origins of Mechanism and Mechanistic Philosophy," *Technology and Culture* 5, no. 1 (1964): 18, 22; Silvio A. Bedini, "The Role of Automata in the History of Technology," in ibid., 29 and figs. 2 and 3.

[35] Described by Joseph Gallmayr in the *Münchner Intelligenzblatt* (1779), 273; Chapuis and Gélis, *Le Monde des Automates*, 1:167.

[36] On the connection between organs and automata in the medieval period, see Merriam Sherwood, "Magic and Mechanics in Medieval Fiction," *Studies in Philology* 44 (October 1947): 585ff.

[37] Marie Pierre Hamel, "Notice historique abrégée pour l'histoire de l'orgue," in *Nouveau manuel complet du facteur d'orgues. Nouvelle édition contenant l'orgue de dom Bédos de Celles… précédé d'une notice historique par M. Hamel …*, ed. Marie Pierre Hamel (Paris: L. Mulo, 1903), xxiv–cxxvi, see esp. l–li; Chapuis and Gélis, *Le Monde des Automates*, 1:106. A 1541 bill records: "A Nicolas Quesnel, ymaginier, pour faire deux ymages des anges mouvantz, pour mettre sur l'amortissement des orgues." Léon Emmanuel Simon Laborde, *Notice des emaux, bijoux et autres objets divers, exposés dans les galeries du Musée du Louvre* (Paris: Vinchon, 1853), 2è Partie, Documents et glossaire, "Images mouvantes"; Chapuis and Gélis, *Le Monde des Automates*, 1:105.

[38] Chapuis and Gélis, *Le Monde des Automates*, 1:106. Joseph Gallmayr built a Saint Cecilia in Munich powered by organ pedals in the latter eighteenth century. Ibid.

The Bretzelmann, still in place, has long hair and a shaggy beard, an aquiline nose and an evil look. When set in motion, he seems to speak with great emphasis, opening and shutting his mouth while shaking his head and gesticulating with his right arm.[39] At Pentecost, throughout the service, the Bretzelmann mocked the priest, laughing, hurling insults and coarse jokes, and singing nasty songs:

> By disordered movements, profane and improper canticles shouted at the top of his lungs, he disturbs the hymns of the arriving pilgrims and covers them with ridicule. In this manner, he turns the devotion of the visitors into distraction, their pious sighs into laughs, but he also troubles the priests who chant the holy office, and he is the cause of an abominable and execrable perturbation during the sacrifice of the holy mass.[40]

Other organs sported disembodied heads that frowned, contorted their faces, rolled their eyes, stuck out their tongues and opened and closed their mouths as the music played. A colossal automaton head animated the church organ in Neustadt-an-der-Harth in Bavaria, and others were to be found across Germany and the Low Countries from the fifteenth century.[41] From the organ gallery of the cathedral in Barcelona, the head of a moor hung by its turban. It made mild facial expressions when the music played softly; when the strains grew louder, it rolled its eyes and grimaced as though in pain.[42] And in the Cloître des Augustins in Montoire, in the Loire Valley, a mechanical head on the organ gallery gnashed its teeth with a noisy clatter.[43]

Early modern Europe, then, was alive with mechanical beings, and the Catholic Church was their main patron. The church was also a primary sponsor, between the late fifteenth and late sixteenth centuries, of the translation and printing of a small flood of ancient texts on mechanical and hydraulic automata, which then informed the construction of such devices throughout the Renaissance. For example, the first printed edition of Vitruvius's *De Architectura*—containing

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[39] *Rohraffen* meant "roaring apes" and referred to the grotesque, bellowing figure of the Bretzelmann. He had help, for the vocal part of his act, from a *Münsterknecht*, a servant of the cathedral hidden in the pendentive that held the organ. But the physical motions were the Bretzelmann's own and were controlled by the organ strings. See *Les Orgues de la Cathédrale de Strasbourg à travers les siècles. Etude historique, ornée de gravures et de planches hors texte, à l'occasion de la bénédiction des Grandes Orgues Silbermann-Roethinger, le 7 juillet 1935* (Librissimo, Phénix Editions, 2002); Conseil Régional d'Alsace, *Orgues Silbermann d'Alsace* (Strasbourg: A.R.D.A.M., 1992); Chapuis and Gélis, *Le Monde des Automates*, 1:108–9; Sherwood, "Magic and Mechanics," 585–86.

[40] "Item rusticanam quondam imaginem: in sublimi sub organis: in ecclesia maiori collocarunt. Qua sic abutuntur. In ipsis sacris diebus Penthecostes: quibus ex tota dyocesi populus processionaliter cum sanctorum reliquijs: deuocionis et laudandi dei gratia canens et iubilans: matricem ecclesiam subintrare consueuit. Nebulo quispiam se post iiam imaginem occultans: incomptis motibus: *voce sonora: prophana et indecora cantica eructans: veniencium hymnis obstrepit: eosque subsannando irridet: ita ut non solum illorum deuocionem in distractionem: gemitus in cachinnos vertat: sed et ipsis clericis diuina psallentibus: sit impedimento: immo diuinis missarum solemnijs (quas non longe inde celebrare contingit) ecclesiastici immo diuini cultus gelatori longe abominandam et execrandam afferat perturbacionem*" (cited passage is italicized). Peter Schott—Emmerich Kemel (ca. 1482–85), in Petri Schotti Argentinensis Patricii: *Juris utriusque doctoris consultissimi: Oratoris et Poetae elegantissimi: graecaeque linguae probe aeruditi: Lucubraciunculae ornatissimae*, ed. Jacob Wimpheling (Strassburg: Martin Schott, 1498), fols. 116a–117b. Published in both the original Latin and in English translation in Murray A. Cowie and Marian L. Cowie, "Geiler von Kayserberg and Abuses in Fifteenth Century Strassburg," *Studies in Philology* 58, no. 3 (1961): 489–90, 494.

[41] Alexandre de Salies, "Lettre sur une tête automatique autrefois attachée à l'orgue des Augustins de Montoire," *Bulletin de la Société archéologique, scientifique et littéraire du Vendômois* 6, no. 2 (1867): 114. Three similar heads continue to grace the organ, built in 1557, of the church of Saint-Savin-en-Lavedan in the Hautes Pyrénées.

[42] Salies, "Lettre sur une tête automatique," 99.

[43] Ibid., 98. On the basis of this head's markedly Lancastrian features and its nickname *Gallima* (which could mean "he who brings death to the French"), Salies suggests that the head may have been an effigy of Henry V, Henry VI, or Humphrey, Duke of Gloucester, who acted as protector during the regency of Henry VI.

descriptions of the third century B.C. engineer Ctesibius's water organ and other automata—appeared in 1486 as a key part of the Renaissance popes' project to build a Christian Rome.[44]

To be sure, automata also appeared in secular settings: on town halls, municipal clock towers,[45] and the grounds of noble estates. Early modern engineers mechanized purely political icons as well as religious ones. A very early example is the clock that Charles IV commissioned for the Frauenkirche in Nuremberg to commemorate his Golden Bull, which established the constitutional structure of the Holy Roman Empire and set the number of electors at seven. On the clock, which was inaugurated in 1361, seven figures known collectively as the *Männleinlaufen* (parade of little men) emerge at noon to bow before the emperor.[46] Another legendary instance was the automaton lion built by Leonardo da Vinci in 1515 for a banquet hosted by Florentine merchants in Lyon in honor of Francis I: "wherefore Leonardo being asked to devise some bizarre thing, made a lion which walked several steps and then opened its breast, showing it full of lilies."[47] The lion represented Lyon and the lilies the French throne.

Clockwork automata, often exhibiting secular themes, were the playthings of princes—especially the Holy Roman emperors—from the late fifteenth century. Hans Bullmann of Nuremberg built android musicians, for which Ferdinand I summoned him to Vienna.[48] Henry VIII,

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[44] The text was edited by Giovanni Sulpizio da Veroli, a close collaborator of the young Cardinal Raffaele Riairo, to whom the edition was dedicated, and who was a central actor in the Renaissance renovation of Rome. Most of Vitruvius's illustrations had been lost; the Veronese friar Fra Giovanni Giocondo reconstituted these in a 1511 edition printed under the auspices of Pope Julius II. Vitruvius's treatise continued to inform the great building projects of the Renaissance popes through the reigns of Leo X and Paul III, not least Saint Peter's Cathedral. See Ingrid D. Rowland, ed., introduction to *Vitruvius: Ten Books on Architecture, The Corsini Incunabulum with the Annotations and Drawings of Giovanni Battista da Sangallo* (Rome: Edizioni dell'Elefante, 2003), 1–31.

[45] The astronomical tower clock in Bern, the Zytglogge, built in 1530, continues to play a four-minute mechanical pageant every hour: a rooster crows, a dancing jester rings the bells, Chronos turns his hourglass, and bears (the city mascot) parade around.

[46] Chapuis and Gélis, *Le Monde des Automates*, 1:165–66. The sovereign and his seven electors reappeared on the clock of the Marienkirche in Lübeck where they paraded before Christ. Ibid., 1:170.

[47] Vasari, *Lives of the Most Eminent Painters*, 4:99. The other (known) primary mentions of this event are Giovanni Paolo Lomazzo, *Libro dei Sogni* (1564) and *Trattato dell'arte della pittura, scoltura et architettura* (1584), both in *Scritti sulle arti*, ed. Roberto Ciardi and Marchi e Bertolli (Florence: Marchi & Bertolli, 1973), 1:53, 2:96 (see also Lomazzo, *Idea del tempio della pittura* [1590; Hildesheim: Olms, 1965], 17, for a mention of "andari Leoni per forza di ruote"); and Michelangelo Buonarroti the Younger, *Descrizione delle felicissime nozze della Cristianissima Maesta' di Madama Maria Medici Regina di Francia e di Navarra* (Florence, 1600), 10. See also Jill Burke, "Meaning and Crisis in the Early Sixteenth Century: Interpreting Leonardo's Lion," *Oxford Art Journal* 29, no. 1 (2006):77–91. Accounts vary as to the French king in question, the occasion, the date, and the place. The currently established view, which I have adopted here, is that of Carlo Pedretti, who discovered the Buonarroti the Younger account in 1973. See Pedretti, *Leonardo architetto* (Milan: Electa, 1973), 322. See also his "Leonardo at Lyon," *Raccolta Vinciana* 19 (1962): 267–72; and his *Leonardo: A Study in Chronology and Style* (New York: Johnson Reprint, 1982), 172. On the mechanical lion and other creations of Leonardo that might be seen as automata—flying machines, the figure of a knight with an internal cable-and-pulley system enabling it to wave its arms and move its head and mouth, and a wheeled cart that might have been a programmable robot-platform—see also Mark Elling Rosheim, *Leonardo's Lost Robots* (New York: Springer, 2006). Even earlier instances of an automaton designed for purely secular political purposes is the iron fly purportedly presented by Johannes Müller (Regiomontanus) (1436–76) to Maximilian I and an eagle that escorted the emperor to the city gates of Nuremberg. The first account of these machines is by Peter Ramus in *Scholarum mathematicarum libri unus et triginta* (Frankfurt, 1627 [1569]), 62. John Dee then mentions Regiomontanus's automata in his "Mathematicall Praeface" to Henry Billingsley's 1570 English translation of Euclid's *Elements*. See John Dee, *The Mathematicall Praeface to the Elements of Geometrie of Euclid of Megara* (1570), ed. Allen Debus (New York: Science History, 1975).

