Chapter 20. Meeting 20, History: Mechanical Musical Automata

20.1. Announcements

- Sonic system draft due: 27 April

20.2. Quiz Review

- ?

20.3. Android

- First usage dates from 1727-51

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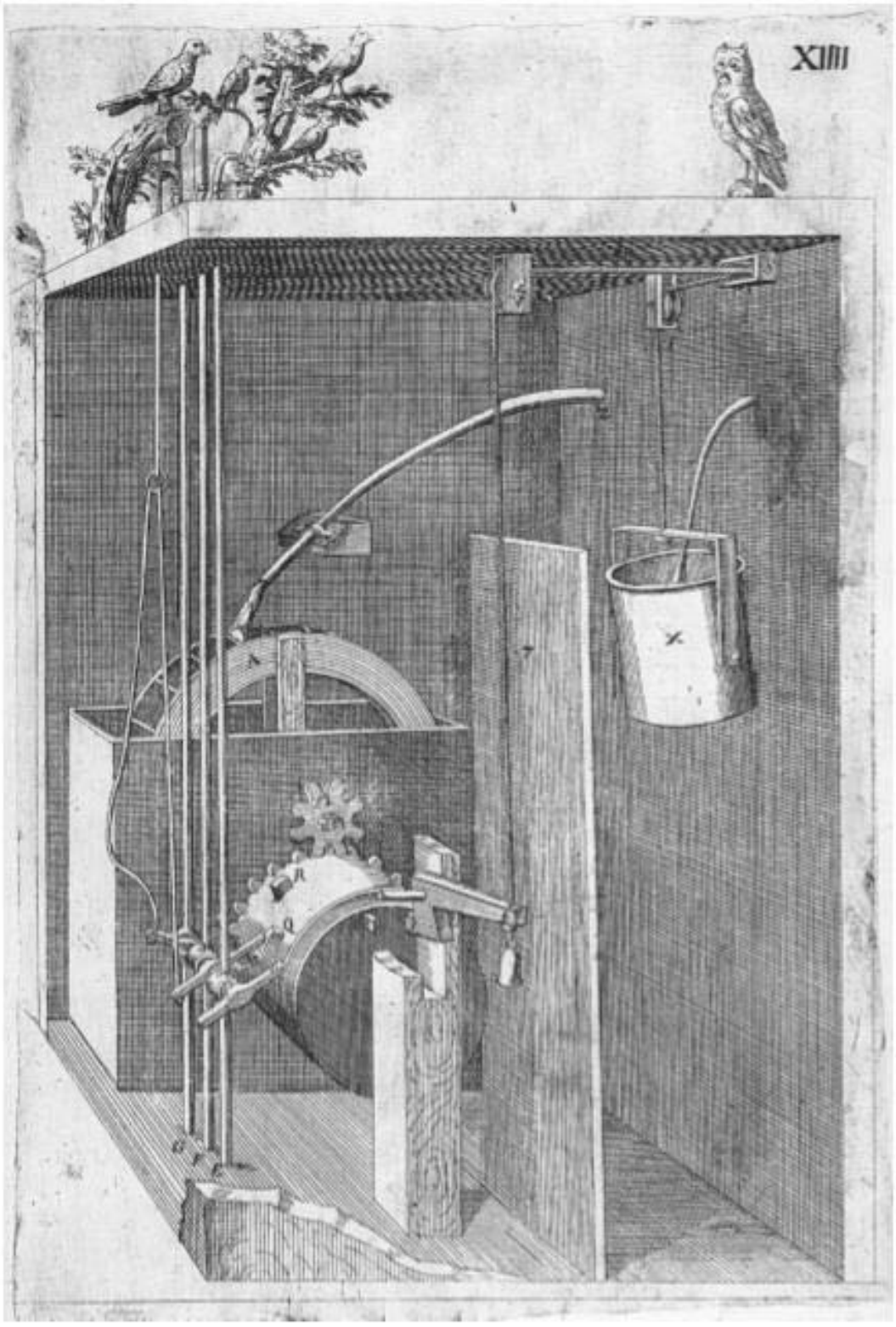
20.4. Mechanical Automata

- Jacques Vaucanson (1709-1782)
- Pierre Jaquet-Droz (1721-1790)
- Wolfgang von Kempelen (1734-1804)
- Joseph Marie Jacquard (1752-1834)
- Charles Babbage (1791-1871)

20.5. Automata: Background

- 18th century mechanical theaters built within clock works
- Often religious scenes of Madonna and Child
- Inspired a wide range of automatic entertainment machines
- Resulted in complex machines and technological advances
- Example: automaton monk from 1560

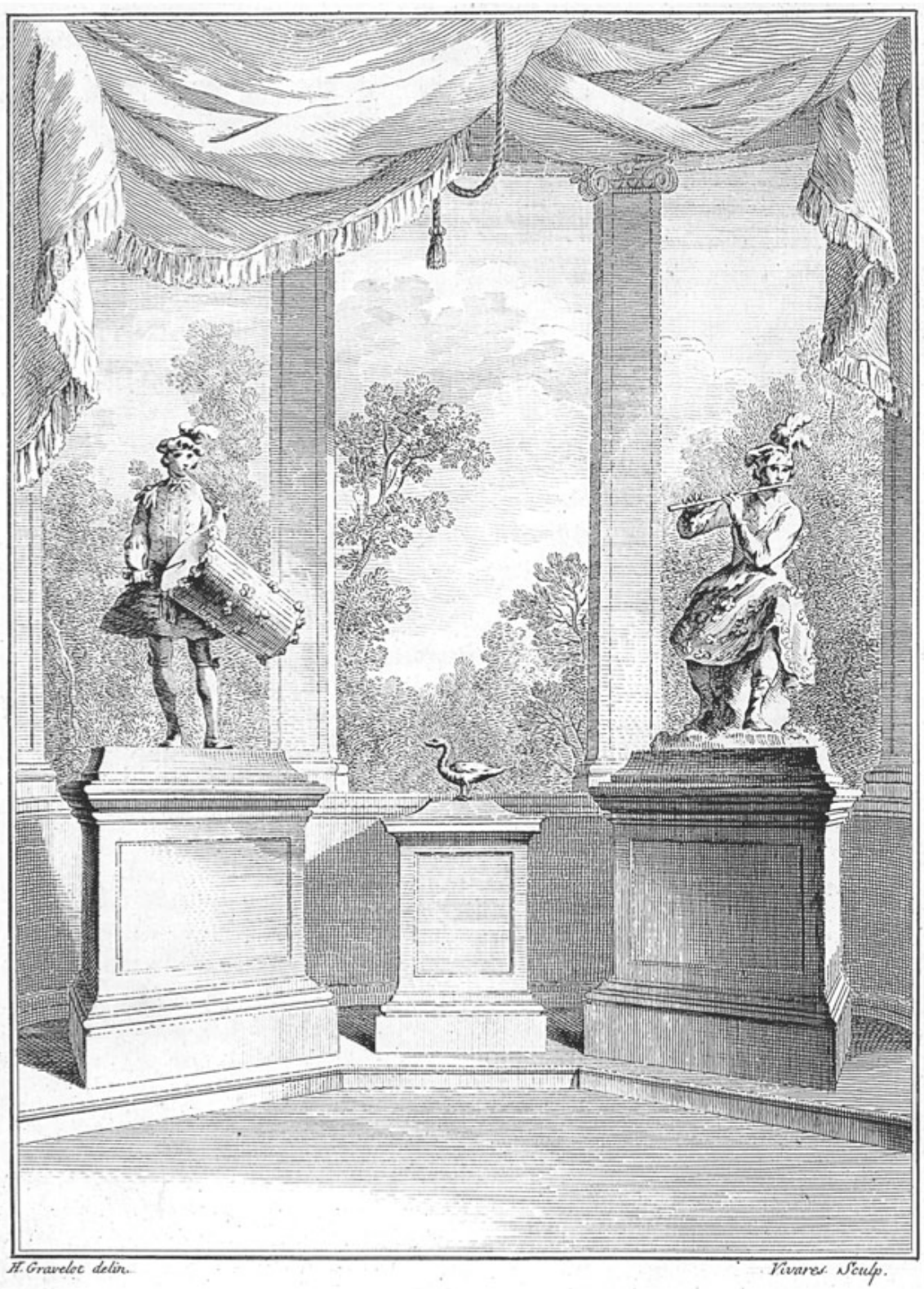
  YouTube (http://www.youtube.com/watch?v=Ycyj76VPOtc)
- Example: automaton of French engineer Isaac de Caus