[48] Johann Gabriel Doppelmayr, *Historische nachricht von den nürnbergishcen mathematicis und künstlern* (Nürnberg: P. C. Monath, 1730), 285. See Chapuis and Gélis, *Le Monde des Automates*, 2:181; and Bedini, "Role of Automata," 31.

according to a 1542 inventory, had an automaton clock at Westminster.[49] Hans Schlottheim, a clockmaker in Augsburg, designed automaton-embellished utensil holders to sit on banquet tables. These were wrought in gold, silver, or brass, typically in the form of a ship. One, which Schlottheim made for Rudolph II around 1580 and is now at the British Museum, has figures moving around a sundial and passing before a throne. Schlottheim also devised two automaton crayfish—one crept forward and the other backward—that were bought by the Prince Elector of Saxony in 1587.[50]

Noble houses hummed and whirred with clock-automata that were miniaturizations of the ones in churches and, indeed, designed by the same people. For example, the Habrecht brothers, who renovated the Strasbourg Cathedral clock in the mid-sixteenth century, also did a brisk business in household automaton clocks.[51] Automata figured too in lay theater.[52] In 1547, John Dee, the future magus and court philosopher to Queen Elizabeth I, but then a nineteen-year-old reader in Greek at Trinity College, Cambridge, built what seems to have been a mechanical flying dung beetle for an undergraduate production of Aristophanes's *Pax*. At the point in the play when Trygaeus, determined to reach Jupiter's Olympian palace, leaps onto his unlovely Pegasus and exhorts it to fly, Dee's artificial insect took to the air, inspiring "a great wondring, and many vaine reportes spread abroad of the meanes how that was effected."[53]

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

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[49] See Chapuis and Gélis, *Le Monde des Automates*, 1:179ff.

[50] Bedini, "Role of Automata," 34; Chapuis and Gélis, *Le Monde des Automates*, 1:192–97, 2:152–53; Chapuis and Droz, *Automata*, 76–77, 242. Aristocratic dining tables were also set with automaton-embellished fountains that poured out wine and perfumed liquor. See Bedini, "Role of Automata," 33. Bedini mentions a fourteenth-century example at the Cleveland Museum of Art. See N. M. Penzer, "A Fourteenth-Century Table Fountain," *Antique Collector* (June 1957): 112–17.

[51] Chapuis and Droz, *Automata*, 67. With the development of springs rather than weights as the motive force, clocks got ever smaller and more elaborate. Clocks often included carillons, as did watches, ultimately, with the addition of pinned barrels to organize the motions. Ibid., 77, 265–66.

[52] The Italian architect and stage designer Nicola Sabbattini regularly included mechanized elements in his sets: crank-operated ocean waves, clouds on pulleys. See Nicola Sabbattini, *Manual for Constructing Theatrical Scenes and Machines* [*Pratica di fabricar scene e macchine ne 'teatri*, 1638], ed. Barnard Hewitt (Coral Gables: University of Miami Press, 1958), 132–33, 149–50. Other principal builders of mechanical sets for secular theater include Giacomo Torelli, the seventeenth-century Italian stage designer and engineer who invented the "chariot-and-pole" system of changing sets and who directed the fêtes of Louis XIV. See Raimondo Guarino, "Torelli a Venezia: l'ingegnere teatrale tra scena e apparato," in *Teatro e storia* A. 7, n. 12, fasc. 1 (1992), 35–72; *Macchine da teatro e teatri di macchine: Branca, Sabbatini, Torelli scenotecnici e meccanici del Seicento. Catalogo della mostra a cura di Enrico Gamba e Vico Montebelli* (Urbino: QuattroVenti, 1995). Another important figure in this area was Ferdinando Galli Bibiena (1657–1743), the most illustrious of an Italian dynasty of architects and set designers. Bibieni wrote *L'architettura civile*, which exists in a modern edition with an introduction by Diane M. Kelder (New York: B. Blom, 1971).

[53] Dee, *Compendious Rehearsal* (1592), in *Autobiographical Tracts of John Dee*, ed. James Crossley (Whitefish, MT: Kessinger, 2005), 5–6. As mentioned above, Dee discusses several legendary automata—Archytas's wooden dove, Albertus Magnus's brazen head, Regiomontanus's iron fly and artificial eagle—as examples of the mathematical art of "thaumaturgike" in his *Mathematicall Praeface*. On Dee's automaton, see Benjamin Woolley, *The Queen's Conjurer: The Science and Magic of Dr. John Dee, Advisor to Queen Elizabeth I* (New York: Henry Holt, 2001), 12–15; and Deborah E. Harkness, *John Dee's Conversations with Angels: Cabala, Alchemy, and the End of Nature* (Cambridge: Cambridge University Press, 1999), 121.

read."[54] 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.[55] And the church also promulgated, in association with clock-work, the plurality of early modern mechanical images of people and animals.

A Franciscan monk of iron and linden-wood built around 1560 and attributed to a man named Juanelo Turriano offers a final example of the early modern mechanization of faith.[56] Turriano's life is a tale in itself. Clockmaker, architect, and engineer to the Holy Roman Em-peror Charles V, and then to his son and heir, King Philip II of Spain, Turriano went into retreat with Charles, after his abdication in 1556, at the monastery of Yuste, near Plasencia.[57] There, the imperial clockmaker built automata to comfort the gouty ex-emperor: an automaton lady who danced and played a tambourine, a flight of wooden sparrows that fluttered and "flew about the room as if alive," a miniature army of prancing horses, and soldiers playing diminutive trum-pets.[58] According to legend, Philip II asked Turriano to build the automaton after Philip's son, Don Carlos, made a miraculous recovery following a head injury. A fifteenth-century Franciscan monk, Diego de Alcalà, whose relics were brought to the prince's bed at the moment of crisis, re-ceived credit for the cure, and the king, to express his eternal gratitude, asked Turriano to build the mechanical monk.

The monk, wearing a tunic, cowl, and sandals, and with its mechanism hidden beneath its habit, is a fully self-contained device, sixteen inches high. It clutches a crucifix and rosary in its left hand. Elizabeth King, the monk's eloquent biographer, describes its performance thus:

> Slowly the monk comes to life. He turns his head to single out one among the company. Left foot stepping forth from under the cassock hem, then right foot, the monk advances in the direction of his gaze, raising the crucifix and rosary before him as he walks. His eyes move: turning his head, he looks to the raised cross and back to his subject. His mouth opens, then closes, affording a glimpse of teeth and interior. He bends his right arm and

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[54] Theodore Bowie, ed., *The Sketchbook of Villard de Honnecourt* (Bloomington: Indiana University Press, 1959), 58c and 58e. [Bibl. nat. de France, MS. Fr. 19093] Nothing is known about the artist apart from what can be inferred from his portfolio.

[55] See Heilbron, *Sun in the Church*; and Landes, *Revolution in Time*, esp. chap. 3.

[56] My discussion of the monk is derived from Elizabeth King's work on it. See King, "Perpetual Devotion: A Sixteenth-Century Machine that Prays," in Riskin, *Genesis Redux*, chap. 13; and King, "Clockwork Prayer: A Sixteenth-Century Mechanical Monk," *Blackbird: An Online Journal of Literature and the Arts* 1, no. 1 (2002). The monk now resides in storage at the Smithsonian Institution's National Museum of American History; it has a twin at the Deutsches Museum in Munich.

[57] On Turriano, see José A. García-Diego, *Los relojes y autómatas de Juanelo Turriano* (Madrid: Tempvs Fvgit, *Monografías Españolas de Relojería*, 1982); Garcia-Diego, *Juanelo Turriano, Charles V's Clockmaker* (Madrid: Editorial Castalia, 1986); King, "Clockwork Prayer"; Bedini and Francis R. Maddison, *Mechanical Universe: The Astrarium of Giovanni De' Dondi* (Philadelphia: American Philosophical Society, 1966), 56–58; Bedini, "Role of Automata," 32; and Chapuis and Gélis, *Le Monde des Automates*, 1:90–91. Originally from Cremona, Turriano was also known as Giovanni Torriani and as Gianello della Torre.

[58] Famiano Strada, *De bello belgico. The history of the Low-Countrey warres*, trans. Sr. Rob. Stapylton (Rome, 1632–47; London: H. Moseley, 1650), 7. See also William Sterling-Maxwell, *The Cloister Life of Charles V* (London: John C. Nimmo, 1891), 116, 178–80, 499; Luis Montañes Fonteñla, "Los Relojes del Emperador" and "Los Relojes de la Exposicion 'Carlos V y su Ambiente,'" *Cuadernos de Relojeria* 18 (September 1958): 3–22; Bedini, "Role of Automata," 32. One of Turriano's automata, a woman playing a lute, remains in existence. It is in the collection of the Kunsthistorisches Museum in Vienna.

with the gathered fingers of his hand he strikes his breast. The small blow is audible. And now he is lowering and turning his head as he walks: the elbow and shoulder in synchronized motion he brings the cross higher, up to his lips, and kisses it. Thirty seconds into the act, he's taken eight steps, beat his chest three times, kissed the cross, and traveled a distance of twenty inches. At what seems like the last moment—for doubtless the subject of his attention has backed away from the table's edge—he looks away, arms still aloft, executes a turn to his right, and makes a new appointment. He will make seven such turns and advances in his campaign if the mainspring has been fully wound. The uninterrupted repetition corresponds exactly to a trance-like performance of prayer, incantation.[59]

Just over a foot in height and weighing five pounds, the monk is somehow formidable. Perhaps even more than his contemporaries—the muttering Christs, the horn-playing angels, the eye-rolling devils, the teeth-chattering heads—he embodies the power of an image, the peculiar power of a moving image,[60] and the extraordinary sway of a moving, devotional image.

Mechanization is often taken as an index of modernization. But automaton icons had a medieval impetus in a tradition of imagery in which the tangible, visible, earthly representations of Christian lore and doctrine were pushed ever farther.[61] The icons were representations in motion, inspirited statues: they were mechanical *and* divine. Rolling their eyes, moving their lips, gesturing, and grimacing, these automata dramatized the intimate, corporeal relation between representation and divinity, icon and saint. As this relation became increasingly fraught, the machinery took on new meanings. Reformism and clockmaking developed side by side from Augsburg to Strasbourg to Geneva. The flood of mechanized religious images coincided both in time and, most importantly, in place with the heating-up of the questions of whether and how religious images blurred the boundary between image and deity.

The Reformation cast a partial hush over the humming, groaning, chirping, whistling, chattering ecclesiastical machinery. The uncouth Bretzelmann of Strasbourg Cathedral was silenced along with many of his fellow organ-automata and, indeed, with many of the church organs themselves, which became emblematic of Catholic ritual.[62] Henry VIII, in establishing the Anglican Church, banned mechanical statues from English churches.[63] The grimacing Rood of Boxley Abbey gave its last performance in 1538, after being snatched from Boxley by Geoffrey Chamber as part of his commissioned defacement of the abbey. Chamber wrote to Thomas Cromwell that he had found in the Rood

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[59] King, "Perpetual Devotion," 264–66.

[60] King writes: "Everyone who sees the monk in action agrees that it is intimidating…. The character of the image, together with its head-on motion, makes an object that is impossible to regard with objective remove." King, "Perpetual Devotion," 274–75.

[61] The art historian David Freedberg has described a certain kind of viewing that occurs in response to powerful religious representations. The devout beholder "reconstitutes" the thing being represented, turning its representation into a presence: "The slip from representation to presentation is crucial … from seeing a token of the Virgin to seeing her there." David Freedberg, *The Power of Images: Studies in the History and Theory of Response* (Chicago: University of Chicago Press, 1989), 28. I am indebted here to King's discussion of Freedberg's observation about religious images as viewed by the monk, in "Perpetual Devotion."

[62] Leaders of the Reformed movement, notably Ulrich Zwingli, denounced the use of organs and other musical instruments in church. See Charles Garside: *Zwingli and the Arts* (New Haven, CT: Yale University Press, 1966); Quentin Faulkner, *Wiser than Despair: The Evolution of Ideas in the Relation of Music and the Christian Church* (Westport, CT: Greenwood Press, 1996), chap. 9; Diarmaid MacCulloch, *The Reformation: A History* (New York: Penguin, 2003), 146, 590.

[63] Chapuis and Gélis, *Le Monde des Automates*, 1:104–1.

certain engines and old wire, with old rotten sticks in the back, which caused the eyes to move and stir in the head thereof, "like unto a lively thing," and also, "the nether lip likewise to move as though it should speak," which was not a little strange to him and others present.[64]

But can it have been any surprise that the Rood was made of wood and wire? It and its many cousins had been built by local artisans—clockmakers, carpenters—and treated by its local beholders with great familiarity, inspiring, by the accounts of contemporary chroniclers, at least as much laughter as awe. The Bretzelmann of Strasbourg Cathedral was obviously funny. Similarly, in the case of the lever-and-pulley-operated Saint Rumwald, "many times it mooved more laughter than devotion, to beholde a great lubber to lifte at that in vaine, which a young boy (or wench) had easily taken up before him."[65]

That mechanical icons were mechanical cannot have been big news. But Chamber and his fellow iconoclasts introduced the idea that such icons were deceptions by virtue of being mechanical. Machinery, that is, could not represent divinity other than deceitfully. One could not know a thing to be mechanical and simultaneously believe it to be divine. The destruction of mechanized icons represented only small swells inside the larger surges of iconoclasm that spread across Europe during the middle decades of the sixteenth century.[66] But the demolition of the Rood and its ilk reveal that one core logic of iconoclasm—the rigorous distinction between the divine and the artifactual—brought with it a fundamentally transformed view of the ontology of machines.

The abbot and monks, when Chamber questioned them, predictably denied any knowledge of the mechanical Rood.[67] But it had inspired great devotion in the people of Kent, as well as pilgrimages from across the realm,[68] so Chamber deemed it an immediate danger and promptly removed it to Maidstone. There he displayed it in the public market and instilled in the townspeople a "wondrous detestation and hatred [of the Rood] so that if the monastery had to be defaced again they would pluck it down or burn it." [69] The chronicler Charles Wriothesley described the events as follows:

> Allso the sayde roode was sett in the market place first at Maydstone, and there shewed openlye to the people the craft of movinge the eyes and lipps, that all the people there might see the illusion that had bene used in the sayde image by the monckes of the saide plaace of manye yeares tyme out of mynde, whereby they had gotten great riches in deceiving the

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[64] Chamber to Cromwell, 7 February 1538, in *Letters and Papers, Foreign and Domestic, of the Reign of Henry VIII*, ed. J. S. Brewer (London: Longman, 1862–1910), vol. 13, pt. I: # 231, p. 79.

[65] Lambarde, *Perambulation of Kent*, 210.

[66] For synoptic discussions of this vast and complex subject, see Alain Besançon, *The Forbidden Image: An Intellectual History of Iconoclasm* (Chicago: University of Chicago Press, 2001), chaps. 5, 6; Carlos N. M. Eire, *The War Against Idols: The Reformation of Worship from Erasmus to Calvin* (Cambridge: Cambridge University Press, 1989), chaps. 3, 4, 6, 8; Freedberg, *The Power of Images*, chap. 8; Sergiusz Michalski, *The Reformation and the Visual Arts: The Protestant Image Question in Western and Eastern Europe* (New York: Routledge, 1993); and Edward Muir, *Ritual in Early Modern Europe* (Cambridge: Cambridge University Press, 1997), chaps. 5, 6. For a study of the relations of Reformation art to iconoclasm, see Joseph Leo Koerner, *The Reformation of the Image* (Chicago: University of Chicago Press, 2004).

[67] William Page, ed., *The Victoria History of the County of Kent* (Rochester, NY: Boydell and Brewer, 1974), 2:154.

[68] On the popularity of the Rood of Grace as a tourist attraction, see William Warham, Archbishop of Canterbury to Thomas Wolsey, 3 May 1524. [R.O.] Extract in Brewer, *Letters and Papers*, vol. 4, pt. 1: # 299, p. 127.

[69] Page, *Victoria History of Kent*, 2:154.

people thinckinge that the sayde image had so moved by the power of God, which now playnlye appeared to the contrarye.[70]

The Rood was then transported to London where John Hilsey, bishop of Rochester, exhibited it during a sermon at Saint Paul's Cross, after which it was torn apart and burned before a crowd of duly admonished onlookers.[71] Again, Wriothesley recorded the occasion:

> This yeare, the 24th daie of Februarie, beinge the Soundaie of Sexagesima and the Sainct Mathias daie, the image of the roode that was at the Abbey of Bexley, in Kent, called the Roode of Grace, was brought to Poules Crosse, and their, at the sermon made by the Bishopp of Rochester, the abuses of the . . . engines, used in old tyme in the said image, was declared, which image was made of paper and cloutes from the legges upward; ech legges and armes were of timber; and so the people had bene eluded and caused to doe great adolatrie by the said image.[72]

Three decades later, the lawyer and historian William Lambarde gave a caustic account of the Rood and "the Monkes, which were in love with the Picture." Of the Rood, Lambarde wrote sarcastically, "it needed not Prometheus fire to make it a lively man, but onely the helpe of the covetous Priestes of Bell, or the aide of some craftie College of Monkes." As for the Rood's colleague, Saint Rumwald, Lambarde revealed it to have been operated by "a religious impostor standing out of sight." He recalled Cromwell's triumph over the monks and their machines: "But what? I shall not neede to reporte, howe lewdly these Monkes, to their own enriching and the spoile of Gods people, abused this wooden God . . . because a good sort be yet on live that sawe the fraude openly detected at Paules Cross."[73]

As with other Reformist initiatives, both sides of the confessional divide participated in this partial rejection of mechanized religious images. By the mid-seventeenth century, certain Catholic monarchs had developed a distaste for automaton angels and mechanical Ascensions. In 1647, Louis XIV and the Queen Mother came to view the automaton angels of Dieppe and found them not to their liking; that was the end of the angels.[74] An interdiction of 1666 put an end to the Virgin's annual mechanical Ascension in Toulouse on the grounds that it distracted the congregation and caused "irreverent reflections."[75]

Still, mechanized devotional objects did not disappear; on the contrary, they survived and flourished. Thus, during the late sixteenth and seventeenth centuries, the proliferating and elaborating machines coexisted with proliferating and elaborating theological and philosophical suspicions of them. The Council of Trent, in its 1563 decree on the use of sacred images, placed a ban on "unusual" images except when they were approved by a bishop.[76] Rather than eliminating mechanical icons, this ban helped to motivate a thematic shift. For example, in the wake of the Council's decree on images, the three-dimensional nativity scene (*presepio*) rose to prominence in Catholic settings as an acceptable representation of the divinity and an answer to the

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[70] Wriothesley, *Chronicle of England*, 1:74.

[71] Page, *Victoria History of Kent*, 2:153–55.

[72] Wriothesley, *Chronicle of England* 1:75.

[73] Lambarde, *Perambulation of Kent*, 207, 206, 210, 208.

[74] Chapuis and Gélis, *Le Monde des Automates*, 1:104.

[75] Auguste, "Gabriel de Ciron et Madame de Mondonville"; Chapuis and Gélis, *Le Monde des Automates*, 1:103.

[76] James Waterworth, ed. and trans., *The Canons and Decrees of the Sacred and Oecumenical Council of Trent* (London: Dolman, 1848), Session the Twenty-Fifth, 235–36.