Isaac de Caus's threatening owl and intimidated birds. (Public domain image)

20.6. Vaucanson: The Flute Player

- Was a Jesuit but renounced religious life for pursuit of automata (Standage 2002)
- Displayed in 1737 (Standage 2003)
- Based on a statue by Antoine Coysevox (2003, p. 613)
- A theory of sound production of the flute
- Acoustically produced sound: different flutes could be substituted
- Concerned with three parameters: air pressure, shape of aperture, length of flute (2003, p. 615)



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See diagram "Fluter de Vaucanson" in Doyon, A., and L. Liaigre.
Jacques Vaucanson, mécanicien de génie. Presses Universitaires de France, 1966.

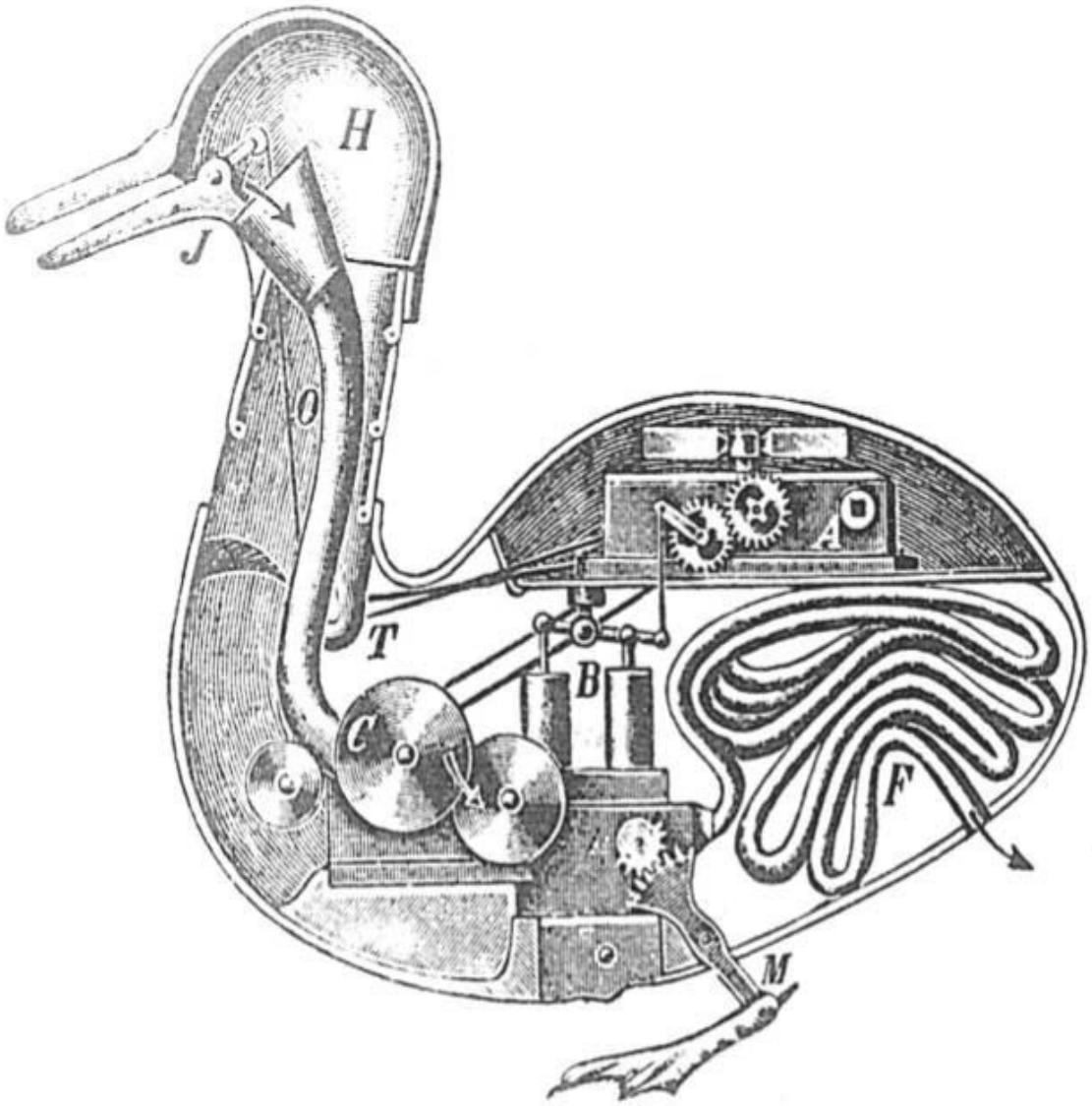
- Used studs on a cylinder to encode data

20.7. Vaucanson: Pipe and Tabor Player

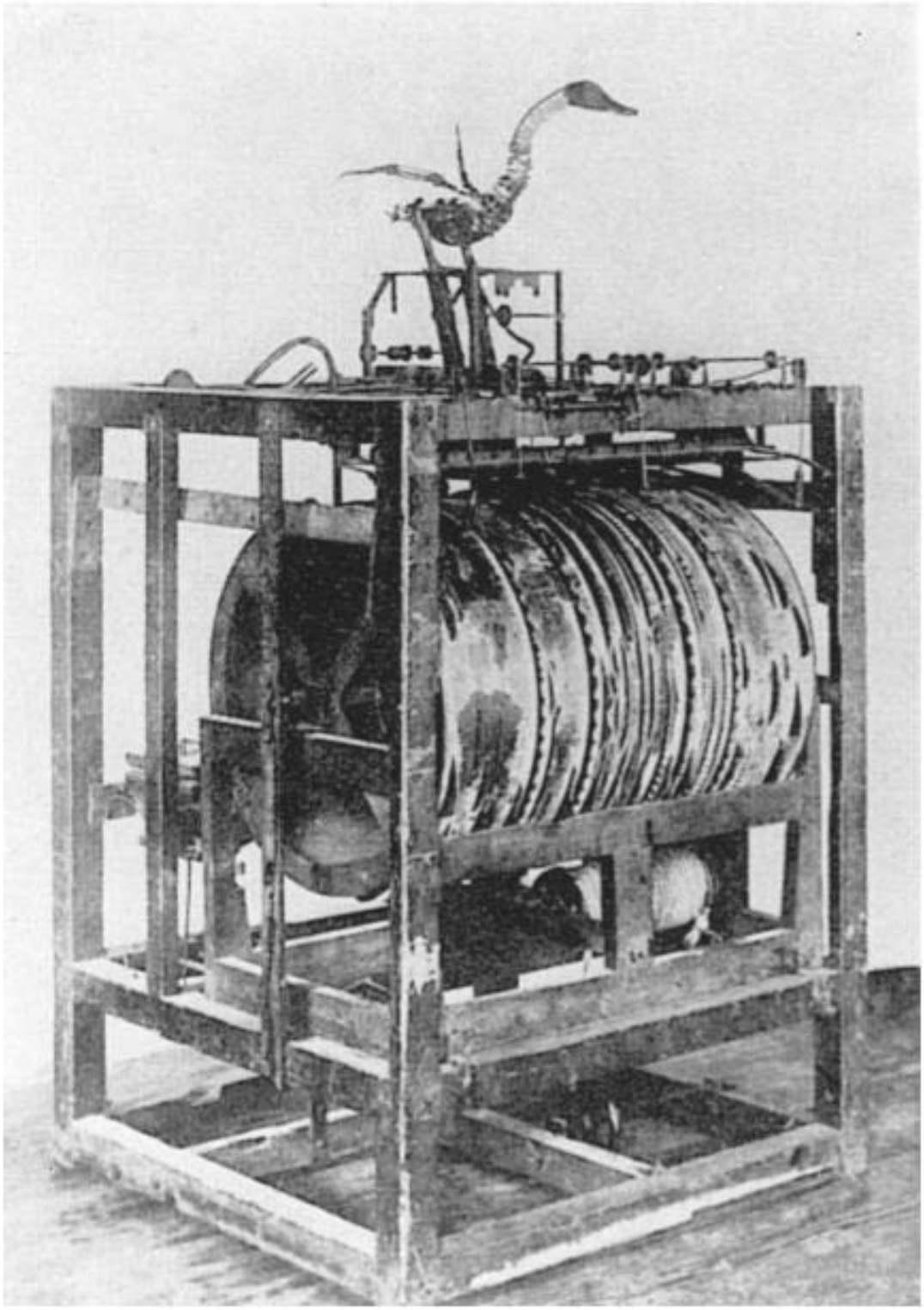
- Displayed in 1738
- Vaucanson "discovered that the blowing pressure for a given note depended upon the preceding note, so that it required more pressure to produce D after an E than after a C..." (2003, p. 616)

20.8. Vaucanson: Defecating Duck

- Displayed in 1738



A mechanical digesting duck, as imagined by a 19th century illustrator. (Public domain image)



Mysterious photo discovered at the Musee des Arts de Metiers in Paris, labeled "Views of Vaucason's Duck received from Dresden." (Public domain image)

YouTube: 3:28 (http://www.youtube.com/watch?v=Pd_21_pfSRo)

- Powered by weight that, with gravity, drove a cylinder
- Part of later projects in moving anatomies: mechanical models of bodily processes such as respiration and circulation: intended for physiological experimentation and to test medical therapies (2003, p. 625)