Lutheran Christmas tree. The Jesuits embraced the *presepio* and made it their own, in large part by mechanizing it. Within a few decades, a fad for mechanical and talking *presepi* was in full swing in aristocratic and wealthy bourgeois homes as well as in churches. The sixteenth-century architect Bernardo Buontalenti built a clockwork *presepio* for his pupil, Francesco, son of Cosimo de' Medici, with opening and closing heavens, flying angels, and figures walking toward the manger. And Schlottheim built an elaborate mechanical crèche around 1589 for the Court of Saxony. The crèche, which is now in the Museum für Sächsische Volkskunst in Dresden, includes shepherds and kings proceeding past the manger while angels fly down from heaven; Joseph rocks the cradle, as an ox and ass rise up to stand before the holy Infant.[77]

A prominent representative of the Jesuitical love of mechanical devotional images was the polymath Athanasius Kircher, who served as a major fulcrum of philosophical activity during the middle decades of the seventeenth century. Among many other devices, Kircher designed a hydraulic machine to represent the Resurrection of the Savior and another device "to exhibit Christ walking on water, and bringing help to Peter who is gradually sinking, by a magnetic trick." In this contraption, the operative features were a strong magnet placed in Peter's chest and the steel out of which were wrought Christ's outstretched hands "or any part of his toga turned toward Peter." The two figures, propped on corks in a basin of water, would then be drawn inexorably together: "the iron hands of Christ soon feel the magnetic power diffused from the breast of Peter. . . . The artifice will be greater if the statue of Christ is flexible in its middle, for in this way it will bend itself, to the great admiration and piety of the spectators."[78]

More generally, as historians of religion have often noted, the Jesuits made clockwork automata a principal tool in their promulgation of Christianity. They arrived before a succession of Chinese emperors bearing gifts of automata. One such offering, dispatched in 1618 by Nicholas Trigault, the Jesuit ambassador of the Chinese Mission, was an elaborate mechanized nativity scene. The works were fully internal and spring-driven. As Trigault described it, the scene included the three Magi giving homage with bows, the Holy Virgin responding with gracious gestures, Joseph rocking the cradle where the Holy Child lay, an ass and an ox thrusting their heads toward the cradle, the Holy Father making a benediction, two angels continuously ascending and descending, and even moving shepherds.[79] The Jesuits included worldly themes as well as

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[77] On the history of the presepio, see Pietro Gargano, *Il presepio: otto secoli di storia, arte, tradizione* (Milano: Fenice 2000, 1995); Nesta De Robeck, *The Christmas Crib* (Milwaukee: Bruce, 1956), chap. 10. and fig. 39. On mechanical nativity scenes, see also Chapuis and Gélis, *Le Monde des Automates*, 2:200–202.

[78] Athanasius Kircher, *Ars Magnesia* (Würzburg, 1631), cited in translation in Michael John Gorman, "Between the Demonic and the Miraculous: Athanasius Kircher and the Baroque Culture of Machines," in *The Great Art of Knowing: The Baroque Encyclopedia of Athanasius Kircher*, ed. Daniel Stolzenberg (Stanford: Stanford University Libraries, 2001), 68. On Kircher's automata, see Bedini, "Role of Automata," 35; Jan Jaap Haspels, *Automatic Musical Instruments, Their Mechanics and Their Music, 1580–1820* (Niroth: Muiziekdruk C. V. Koedijk, 1987); Paula Findlen, "Scientific Spectacle in Baroque Rome: Athanasius Kircher and the Roman College Museum," *Roma Moderna e Comtemporanea* 3 (1995): 635–65; Findlen, "Introduction: The Last Man Who Knew Everything … or Did He? Athanasius Kircher, S.J. (1602–80) and His World," in *Athanasius Kircher: The Last Man Who Knew Everything*, ed. Paula Findlen (New York: Routledge, 2004), 34–35; Thomas L. Hankins and Robert J. Silverman, *Instruments and the Imagination* (Princeton, NJ: Princeton University Press, 1995), chaps. 2–4; Gorman, "Between the Demonic and the Miraculous"; and Penelope Gouk, "Making Music, Making Knowledge: The Harmonious Universe of Athanasius Kircher," in Stolzenberg, *The Great Art of Knowing*, 71–84.

[79] The mechanical nativity scene had been donated by Ferdinand of Bavaria, the elector of Cologne. It and the other automata that Trigault shipped in 1618 did not arrive directly at their destination since the Emperor Wan-Li was even then expelling the Jesuits from China. But a couple of decades later, after the Ming dynasty gave way to the Manchurian T'sing dynasty, many of the automata arrived belatedly as the Jesuits returned under Emperor Shun-che

religious ones in their automatic offerings. The Jesuit priest Gabriel de Magalhaens, who arrived in China in 1640, presented to the Emperor Kang'hi a spring-driven android knight that marched about with a drawn sword for a quarter of an hour.[80] The Jesuits spread explicitly Christian automata as well as secular ones with missionary purposes around the world.

Secular automata proliferated alongside religious ones. Many of the same clockmakers and engineers who designed religious automata for churches also built secular ones for private patrons or public settings. In the clockmaking region of southern Germany during the late sixteenth and early seventeenth centuries, mechanical animals like Schlottheim's mechanical crayfish became popular: automaton spiders; Neptune astride a creeping bronze tortoise; a life-sized bear, wearing real fur and beating on a drum.[81] In the 1680s and 1690s, clockmakers began to fabricate animated paintings (*tableaux mécaniques*) depicting hunting parties and other rustic scenes.[82]

Waterworks on the grounds of estates constituted the main secular tradition in automata. The wealthy and powerful found in lifelike machinery an endless source of comedy, and of the most bawdily uproarious, knee-slapping variety. 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. The second part takes up the relation of machinery to the vitality represented by a remarkably vivacious vulgarity. From the sublime, onward to the ridiculous.

II. WATERWORKS

Over a period of several centuries, spraying their unsuspecting guests with water automatically and other mechanized acts of hospitable abuse was a favorite pastime of Italian, French, and German aristocrats.[83] "Frolicsome engines" (*engiens d'esbattement*)[84] were to be found as early as the late thirteenth century at the chateau of Hesdin (in present-day Pas-de-Calais), seat of the comtes d'Artois. The machines are mentioned, beginning in 1299, in the account books of Robert II (Robert the Noble), comte d'Artois. The following year, the family appointed a castle "Master of Engines" (*Maistre des engiens du chastel*). After that, the *engiens* make regular appearances in the accounts, continuing through the reign of Robert II's successor, Mathilde (known as Mahaut), comtesse d'Artois. From these entries, we gather that the engines included mechanical monkeys with real (regularly replaced) skins,[85] monkeys which, after 1312, sported horns.[86]

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and set up clockmaking workshops. See Edmond Lamalle, "La propagande du P. Nicolas Trigault en faveur des missions de Chine (1616)," *Archivum Historicum Societatis Jesu* 9, no. 1 (1940): 49–120; Chapuis and Droz, *Automata*, 77–84; and Jonathan D. Spence, *The Memory Palace of Matteo Ricci* (New York: Penguin, 1985), 180–84. On the Jesuits' clockwork gifts in China, see also *China in the Sixteenth Century: The Journals of Matthew Ricci*, ed. Nicholas Trigault, trans. Louis J. Gallagher (1615; New York: Random House), bk. 1, chap. 4 and bk. 4, chap. 12.

[80] Louis Pfister, *Notices biographiques et bibliographiques sur les Jésuites de l'ancienne mission de Chine (1552–1773)* (Shanghai: Imprimerie de la Mission Catholique, 1932, 1934), notice 88; Chapuis and Droz, *Automata*, 315.

[81] Chapuis and Gélis, *Le Monde des Automates*, 1:192; 2:141–43, 152–53; Chapuis and Droz, *Automata*, 242.

[82] Principal builders of animated paintings during the last decades of the seventeenth century included the clockmakers Abraham and Christian-Théodore Danbeck and Christophe Leo of Augsburg, and during the early eighteenth century Jean Truchet (le père Sébastien). See Chapuis and Gélis, *Le Monde des Automates*, 1:319.

[83] Late medieval and early modern palace waterworks were informed by translations of ancient texts, notably the works of Hero of Alexandria, and made virtually no changes to the ancient mechanisms. See Bedini, "Role of Automata," 26.

[84] Jules-Marie Richard, *Une petite-nièce de saint Louis. Mahaut, comtesse d'Artois et de Bourgogne (1302–1329). Etude sur la vie privée, les Arts et l'Industrie, en Artois et à Paris au commencement du XIVe siècle* (Paris: Champion, 1887) (a study of the comtesse Mahaut's account books), 333; Sherwood, "Magic and Mechanics," 589–90.

[85] Archives nationales de France (hereafter cited as Arch. nat., Fr.), KK 393; Richard, *Une petite-nièce de saint Louis*, 308.

There were also "an elephant and a he-goat"[87] and a machine referred to as "the boar's head."[88] From 1419 until his death in 1467, the comtesse Mahaut's descendant, Philippe le Bon, Duke of Burgundy, conducted a thorough refurbishment of the stock he had been left by his forebears and expanded it considerably. His own account books contain a meticulous catalog of the many mechanized tricks he inflicted on visitors. These included

> painting of 3 personages that spout water and wet people at will . . . a machine for wetting ladies when they step on it . . . an "engien" which, when its knobs are touched, strikes in the face those who are underneath and covers them with black or white . . . another machine by which all who pass through will be struck and beaten by sound cuffs on their head and shoulders . . . a wooden hermit who speaks to people who come to that room . . . 6 personages more than there were before, which wet people in various ways . . . eight pipes for wetting ladies from below and three pipes by which, when people stop in front of them, they are all whitened and covered with flour . . . a window where, when people wish to open it, a personage in front of it wets people and closes the window again in spite of them . . . a lectern on which there is a book of ballades, and, when they try to read it, people are all covered with black, and, as soon as they look inside, they are all wet with water . . . [a] mirror where people are sent to look at themselves when they are besmirched, and, when they look into it, they are once more all covered with flour, and all whitened . . . a personage of wood that appears above a bench in the middle of the gallery and fools [people] and speaks by a trick and cries out on behalf of *Monsieur le Duc* that everyone should go out of the gallery, and those who go because of that summons will be beaten by tall personages dressed like "sots" and "sottes," who will apply the rods aforesaid, or they will have to fall into the water at the entrance to the bridge, and those who do not want to leave will be so wetted that they will not know where to go to escape from the water . . . a window in which there is a box suspended in the air, and on that box there is an owl which makes various faces in looking at people and gives an answer to everything that one wishes to ask it, and its voice can be heard in that box. . . .[89]

The Hesdin *engiens d'esbattement*, in all their malicious glory, achieved great notoriety and inspired many imitations in the following century.[90]

By 1580 and 1581, when Montaigne was traveling through Europe, hydraulic automata had grown so commonplace in noble palaces and on the grounds of bourgeois estates that he grew bored with them. Outside Augsburg, at the summer place of the rich banking family Fuggers, Montaigne saw sprays of water from "little brass jets which cannot be seen," activated by concealed springs. "While the ladies are busy watching the fish play, you have only to release some spring: immediately all these jets spurt out thin, hard streams of water to the height of a man's head, and fill the petticoats and thighs of the ladies with this coolness." Elsewhere, hidden jets

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[86] Archives départementales du Pas-de-Calais (hereafter cited as A.D. P.d.C.), A 297; Richard, *Une petite-nièce de saint Louis*, 336.