20.9. Vaucanson: Automated Loom

- Created in 1747

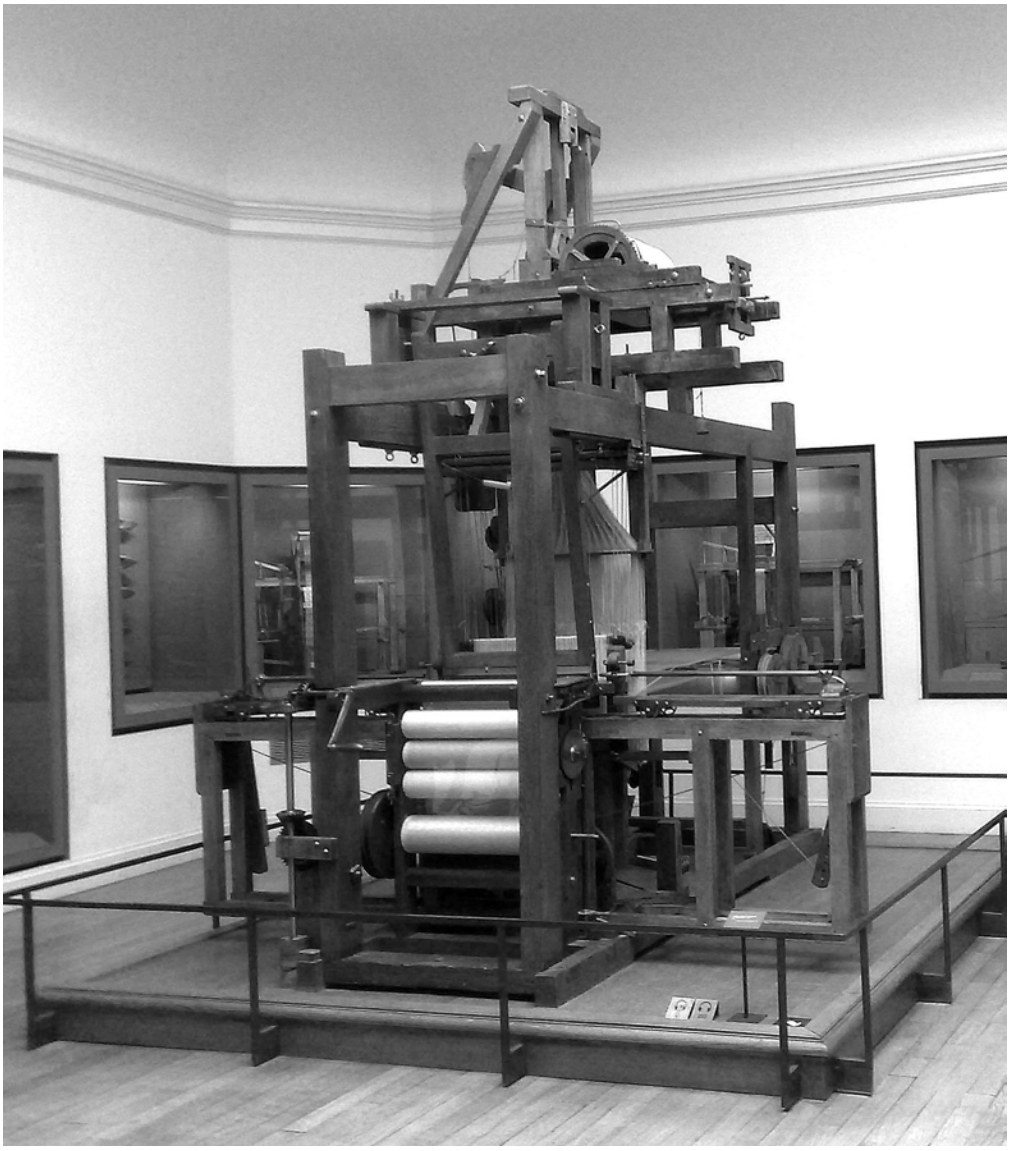
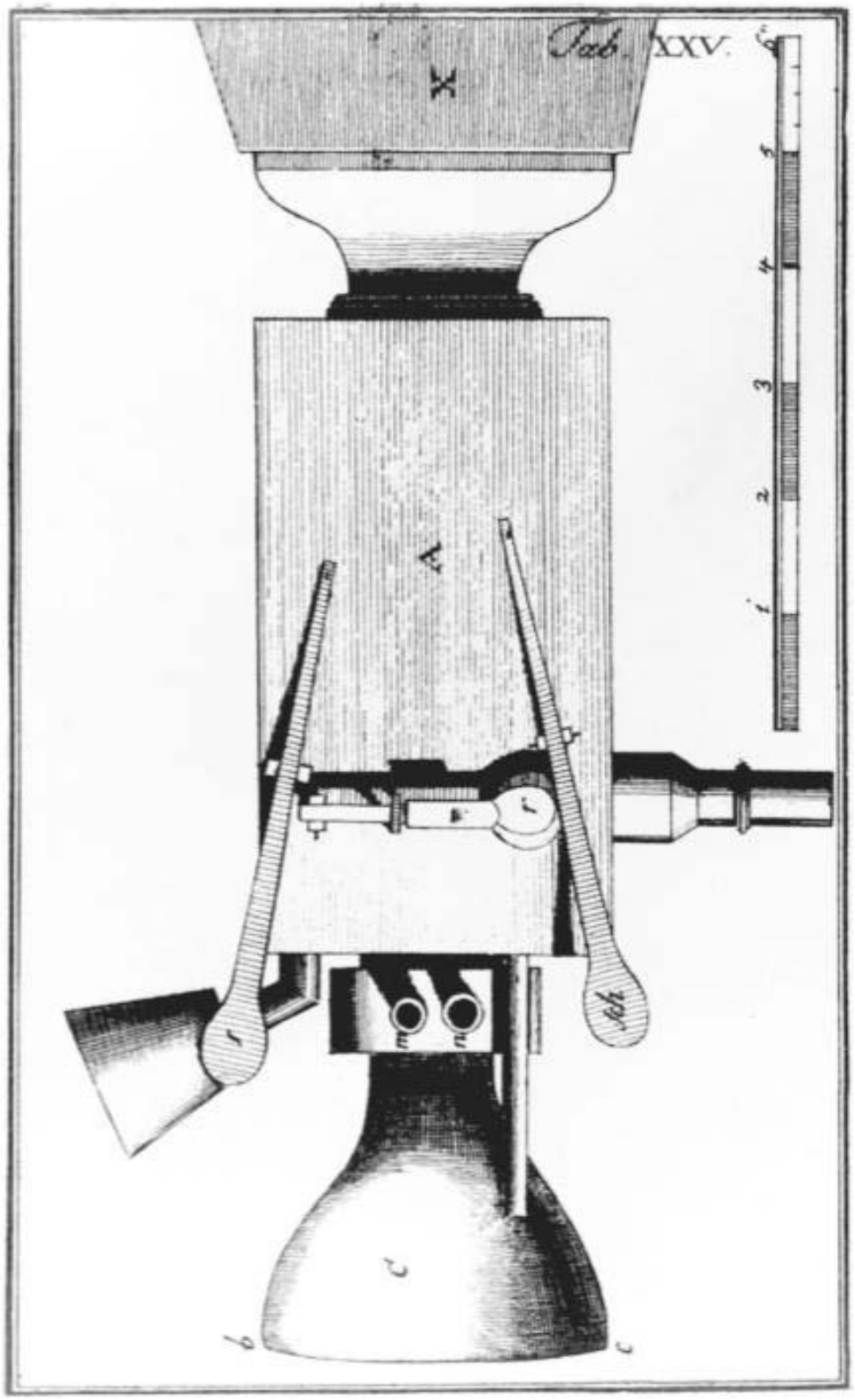


Photo courtesy of bjepson on Flickr.

- Resulted from an analysis of what could be automated in the production of silk
- Did not recreate the same process used by humans
- Task formerly known to take intelligence (reading patterns) was demoted; process that was not known to take intelligence (silk reeling) was promoted

20.10. Kempelen: Speaking Machine

- Kempelen was familiar with Vaucanson's work (Standage 2003)
- Published description of speaking machine in 1791



Kempelen's speaking machine. (Public domain image)

(Public domain image)

- Part of a tradition of "speaking heads"; Christian Kratzenstein built models of the vocal tract in 1779
- Used bellows, reeds, and models of lungs and mouth: known to say "mama" and "papa"

  YouTube (http://www.youtube.com/watch?v=zYRVqrfY3tQ)
- Kempelen "reported that he had first tried to produce each sound in a given word or phrase independently but failed because the successive sounds needed to take their shape from one another" (2003, p. 619)

20.11. Kempelen: The Turk

- Kempelen, after seeing a magician at the court of the empress of Austria-Hungary, declared that he could do better; was given six months leave (2003)

- Spring of 1770 returned with the Turk

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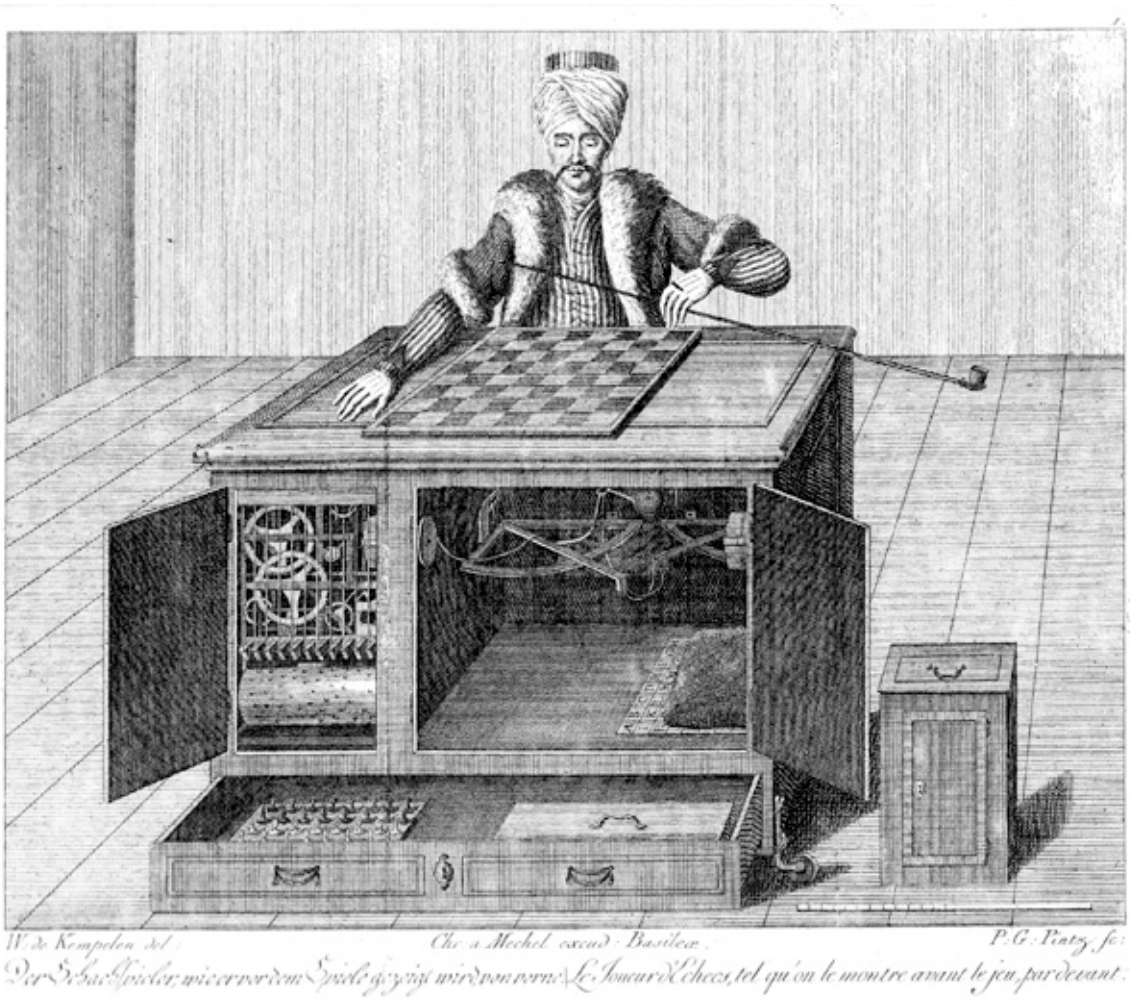

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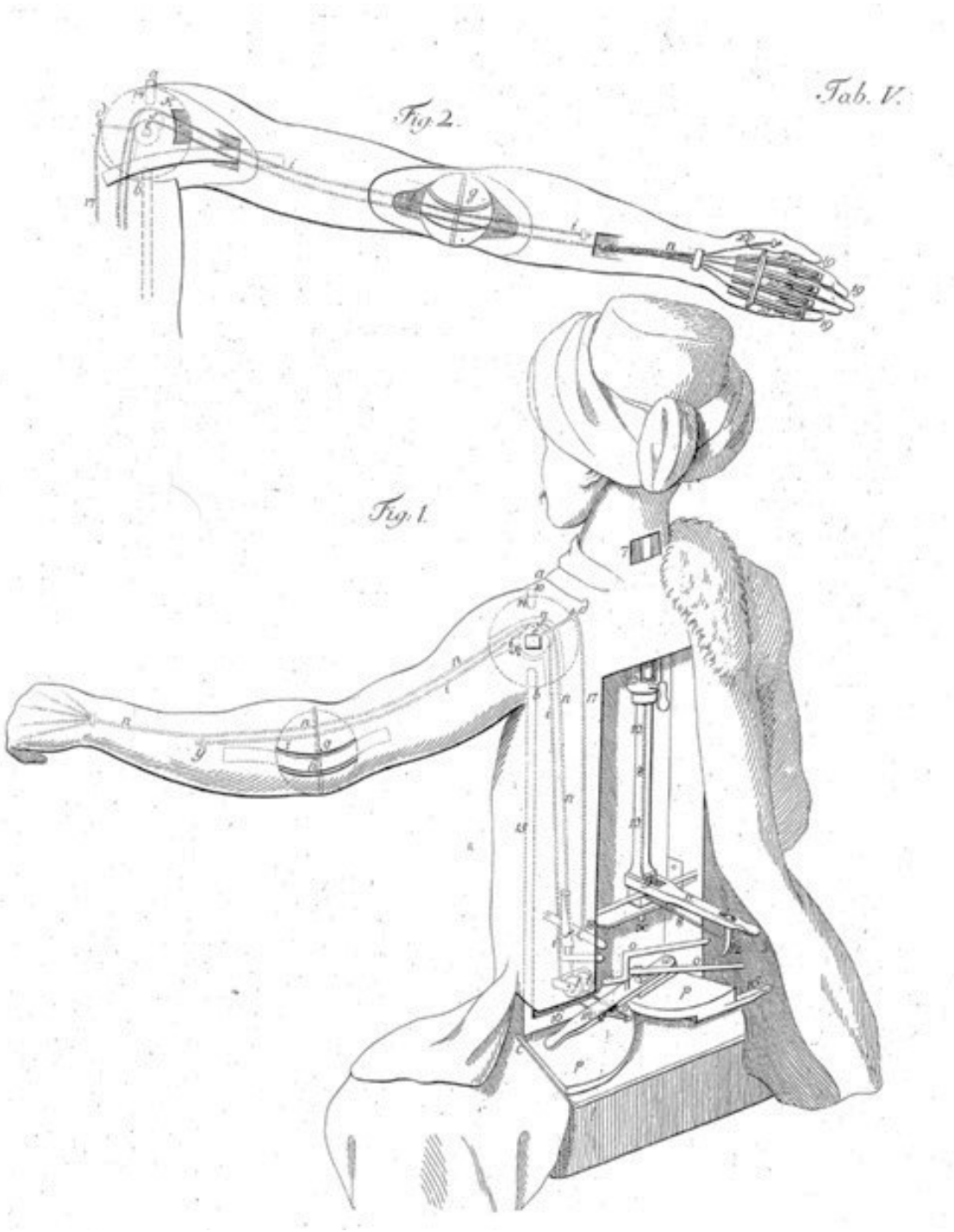

(Public domain image)

- Had an elaborate presentation of the inside of the machine, used a candle to show panels, turned machine around
- Placed two candelabras on top of the cabinet
- Turned a key and made loud, mechanical noises

- Beat most opponents in less than half an hour
- First tour of Europe; in Paris it played Benjamin Franklin and lost to Philidor
- Owned and exhibited by Johann Mälzel from 1808 to 1828 in Milan, Paris, Uniter Kingdom, New York City, Boston, Philadelphia, and Baltimore
- Would play chess, perform end-games (the Knight's Tour), would answer audience questions by point to a board
- Destroyed in a fire in a Philadelphia museum in 1854
- Documentaries and other programs

  YouTube (http://www.youtube.com/watch?v=RdT4yG8wczQ)