[87] A.D. P.d.C., A 548; Richard, *Une petite-nièce de saint Louis*, 341.

[88] A.D. P.d.C., A 648; Richard, *Une petite-nièce de saint Louis*, 342.

[89] *V^e compte de Jehan Abonnel dit Legros, conseilleur et receveur général de toutes les finances de monseigneur le duc de Bourgoingne. . .*, in the *Recette générale des finances, Chambre des comptes de Lille*, Archives departementales du Nord, série B no. 1948 (Registre); Laborde, *Les Ducs de Bourgogne: études sur les lettres, les arts et l'industrie pendant le XVe siècle, et plus particulièrement dans les Pays-Bas et le duché de Bourgogne* (Paris: Plon frères, 1849–52), Seconde Partie, Tome 1:268–71; Sherwood, "Magic and Mechanics," 587–90 (the quoted passage is taken from the excerpt cited in translation in Sherwood); Price, "Automata and the Origins of Mechanism," 20–21; Chapuis and Gélis, *Le Monde des Automates*, 1:72.

[90] On the fame and influence of the Hesdin engines, see Sherwood, "Magic and Mechanics," 590; and Price, "Automata and the Origins of Mechanism," 21.

could be triggered to gush directly into the face of a visitor who stopped to admire a particular fountain.[91] In one room, the Fuggers palace also had an automaton lion that sprang forward when a door was opened.[92]

At Pratolino, a palace of Francesco I de' Medici, Grand Duke of Tuscany, Montaigne marveled at Buontalenti's elaborate installations. In one "miraculous" grotto he saw

> not only music and harmony made by the movement of the water, but also a movement of several statues and doors with various actions, caused by the water; several animals that plunge in to drink; and things like that. At one single movement the whole grotto is full of water, and all the seats squirt water on your buttocks; and if you flee from the grotto and climb the castle stairs and anyone takes pleasure in this sport, there come out of every other step of the stairs, right up to the top of the house, a thousand jets of water that give you a bath.[93]

The grotto at Pratolino also had singing birds and an automaton lady who emerged from behind a door to fill a cup with water.[94] Another of the Grand Duke's residences boasted a grotto bustling with hydraulically driven "water mills and windmills, little church bells, soldiers of the guard, animals, hunts, and a thousand such things."[95]

Montaigne was unimpressed even by the already famous Villa d'Este in Tivoli. The Tivoli palace and gardens had been built during the 1550s and 1560s by Cardinal Ippolito II d'Este, then Governor of Tivoli, as consolation after an unsuccessful campaign to win the papacy. Completed in 1572, the grottoes were already old news, and Montaigne, arriving 1580, declined to write a lengthy description of them since there were already "published books and pictures on the subject." Moreover, the "gushing of an infinity of jets of water checked and launched by a single spring that can be worked from far off, I had seen elsewhere on my trip." He then provided a jaded, if meticulous, account of the water organ:

> The music of the organ, which is real music and a natural organ, though always playing the same thing, is effected by means of the water, which falls with great violence into a round arched cave and agitates the air that is in there and forces it, in order to get out, to go through the pipes of the organ and supply it with wind. Another stream of water, driving a wheel with certain teeth on it, causes the organ keyboard to be struck in a certain order; so you hear an imitation of the sound of trumpets. In another place you hear the song of birds, which are little bronze flutes . . . this by an artifice like that of the organ; and then by other springs they set in motion an owl, which, appearing at the top of the rock, makes this harmony cease instantly, for the birds are frightened by his presence; and then he leaves the

[91] Michel de Montaigne, *Travel Journal*, ed. and trans. Donald M. Frame (San Francisco: North Point, 1983), 37.

[92] Chapuis and Gélis, *Le Monde des Automates*, 1:74.

[93] Montaigne, *Travel Journal*, 64. See also Salomon De Caus, *Les Raisons des forces mouvantes avec diverses machines tant utiles que plaisantes, auxquelles sont adjoints plusieurs dessings de grotes & fontaines* (Francfort: J. Norton, 1615), 1:29 (owl and birds), 2:13 (Pratolino).

[94] Christian Hülsen, "Ein deutscher Architekt in Florenz (1600)," with drawing of the grotto in question by Henri Schickhardt, in *Mitteilungen des Kunsthistorischen Instituts in Florenz* (1912–1917), 2:152–93; Chapuis and Gélis, *Le Monde des Automates*, 1:75. On hydraulic entertainments in Italy, see also Philippe Morel, *Les Grottes maniéristes en Italie au XVIe siècle: Théâtre et alchimie de la nature* (Paris: Macula, 1998).

[95] Montaigne, *Travel Journal*, 143.

place to them again. This goes on alternately as long as you want. . . . All these inventions, or similar ones, produced by the same natural causes, I have seen elsewhere.[96]

Twenty years after Montaigne's travels, when Henri IV decided his palaces needed embellishment, he lured away Tomaso Francini, engineer to Ferdinando I de' Medici, then Grand Duke of Tuscany, to supply the requisite waterworks. Francini began at Saint-Germain-en-Laye, where he mechanized a small throng of classical gods and heroes and other moving figures all in bronze.[97]

There were grottoes devoted to Neptune, Mercury, Orpheus, Hercules, Bacchus, Perseus, and Andromeda. John Evelyn visited the palace at Saint-Germain-en-Laye in 1644 and recorded in his diary what he had seen there.[98] He and other visitors described an automaton Neptune with a streaming blue beard, brandishing his trident, naked astride a chariot pulled by seahorses, accompanied by three round-bellied, horn-playing tritons. Farriers, "their faces black with filth and sweat," hammered iron on an anvil and —"that which is most pleasant and seems made to provoke laughter"—drenched their eager audiences with surprise sprays of water. Mercury posed by a window with one foot carelessly propped, "loudly intoning a trumpet." Elsewhere, Orpheus played his lyre for an audience of animals and trees who, including the trees, stretched and craned toward him.[99] A towering Perseus descended upon a mighty dragon arising from beneath the waves. Perseus swung his sword to behead the fearsome beast, sending it, slain, back down into the watery depths; whereupon farther back in the grotto, Andromeda promptly lost her chains. Meanwhile busy figures of artisans—blacksmiths, weavers, millers, carpenters, knife-grinders, fishermen—went about their sundry tasks.[100]

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[96] Ibid., 99. The owl-and-birds arrangement was taken from a much-imitated design by Hero of Alexandria. See *The Pneumatics of Hero of Alexandria*, ed. and trans. Bennett Woodcroft (London: Taylor Walton and Maberly, 1851), #15. On Hero's automaton, see Sylvia Berryman, "The Imitation of Life in Ancient Greek Philosophy," in Riskin, *Genesis Redux*, chap. 2.

[97] The primary source of information about the Francini fountains at Saint-Germain-en-Laye is a collection of engravings by Abraham Bosse, done from Francini's own designs. Tomaso Francini's brother, Alessandro, who collaborated with him on the fountains at Fontainebleau, is listed as the author of the collection: Alessandro Francini, *Recueil. Modèles de grottes et de fontaines. Dessins lavés.* BNF Estampes et photographie, Réserve Hd-100(A)-Pet Fol; also in the Archives nationales, O¹ 1598. There is also John Evelyn's description in his diary: Evelyn, *Diary and Correspondence*, ed. William Bray (London: George Bell and Sons, 1883), 1, entry for 27 February 1644. See also Evelyn, *Elysium Britannicum, or the Royal Gardens*, ed. John E. Ingram (Philadelphia: University of Pennsylvania Press, 2000), bk. 2, chap. 9, "Of Fountains, Cascades, Rivulets, Piscenas, Canales, and Water-works"; bk. 2, chap. 12, "Of Artificial Echoe[']s, Automats, and Hydraulic motions"; bk. 3, chap. 9, "Of the most famous Gardens in the World, Ancient and Modern." For other primary accounts of the hydraulic automata at Saint-Germain-en-Laye, see Georges Houdard, *Les Châteaux royaux de Saint-Germain-en-Laye, 1124–1789: Etude historique d'après des documents inédits recueillis aux Archives Nationales et à la Bibliothèque Nationale* (Saint-Germain-en-Laye: Maurice Mirvault, 1910–11), vol. 2. For secondary descriptions, see Albert Mousset, *Les Francine, créateurs des eaux de Versailles, intendants des eaux et fontaines de France de 1623–1784* (Paris: E. Champion, 1930), chap.1 and plates 2, 3, 4; Lionel du Sorbiers de la Tourrasse, *Le Château-neuf de Saint-Germain-en-Laye, ses terrasses et ses grottes* (Paris: édition de la Gazette des beaux-arts, 1924); Alfred Marie, *Jardins français créés à la Renaissance* (Paris: Vincent Fréal & Cie., 1955); Chapuis and Droz, *Automata*, 43–47. The fountains were abandoned after Louis XIV moved his court to Versailles in 1682, and virtually no trace of them remains. On the fountains at Versailles as emblems of material power, see Chandra Mukerji, *Territorial Ambitions and the Gardens of Versailles* (Cambridge: Cambridge University Press, 1997), esp. 181–97.

[98] Evelyn, *Diary*, entry for 27 February 1644.

[99] André du Chesne, *Les Antiquités et recherches des villes, chasteaux, et places plus remarquables de toute la France* (Paris: Pierre Rocolet, 1637), 221–24.

[100] Evelyn, *Diary*, entry for 27 February 1644; Mousset, *Les Francine*, 35–41.

Another dragon appeared in the Dragon Grotto, shaking its terrible head and wings while belching steam. This Dragon, despite its ferocity, was surrounded by "various little birds, which really one would say were not painted & counterfeit, but living and fluttering their wings, which make the air resound with a thousand sorts of song; and above all the Nightingales there vie to make music in several choirs." There were cuckoos, too, and in yet another grotto, a nymph played at an organ.[101] The Grotto of Torches—a subterranean chamber lit only by flames—displayed a heady sequence of scenes "by force of water": first, an idyllic, island-dotted sea in which fishes and sea-monsters sported happily beneath a rising sun; then, a violent storm, thunder and lightning, wrecked ships heaved up on shore. Next came a calm and fertile vista, a flowerbed in bloom and trees filled with fruit. In the distance, the king and his family strolled, all except the dauphin, who arrived from on high in a chariot carried by two angels. The angels crowned the prince with a glittering coronet. Finally, there was a desolate landscape, a desert littered with ruins where reptiles, insects, and other wild creatures crawled about. At the last, a fairy emerged playing a flute and the animals gathered round to listen.[102]

What was it like to live amidst such machines, to be familiar with them, to have them shape one's earliest intuitions about machinery: how it works, what it does, how it compares to living creatures? We can form a reasonable impression thanks to a meticulous daily record of the life of a child who grew up with the hydraulic grottoes of Saint-Germain-en-Laye in his garden. The record includes every passing fancy, every lisping pronouncement, the menu at each meal down to the numbers of prunes or grapes consumed and careful descriptions of all bowel movements. The child was the future Louis XIII, the son of Henri IV and Maria de' Medici, born just when Francini was working on his father's fountains. The dauphin's birth was recorded by his doctor and caretaker, Jean Hérouard, on September 27, 1601, as having taken place at "ten-thirty and a half quarter according to my watch made in Abbeville by M. Plantard."[103] The prince would spend his childhood mostly at Saint-Germain-en-Laye where he developed a passion for mechanical things.