  YouTube (http://www.youtube.com/watch?v=K3U83LnwMCc)

20.12. Jaquet Droz: The Harpsichord Player

- Built between 1768 and 1774
- Henri Louis Jaquet-Droz builds a harpsichord player machine

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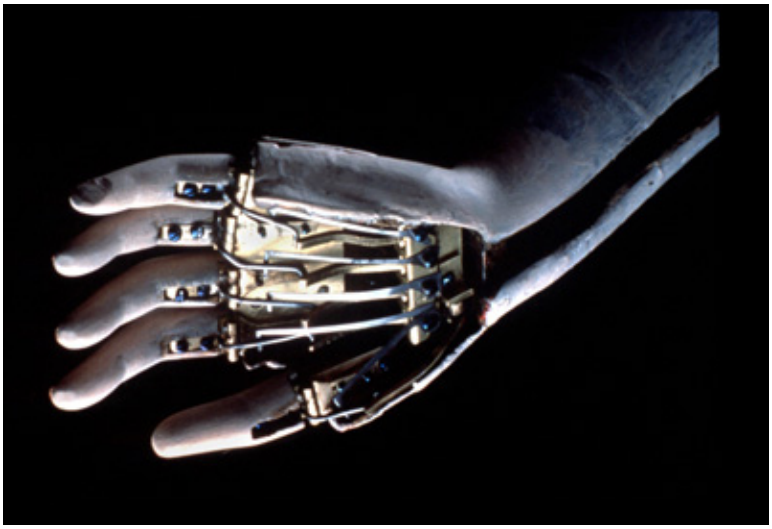
- Programmed with studs on a cylinder
- Family used designs to construct prosthetic limbs (Riskin 2003, p. 625)



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- Part of a collection of three automata: the writer, the drawer, and the musician

  YouTube (http://www.youtube.com/watch?v=Pd_21_pfSRo)

- Other Jaquet-Droz Devices:

  Singing Bird Box:

  YouTube (http://www.youtube.com/watch?v=HjLy0zausRU)

20.13. Jacquard: Automatic Loom

- Studied Vaucanson's loom in Paris
- Built in 1801

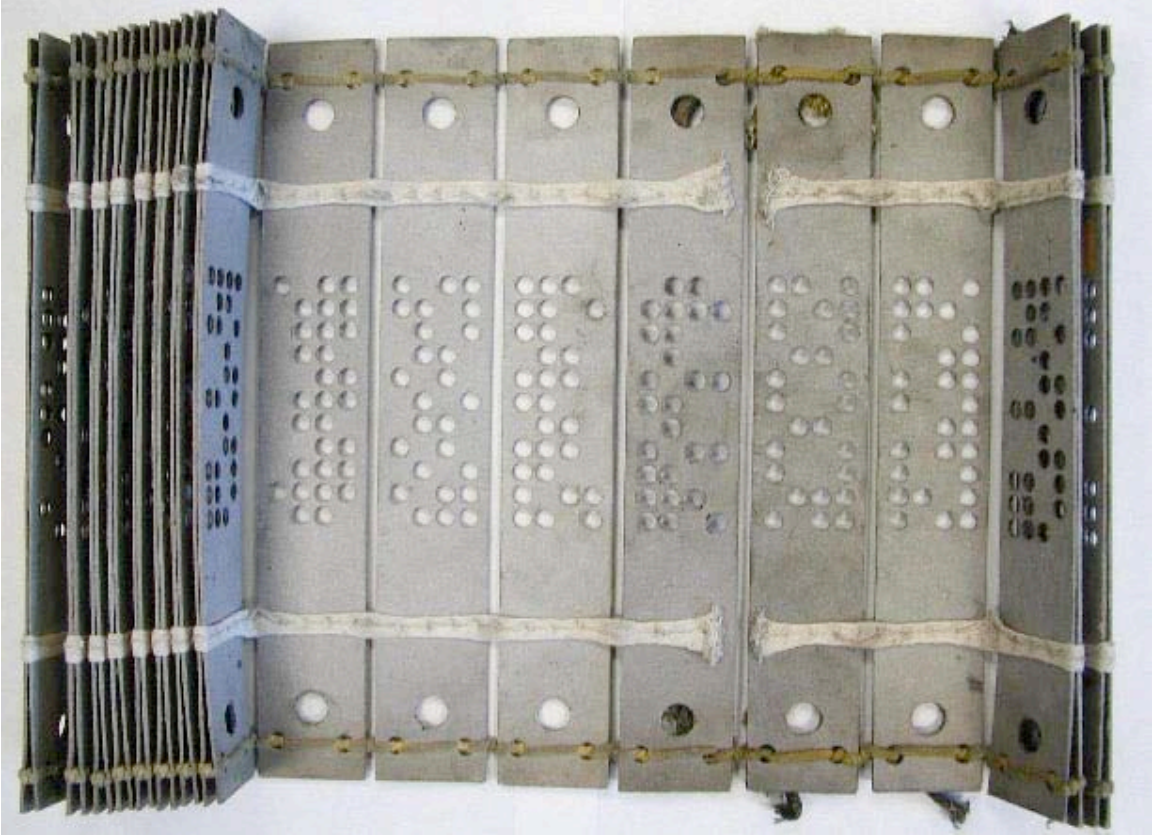

Photo courtesy of Douglas W. Jones at the University of Iowa.

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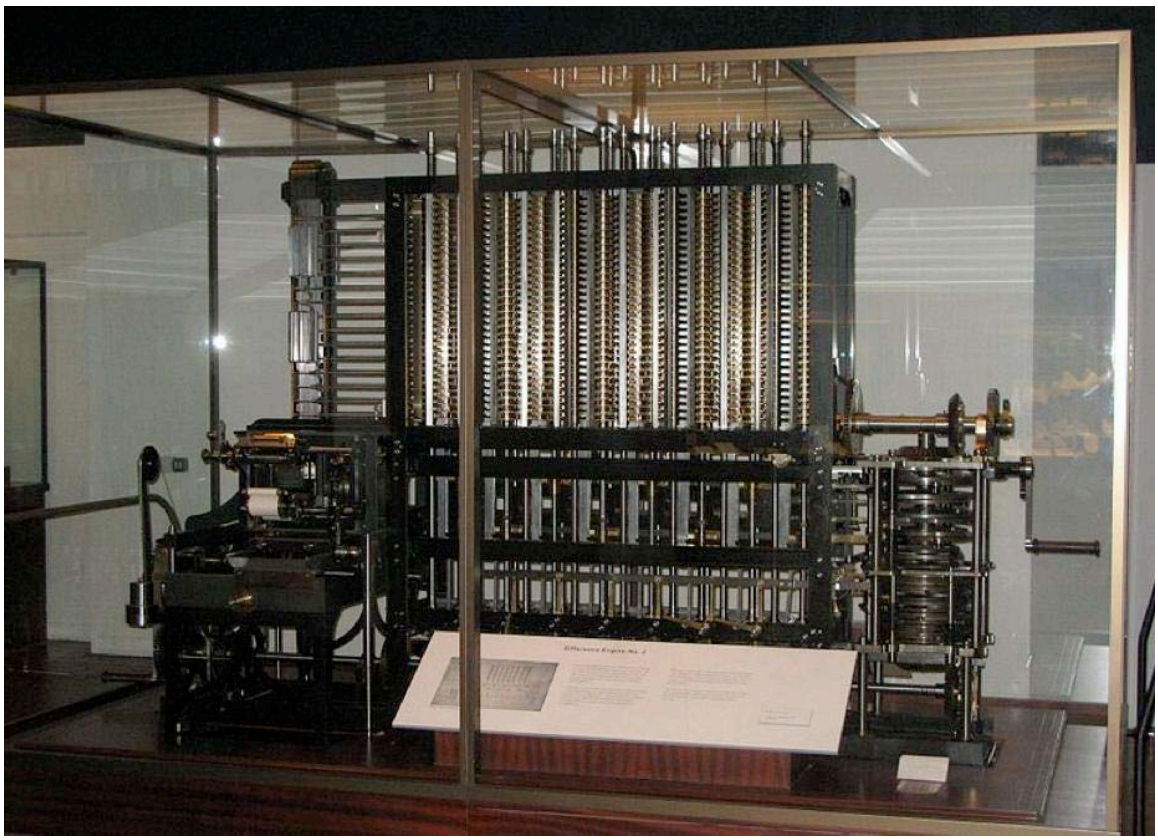
- Loom operations could be stored and recalled later
- Multiple cards could be strung together
- Based on technologies of numerous inventors from the 1700s, including Jacques Vaucanson