As a toddler, the dauphin watched the workers from his windows[104] and, from the age of three, in the spring of 1605, he began visiting the grottoes several times each week.[105] Hérouard's diary describes him in bed one morning instructing a chambermaid, "Pretend dat I am Ofus [Orpheus] and you are da fountainee [fountaineer], you sing da canaries."[106] Soon afterward, he was working the grotto faucets, spraying himself and everyone else with water.[107] The prince plagued Francini with visits to his workshop, demanding the name of each instrument and explanations of how they worked.[108] At home, he talked continuously about Francini and pre-

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[101] Du Chesne, *Les antiquités*, 222; Evelyn, *Diary*, entry for 27 February 1644.

[102] Evelyn, *Diary*, entry for 27 February 1644; Mousset, *Les Francine*, 38.

[103] "a dix heures et demie et demy quart selon ma monstre faicte a Abbeville par M. Plantard." Jean Hérouard, *Journal de Jean Héroard*, ed. Madeleine Foisil (Paris: Fayard, 1989), 1:370 (entry for 27 September 1601).

[104] See, e.g., the entry for 6 June 1605, Hérouard, *Journal*, 1:676.

[105] In April and May 1605 alone, visits to the grottoes are recorded on 11, 13, 14, 17, and 29 April; 2, 8, 9, 15, 27, and 29 May. Hérouard, *Journal*, 1:638, 639, 643, 653, 655, 657, 658, 660, 666, 668.

[106] "Faite semblan que je sui Ophée (Orphée) e vous le fontenié (-er), dite chante le (les) canarie." Hérouard, *Journal*, 1: 633 (entry for 20 March 1605).

[107] See entries for 13, 14, and 17 April 1605, Hérouard, *Journal*, 1:638, 639, 643.

[108] See entries for 25 May, 2 June, 3 July, 30 July, 20 August, 28 August, and 25 October 1605; 9 May, 15 June, and 8 July 1606, Hérouard, *Journal*, 1:664–65, 672, 703, 722, 741, 759, 809, 943, 987, 1000.

tended to be Francini, making wax models, working the fountains, collecting his pay. He played fountains in bed, in his gilt washbasin, and under the dining table—"*fssss*" and "*dss*"—making believe he was spraying people with water. On one occasion, he was rebuked by a nurse for climbing under the table to play fountains to the neglect of a visiting dignitary.[109] Francini built a small wooden fountain for the dauphin, which was installed near his rooms on his fourth birthday.[110] While work on the fountain was underway, the prince went continually to the workshop to see it, begging, "let's go see my fountain at Francino's place."[111]

At first, the dauphin could not be persuaded to enter the Orpheus grotto. Finally his governess, Mme. de Montglat, enticed him in with a handful of sugared peas, having first covered the figure of Orpheus with a drape. Thereafter, the prince boasted that he had been to the very back of the grotto and was not afraid even to touch Orpheus himself.[112] In addition to occasional notes of fear, the passion also contained more than a hint of childish eroticism. Hérouard dutifully recorded on one occasion: "says he has a faucet in his ass and another in his willie: '*fs fs*'." The future absolutist—who was given to exposing himself to the servants and whose "willie" was the focus of much teasing attention from all members of the household including the King and Queen—was especially fond of the willie-fountain joke, which he repeated frequently.[113]

The day the dauphin's governor, M. de Souvé (Gilles, marquis de Courtenevaux), arrived at Saint-Germain-en-Laye, shortly before the prince's seventh birthday, Louis insisted on taking the tired traveler on an immediate tour of the grottoes, where he worked the faucets himself.[114] As a child king, having ascended to the throne at age nine after his father's assassination, Louis XIII continued to visit Francini, going straight to his workshop upon arriving at the palace, and amusing himself for hours at a time by forging, soldering, and filing fountain pipes.[115]

Louis XIII liked clockwork as well as hydraulic automata. Hérouard's journal describes the dauphin, age four, beating his spoon against his plate and announcing to his governess: "Maman ga [Mme. de Montglat] I am ringing da hour *dan*, *dan*, it rings like da jackamart who beats on da anvil."[116] Here he is at six, shopping in Paris along the rue Saint Honoré, choosing a spring-driven toy carriage on offer for 15 *écus*.[117] Later in the same year, the dauphin was given a cabinet fabricated in Nuremberg with "a great number of personages doing diverse actions by the movement of sand." The personages enacted Christ's Passion and the taking of Jerusalem. The

[109] See entries for 16 April, 18 April, 1 June, 2 June, 6 June, 10 June, 13 June, 15 June, 22 June, 26 June, 30 June, and 3 August 1605, Hérouard, *Journal*, 1:640, 643, 671, 672, 673, 676, 681, 684, 686, 692, 696, 698, 725.

[110] See entries for 12 February, 13 March, and 27 September 1605, Hérouard, *Journal*, 1:596, 614, 767.

[111] "Maman ga, allon voir ma fontaine ché Francino." M. "Mr, je n'ay point de carrosse." D. "Nous iron bien a pié." Madame luy dict: "Mousieu i a bien loin." D. "Madame, nou passerons pa le jadin nou i seron incontinent." Entry for 25 May 1605, Hérouard, *Journal*, 1:664–65. "Maman ga" was Madame de Montglat (Françoise de Longuejoue), the Dauphin's governess. See also the entries for 30 May and 7 June 1605, Hérouard, *Journal*, 1:669, 678.

[112] See entries for 29 April and 2 June 1605, Hérouard, *Journal*, 1:653, 672.

[113] "Dict qu'il y a ung robinet a son cul et ung autre sa guillery: '*fs fs*'." Entry for 18 April 1605, Hérouard, *Journal*, 1:643. For some repetitions of the joke, see entries for 2 April, 1 June, 10 June 1605, Hérouard, *Journal*, 1:638, 671, 681. The eroticism that pervades Hérouard's journal has occasioned a good deal of analysis. See, for example, Philippe Ariès, *L'Enfant et la vie familiale sous l'Ancien Régime* (Paris: Plon, 1960).

[114] Hérouard, *Journal*, 1:1502 (entry for 12 September 1608).

[115] See entries for 31 July 1611 and 27 October 1612, Hérouard, *Journal*, 2:1939, 2066.

[116] "Maman ga, je sone les heure, dan, dan, i (il) sone come le jaquemar qui frape su l'enclume." Hérouard, *Journal*, 1:699 (entry for 30 June 1605). The prince referred to the clock at Fontainebleau.

[117] Hérouard, *Journal*, 1:1396 (entry for 5 March 1608).

prince played fervently with the instrument, quickly grasping how to make it stop and go, demonstrating it to everyone in the palace, and discoursing about the works with mispronunciations that charmed his guardian: "*contrepès*, pour countrepoids."[118]

This intimacy with and predilection for mechanical games persisted through generations of French princes. Louis XIV was born at Saint-Germain-en-Laye and received mechanical toys—automaton clocks, a carriage and company of soldiers, a mechanical theater that enacted an opera in five acts—well into his dotage.[119] His son, Louis XIII's grandson, had an arsenal of automaton toys including another mechanical army of a hundred soldiers.[120]

You didn't need to be a king or a prince: the popes, too, competed in the game of hydraulic trickery. When Ippolito Aldobrandini became Pope Clement VIII in 1592, he assigned his nephew, Cardinal Pietro Aldobrandini, the task of building a villa of unprecedented magnificence. Aldobrandini engaged the hydraulic engineers Orazio Olivieri and Giovanni Guglielmi to design what Edith Wharton, on her tour of Italian villas, would describe as "the inevitable *théâtre d'eau.*"[121] At the Villa Aldobrandini, the waterworks included a room of hydraulic and pneumatic marvels, the Stanza dei Venti (Room of Winds), which would draw visitors throughout the seventeenth and eighteenth centuries. Water from hidden, spring-triggered spouts, it should go without saying, leapt out to spray hapless visitors. Other spouts of water and water-powered jets of air played organ- and fife-music and produced eerie sounds—thunder, wind, rain, whistles, shrieks—while wooden globes danced magico-mechanically across the floor.[122]

The popes, their nephews and their grand-nephews, all the little cardinals and archbishops wanted their own hydro-mechanical toys. Markus Sittikus von Hohenems, sovereign and archbishop of Salzburg from 1612 until his death in 1619, installed waterworks at his Schloss Hellbrunn that remain in operation almost four centuries later.[123] When he was elected archbishop, Sittikus was already a connoisseur of automata. He had lived briefly at the Villa Aldobrandini; moreover, his uncle, Cardinal Marco Sittico Altemps, nephew of Pope Pius IV, had built the

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[118] Ibid., 1:1434 (entry for 16 May 1608).

[119] Antoine Morand's clock with automata, made in 1706 to honor Louis XIV, is currently in the Musée de Versailles. Chapuis and Gélis, *Le Monde des Automates*, 1:233–37. François-Joseph de Camus built a mechanical carriage for the future Louis XIV, then still the dauphin, with moving figures of soldiers and a lady. The carriage may have been melted down along with all other objects of precious metal, by order of the king, in 1709, when war had depleted the royal treasury. See Charles-Etienne-Louis de Camus, *Traité des forces mouvantes pour la pratique des arts et des métiers* (Paris: C. Jombert, 1722), 521–33; Chapuis and Gélis, *Le Monde des Automates*, 2:13–18. Jean Truchet (le père Sébastien) built the mechanical opera. It is described in Bernard le Bouvier de Fontenelle, *Suite des éloges des Académiciens* (Paris: Osmont, 1733), 170; and in Louis Abel de Fontenay, *Dictionnaire des artistes* (Paris, 1772), s.v. "Notice sur le P. Truchet." See Chapuis and Gélis, *Le Monde des Automates*, 1:337.