20.14. Babbage: The Difference Engine

- Babbage had played chess against the Turk, but suspected it was under human control (Standage 2003)
- Sketched out plan for mathematical automaton in 1821, shortly after playing the Turk (Standage 2003)
- Produced improved design between 1847 and 1849
- Essentially columns that store integers; columns can add value of column n+1 to column n to produce a new value for n
- Automatic calculation of polynomial functions with Newton's method of divided differences: finding value that must be added to obtain the next result:

x	f(x) $2x^2 + 3x + 5$	First Difference	Second Difference
1	10	9	4
2	19	13	4
3	32	17	4
4	49	21	
5	70		

- 25,000 parts, 15 tons, 8 feet high: never completed
- Employed rotating cylinders that stored a single digit
- 1989-1991: Difference Engine No 2 constructed and used



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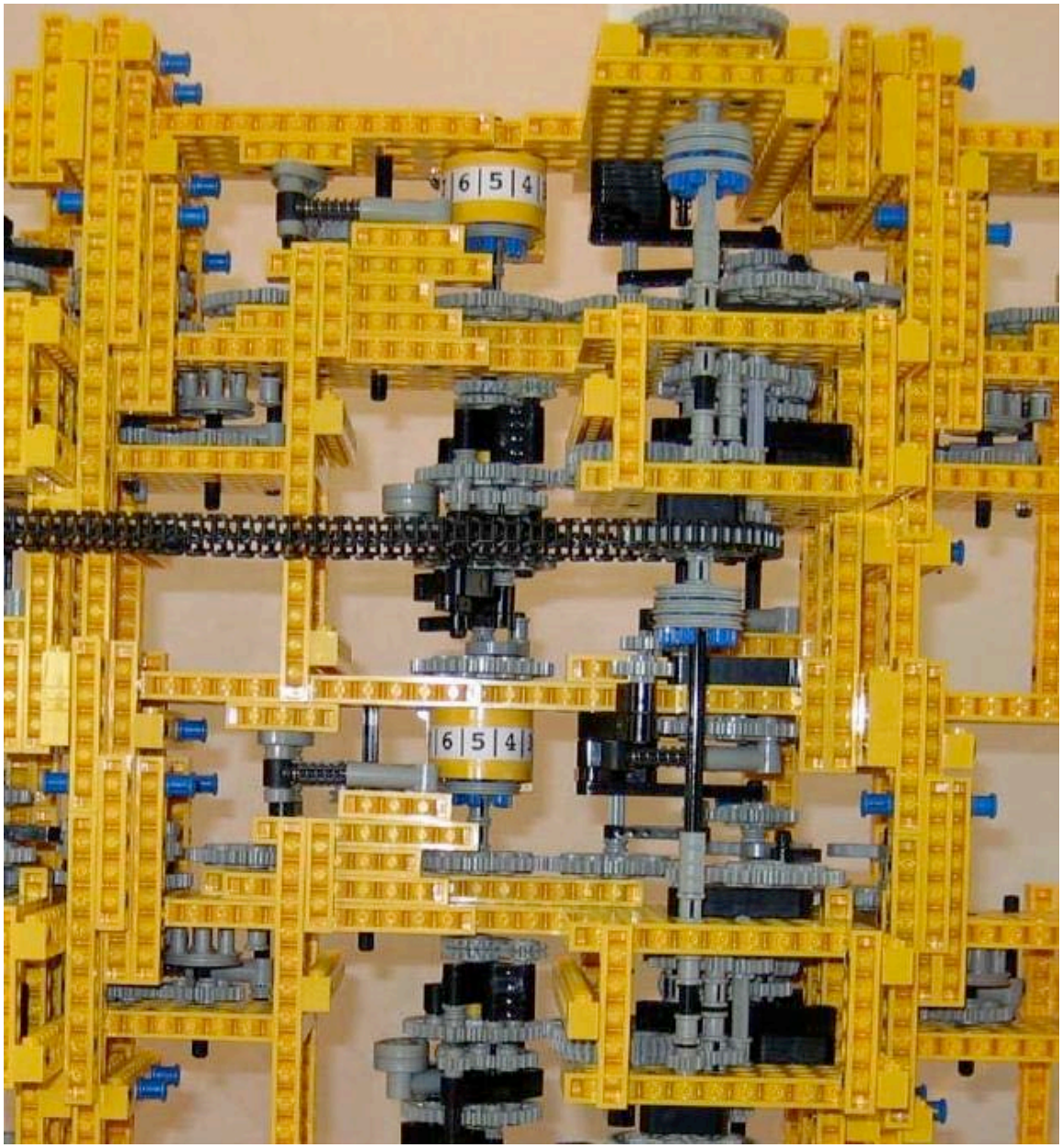
- A difference engine built of Lego by Andrew Carol

http://acarol.woz.org



Courtesy of Andrew Carol. Used with permission.