[120] The automaton army was built by Gottfried Hautsch in Nuremberg for Louis, le Dauphin du Viennois (le Grand Dauphin), born in 1661. See Doppelmayr, *Historische nachricht*, 304; Chapuis and Gélis, *Le Monde des Automates*, 2:12–13.

[121] The engineers were Orazio Olivieri and Giovanni Guglielmi. Edith Wharton, *Italian Villas and Their Gardens* (1904; New York: Da Capo, 1977), 154. Other spouts of water and water-powered jets of air played organ and fife music and produced eerie sounds—thunder, wind, rain, whistles, shrieks—while wooden globes danced magico-mechanically across the floor. On the Villa Aldobrandini (originally named the Villa Belvedere), see Carla Benocci, *Villa Aldobrandini a Roma* (Rome: Argos, 1992). Giovanni Battista Falda's engraving of the Stanza dei Venti is in *Le fontane di Roma*, pt. 2, *Le fontane delle ville di Frascati* (Rome: Giovanni Giacomo de' Rossi, 1691), plate 7.

[122] See Giovanni Battista Falda's engraving of the Stanza dei Venti in *Le fontane delle ville di Frascati*, plate 7.

[123] On Sittikus and the Schloss Hellbrunn, see Chapuis and Gélis, *Le Monde de Automates*, 1:76–77; Chapuis, "The Amazing Automata at Hellbrunn," *Horological Journal* (June 1954): 388–89; Bedini, "Role of Automata," 27; Wilfried Schaber, *Hellbrunn: Schloss, Park und Wasserspiele* (Salzburg: Schlossverwaltung Hellbrunn, 2004).

Villa Mondragone, which had a renowned Water Theater designed by the engineer Giovanni Fontana.[124] In Sittikus's garden, visitors are still invited to seat themselves around a stone table, on stone benches with hidden spouts that release jets of water on command, drenching the obedient from below.

In the Neptune Grotto to which they proceed, dripping and uproarious, guests gape at the Germaul, a stone gargoyle that rolls its eyes menacingly and sticks out its tongue. Fleeing the Germaul, the visitors are again watered down from spring-triggered spouts concealed in the walls. Arriving re-moistened in the Birdcall Grotto, they are surrounded by the hydraulically produced sound of chirping and twittering birds. Afterward, they are led along the Royal Way past five small grottoes, each housing a scene enacted by automata: a miller grinding his wheat; a potter working at his wheel; a scissors grinder and his wife sharpening blades on a wheel while their child plays at their feet; Perseus freeing Andromeda from the dragon; Apollo flaying Marsyas. Next, present-day visitors arrive at an elaborate water-driven Mechanical Theater displaying a town square populated by more than a hundred moving figures: carpenters, innkeepers, musicians, and other street performers, a barber giving a client a shave, a butcher slaughtering an ox, a farmer pushing an old woman in a wheelbarrow, a marching military guard, a dancing bear. The Mechanical Theater, completed in 1752, was the contribution of Archbishop Andreas Jakob Graf von Dietrichstein; it replaced an earlier hydraulically powered mechanical scene representing a forge.

At the time that Sittikus's waterworks were being installed, princes across the land were importing hydraulic engineers to install automata on their palace grounds; it was routinely one of their first acts as sovereign. The adolescent Palatine elector, Frederick, brought his hydraulic engineer along with his seventeen-year-old bride, Elizabeth, daughter of King James I. Elizabeth traveled to Heidelberg for her wedding in 1613 accompanied by Salomon De Caus, an engineer from northern France and Huguenot refugee at her father's court.[125] De Caus would remain at Heidelberg as Frederick's engineer until 1620 when the elector, then also king of Bohemia, would lose his crown to the Holy Roman Emperor Ferdinand II and have to flee with his family to The Hague. The brevity of Frederick's Bohemian reign, which lasted a single winter, earned him the nickname "Winter King." But De Caus had time to transform the palace gardens into yet another hydraulic wonderland.

The waterworks' creator described grottoes in which fabulous creatures performed magico-mechanical feats.[126] In one, water poured from the breasts of a woman in the middle of the cavern, and from the mouth of a fish held by a man seated beside her. The couple was serenaded by a Satyr playing a flute, and opposite him, by the Nymph Echo, softly repeating each phrase. In the Grotto of Orpheus, the minstrel played his cello, charming the beasts around him—leopard, ram, lion, boar, stag, sheep, rabbit, and snake—who danced in time to the music. The Grotto of Neptune contained the god of the sea himself and some attendant creatures—a pair of swimming horses whose reigns he gripped, a couple of wading nymphs playing horns, and a cherub

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[124] See Falda's engraving of the Semicircular Water Theater of the Villa Mondragone in *Le fontane della ville di Frascati*, plate 18.

[125] The story of the wedding and De Caus's work in Heidelberg is told in Frances Yates, *The Rosicrucian Enlightenment* (London: Routledge, 1972), chap. 1. Yates suggests that De Caus invented the mechanical use of steam power (p. 19).

[126] De Caus, *Les Raisons des forces mouvantes* (1615) and *Hortus Palatinus* (Frankfurt, 1620).

astride two dolphins—all turning in stately circles around a great Gothic rock upon which a siren held a jug spouting water.[127]

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 of Alexandria, which were repeatedly translated and printed over the course of the sixteenth century.[128] In turn, these inspired modern works that borrowed extensively from the classical ones. An influential example is Agostino Ramelli's *Le diverse e artificiose machine* (1588), which contains a plan for an "ingenious and delightful" fountain of twittering birds, based closely on designs from Hero's *Pneumatica*. Within the fountain, a nest of compartments is joined by a network of siphons. The siphons are connected above, through pipes, to little figures of birds with flutes in them. As water descends through the fountain, the siphons begin to function, emptying certain compartments and filling others, forcing air up through the various pipes in turn. The air, as it comes out the tops of the pipes into the birds with their flutes, makes them flutter and trill.[129]

De Caus was the author of another such work, *Les raisons des forces mouvantes avec diverses machines tant utiles que plaisantes* (1615), which has trees full of automaton birds, including one in direct imitation of a design by Hero, just like the one Montaigne had noted at the Villa d'Este: the birds flutter and chirp while an owl turns slowly toward them. When the intimidating owl faces the birds, they fall silent, but as he turns away, they resume their ruckus.[130] De Caus's treatise also contains meticulous accounts of the mechanisms of hydraulic grottoes like those of the Palatine gardens. In one, Galatea rides astride a big seashell drawn by two dolphins. Behind her, a Cyclops has put his club aside to play on a flageolet, while sheep gambol about. The mechanism is made entirely of wood, driven by two waterwheels. These are put in motion by jets of water from two pipes that emerge from a common reservoir. The pipes have valves that open and close alternately by means of a system of counterpoises, so that the wheelwork turns one way and then the other as Galatea and her dolphins move back and forth across the scene. A third waterwheel, through a train of gear-wheels, drives a pinned barrel that is in turn connected with the keys of the flageolet.[131]

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[127] De Caus, *Les Raisons des forces mouvantes*, 2:n. pg., 2: 6v, 1:34v; see also Chapuis and Gélis, *Le Monde des Automates*, 1:78–82.

[128] Giorgio Valla, *Georgii Vallae Placentini viri clari de expetendis, et fugiendis rebus opus* (Venetiis: In aedibvs Aldi Romani, 1501); Federigo Commandino, *Aristarchi de Magnitudinus, et Distantiis Sollis, et Lunae, Liber* (Pisavri: apud Camillum Francischinum, 1572); Giovanni Battisti Aleotti, *Gli artificiosi et curiosi moti spirituali di Herrone* (Ferrara: Vittorio Baldini, 1589). Subsequent editions included Alessandro Giorgi da Urbino, *Spirituali di Herone Alessandrino* (Urbino: Press, 1592, 1595). See also Bedini, "Role of Automata," 25.

[129] Agostino Ramelli, *The Various and Ingenious Machines of Agostino Ramelli (1588)*, ed. Eugene S. Ferguson, trans. Martha Teach Gnudi (Baltimore: Johns Hopkins University Press, 1976), chap. 186; see also chap. 187, which describes an essentially similar arrangement in which the effects are produced by a concealed person blowing through a pipe rather than by the flow of water. Another example is Giambattista della Porta, *Pneumaticorum libri tres: Quibus accesserunt curvilineorum elementorum libri duo* (Naples: J. J. Carlinus, 1601).

[130] De Caus, *Les Raisons des forces mouvantes*, 1:30: "Pour faire representer plusieurs oiseaux lesquels chanteront diversement quand une chöuette se tournera vers iceux, & quand ladite chöuette se retournera, ils cesseront de chanter."

[131] De Caus, *Les Raisons des forces mouvantes*, 1:34: "Machine par laquelle l'on representera une Galatee qui sera trainee sur l'eau par deux daufins, allant en ligne droite, & se retournant d'elle mesme, cependant qu'un ciclope Jöue dessus un flajollet."

By the 1660s, when Evelyn was at work on his gardening manuals, he considered it a matter of course that an essential part of the business would be to instruct "our docill Gardiner, how he may himselfe make & contrive these wonderfull Automats, . . . which at present so celebrate the Gardens of the greatest Princes; . . . & many other famous Gardens of the most illustrious persons of the World." It was not just an added flourish but actually "necessary," Evelyn counseled, "in these Inventions, to give some motion to the living creatures . . . that they may the [better] imitate nature." The possibilities were legion:

> We may . . . people our Rocks with *Fowle, Conies, Capricornes, Goates* [& rapitary beasts, with] *Hermites, Satyres,* [Masceras] *Shepheards,* [rustic workes river gods Antiqs etc] and with divers *Machines* or *Mills* made to move by the ingenious placing of wheels, painted & turned by some seacret pipes of waters; The *Figures* above named may be formed of Potters earth, well moulded and baked; but if the states must be larger, of stone or Mettal: By these motions, histories, [*Andromedas*] and *sceanes* may be represented.[132]

In addition to the elaborate networks of levers, wheels, gears, flowing fluids, and falling weights, the advent of organ-barrel programming helped in the building of complex systems of lifelike motions. Kircher—who designed and described many automata including an "automatic organ machine which utters the voices of animals and birds"—was the first to publish a systematic account of the camshaft in 1650.[133] But by then, pinned cylinders had already been in use for several decades.[134] One of the earliest known examples was in an organ clock presented by Queen Elizabeth to the Sultan of Turkey in 1599.[135]

During the first decades of the seventeenth century, the use of camshafts spread quickly. De Caus adopted them to organize the motions in his reproductions of Hero's singing and fluttering birds.[136] The Augsburg clockmaker Achilles Langenbucher put the new technology to work in mechanical musical ensembles composed of many playerless instruments.[137] Evelyn included an extensive description of the camshaft (the "Phonotactic Cylinder") in *Elysium Britannicum.*[138] His discussion included explicit instructions for making such a device, which, like the construction of automata more generally, he considered to be essential to the art of gardening:

> A *Cylinder* may be fitted so as to move, take out, & change the Teeth at pleasure, to place other in their stead: and so new *Composition* may be applied; . . . For example of this: Divide a *Cylinder* into 24 *Measures,* each of these [full] divide againe into 8 equal spaces, as we noted for *Quavers;* you shall bore holes, at every point of these divisions; as being [furnished] with a greate number [of] *Teeth* (as the *Printers* box is with Letters) for all sorts of

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[132] Evelyn, *Elysium Britannicum,* 231, 242, 191. (The markings indicate Evelyn's amendments in the manuscript.)

[133] Kircher, *Musurgia Universalis* (Rome: Francisi Corbelletti, 1650), 2:347; Bedini, "Role of Automata," 35.

[134] Price writes that in automaton clocks, "For the first time [around 1550], wheelwork is used instead of levers, gears instead of strings, organ-barrel programming instead of sequential delay devised hydraulically." Price, "Automata and the Origins of Mechanism," 22.

[135] This was a collaborative work. The goldsmith Randolph Bull, clockmaker to the queen, built the clock part of the device while the organ maker Thomas Dallam built the organ part and supervised installation in the sultan's palace. See C. B. Drover, "Thomas Dallam's Organ Clock," *Antiquarian Horology* 1, no. 10 (1956): 150–52; Bedini, "Role of Automata," 35.

[136] De Caus, *Les Raisons des forces mouvantes,* 1:29.

[137] Price, "Automata and the Origins of Mechanism," 20. Langenbucher's Pomeranian Chest, presented to Duke Philip of Pomerania in 1617, held an automatic organ of twenty-one pipes that played four pieces of music.

[138] Evelyn, *Elysium Britannicum,* 232–42.

Notse, which may keepe in a divided Drawer somewhere about the Organ, you may insert a new *Composition* or Tunes at pleasure in your *Cylinder* which, the more large & ample it is, will be so much the better for our purpose.[139]

By means of a camshaft, a single flow of fluid could work myriad effects. Evelyn singled out, as most "expeditious" and "ingenious," those waterworks that "onely with the [precipitation] of water alone produce wind sufficient for all our motions."[140] A single "Artificiall Ventiduct" created by filling a chamber with water, thereby forcing out the air, could be "sufficient either to refrigerate a roome in Summer, or to animate any . . . Bird, blow the Fire, [or] turne any Image or wheele."[141] Similarly, through the "rarifaction" of air by heating, one could create a stream of wind; this wind could then turn a cogwheel that could pluck wires to play a tune or make another patterned sound, as in the case of the "celebrated statue of Memnon, which is reported to have spoaken & uttered a voice like a man, so soone as the Sun arose & darted his rayes upon it." The same wind, Evelyn noted, might "also serve to make artificiall Eyes & hands move; And Birds furnished with proper calls & whistles, will be heard to sing, to move their tailes, heads & clap their wings."[142]

In sum, hydaulic and mechanical figures became commonplace. Treatises such as De Caus's and Evelyn's helped to spread familiarity with hydraulic antics below the sphere of popes and princes. Martin Löhner, a hydraulic engineer and the Master of Wells [*Brunnenmeister*] for Nüremberg, established a much-visited host of automata at his own comparatively humble house: Vulcan laboring at his forge; Hercules bludgeoning his dragon; Acteon surprising Diana and her nymphs in their bath, whereupon Diana threw water at Acteon, who turned away, grew antlers on his head, and was attacked by his own dogs; Cerberus spitting fire at Hercules; a lion emerging from his cave to drink from a basin, then retiring; the nine Muses, each engaged at her appointed art.[143] Waterworks were de rigueur not only for popes, cardinals, archbishops, and kings, but also for ministers. Richelieu had his own at his residence at Reuil. Evelyn, visiting in 1644, pronounced that garden "so magnificent, that I doubt whether Italy has any exceeding it." He recorded having been shot by streams of water, on his way out of one of Richelieu's grottoes, from muskets held by "two extravagant [automaton] musketeers."[144]

One might think the joke would wear thin, but one would be wrong. The sport proceeded right on through the seventeenth century. Evelyn described with malicious satisfaction, circa 1660, the "wayes of contriving seacret pipes to lie so as may wett the [gazing] Spectators, underneath, behind, in front and at every side according as the Fontaneere is pleased to turne & governe these clandestine & prepostrous showers." Evelyn included, for example, a design for making "a chaire which shall wett those that sit upon it, though no water appeare." The functional features are a water-filled cushion attached to a pipe that rises through the back of the chair and has an opening, concealed in "the carvd head of a Lyon or some other beast," at the

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[139] Ibid., 241.

[140] Ibid., 232.

[141] Ibid., 244.

[142] Ibid., 249–50. Evelyn cites Pliny, Philostratus, Pausanius, Lucian, Tacitus, Strabo, and Kircher as authorities on the legendary statue. See also Kircher, *Oedipus Aegyptiacus, hoc est, Vniuersalis hieroglyphicae veterum doctrinae temporum iniuria abolitae instauratio* (Romae: Ex typographia Vitalis Mascardi, 1652–54), 3:488.

[143] On Martin Löhner and his automata, see Doppelmayr, *Historische nachricht*, 306; Chapuis and Gélis, *Le Monde des Automates*, 1:76.

[144] Evelyn, *Diary and Correspondence*, 1 (entry for 27 February 1644).

top. Thus when the victim sits down on the cushion, he unknowingly squeezes water up into the pipe to "spurt into his neck immediately." This "waggish invention," Evelyn said, he had found in the garden of the Pope's cross-bearer.[145]

The gulled continued to take their licks with unflagging surprise and delight. Anne-Louise d'Orléans, duchesse de Montpensier, the memoirist and wayward cousin of Louis XIV, cheerfully recorded her experience at the Essonnes estate of the master of finances for the royal household, where she visited with her friend, Madame de Lixein, in the summer of 1656:

> As I passed through a grotto, they released the fountains, which came out of the pavement. Everyone fled; Madame de Lixein fell and a thousand people fell on her. . . . We saw her being led out by two people, her mask muddy, and her face the same; her handkerchief torn, her clothes, her oversleeves, in short, disconcerted in the funniest way in the world, and I cannot remember it without laughing. I laughed in her face and she started laughing too, finding that she was in a state to inspire it. She took this accident as a person of humor. She took no meal and went right to bed. . . . Upon returning, I visited her: we laughed a lot again, she and I.[146]

Robert Darnton has suggested that historians take note of the mystifying jokes of the past, as these indicate "where to grasp a foreign system of meaning in order to unravel it."[147] To what exotic tapestry do these mischievous machines in their endless funniness connect? Bergson described the quintessential comic situation as "something mechanical encrusted on the living": the appearance of a human being as an automaton. We laugh, Bergson claimed, as a "corrective": to reassert the distance between machinery and life.[148] But, as Darnton's recommendation assumes, humor has a history[149] and the need to establish that human beings are not machines cannot have had the same urgency in 1500 or 1600 as it had in 1900. Rabelais's, not Chaplin's, was the sense of humor at play. The frolicsome engines cataloged in this essay represented something like the opposite of Bergson's scenario: not people as rote automata but machines as responsively alive. The machines' human targets, laughing at the machines' whimsical vitality, do not seem to me to have been reasserting their own transcendence of machinery. I think they

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[145] Evelyn, *Elysium Britannicum*, 184, 439.

[146] Anne-Louise d'Orléans, duchesse de Montpensier, *Mémoires de Mlle. de Montpensier*, ed. Bernard Quilliet (Paris: Mercure de France, 2005), chap. 23 (July—September, 1656). The owner of the estate, whom the writer identifies as "Esselin," was Louis Cauchon d'Hesselin, who served as Maître de la chambre aux deniers de la maison du roi. Madame de Lixein was Henriette de Lorraine, daughter of François de Lorraine, who had married the Prince of Lixen.

[147] Robert Darnton, *The Great Cat Massacre and Other Episodes in French Cultural History* (New York: Vintage, 1985), 78.

[148] Henri Bergson, *Laughter: An Essay on the Meaning of the Comic*, trans. Cloudesley Brereton and Fred Rothwell (Whitefish, MT: Kessinger, 2004), 16, 81 (first published in French as *Le Rire: essai sur la significance du comique* [Paris: Editions Alcan, 1900]). For Freud's use of Bergson's theory of humor in his own very different account, see Sigmund Freud, *Jokes and Their Relation to the Unconscious*, trans. James Strachey (New York: W. W. Norton, 1963, chap. 7, esp. 259–60 (first published in German *as Der Witz und Seine Beziehung zum Unbewussten* [Leibzig: Deuticke, 1905]).

[149] For an anthology of recent treatments of this subject, see Jan M. Bremmer and Herman Roodenburg, eds., *A Cultural History of Humour: From Antiquity to the Present Day* (Cambridge: Polity Press, 1997). Peter Burke, in chap. 5 of the volume, "Frontiers of the Comic in Early Modern Italy, c. 1350–1750," mentions Renaissance palace waterworks in passing (p. 65). The history of humor is an integral part of the discussion in Norbert Elias's classic work, *The Civilizing Process: Sociogenetic and Psychogenetic Investigations* (London: Blackwell, 1994) (first published in German as *Über den Prozess der Zivilisation* [Basel: Haus zum Falken, 1939]).

were doing something more like delighting in a base corporeality that they thought anchored even the very highest of human lives in an actively material world.

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Arriving, then, at the mid-seventeenth century, when the idea of the animal-machine began to flourish in philosophical discussion, we can see that mechanical images of living creatures were already everywhere. They were familiar, not only to the nobility and the wealthy bourgeoisie, but to their servants, and to the engineers and the artisans who built the machines, as well as to the audiences who flocked to witness them, and the literate who read about them. The culture of lifelike machinery surrounding these devices projected no antithesis between machinery and either divinity or vitality. On the contrary, the automata represented spirit in every corporeal guise available, and life at its very liveliest. Here, then, was the culture that gave rise to the seventeenth-century animal-machine. That comparatively confined being represented a narrowing of intellectual and cultural possibilities. To make full sense of this development, we must consider the world that preceded it. Before machines became mindless and rote, they were the life of the party. $\boxed{A}$