20.15. Babbage: The Analytical Engine

- Continued working on until death in 1871
- Machine that could be programmed with punched cards
- Loops of punched cards such as those used in the Jacquard loom
- Ada Lovelace designed as program for the Analytical Engine

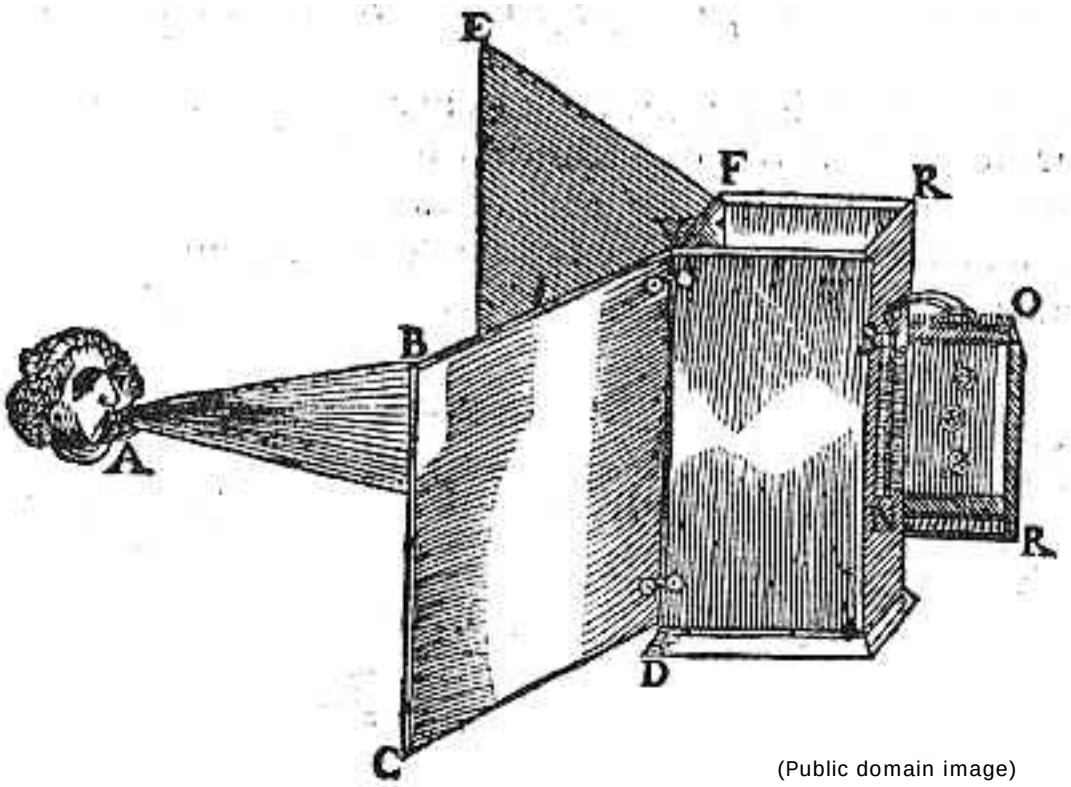
- Daughter of Lord Byron
- Translated article on the Analytical Engine by Luigi Menabrea added notes that included algorithm
- Suggested in 1843: if "the fundamental relations of pitched sounds in the science of harmony and of musical composition" could accommodate these adaptations, "the engine might compose elaborate and scientific pieces of music of any degree of complexity or extent" (1842)

20.16. Reading: Riskin: The Defecating Duck, or, the Ambiguous Origins of Artificial Life

- Riskin, J. 2003. "The Defecating Duck, or, the Ambiguous Origins of Artificial Life." *Critical Inquiry* 29(4): 599-633.
- Why does Riskin isolate the Defecating Duck as important?
- "by building a machine that played the flute and another that shat, and placing them alongside each other, Vaucanson, rather than demonstrating the equivalence of art and shit as the products of mechanical processes, was testing the capacity of each, the artistic and the organic product, to distinguish the creatures that produced them from machines" (2003, p. 610)
- It seems that, even though some knew that The Turk was not truly autonomous, many still appreciated its functioning: why?
- "not only has our understanding of what constitutes intelligence changed according to what we have been able to make machines do but, simultaneously, our understanding of what machines can do has altered according to what we have taken intelligence to be"
- Is music a sign of intelligence? How does this affect our interpretation of musical automata?
- How might musical automata employ similar theatrical, or fraudulent, presentations?

20.17. Musical Automata

- Take many forms, often encoding data on a disc or cylinder
- Nondeterministic musical automata often used wind
  - The aeolian harp



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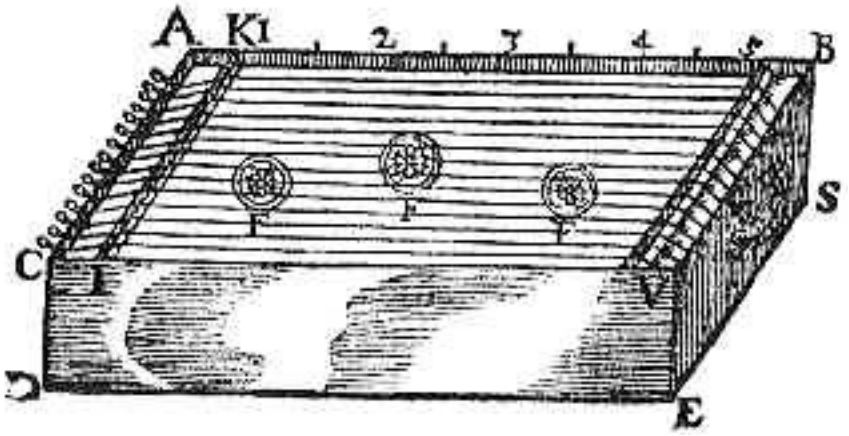

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- Various arrangements of wind bells used in East and South-East Asia

- The windchime

- Mechanical models often deterministic
  - Music boxes from the early 19th cenury

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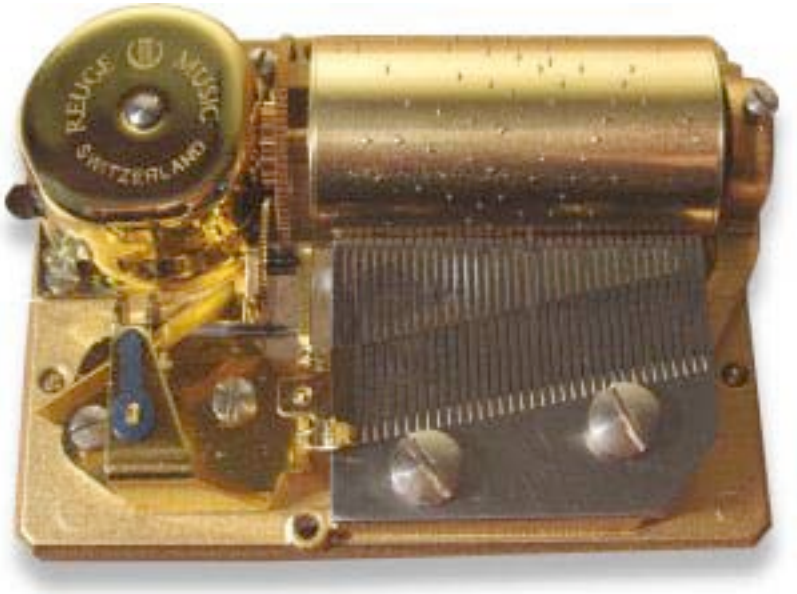

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- Barrel organs employed a wide range of sounds sources

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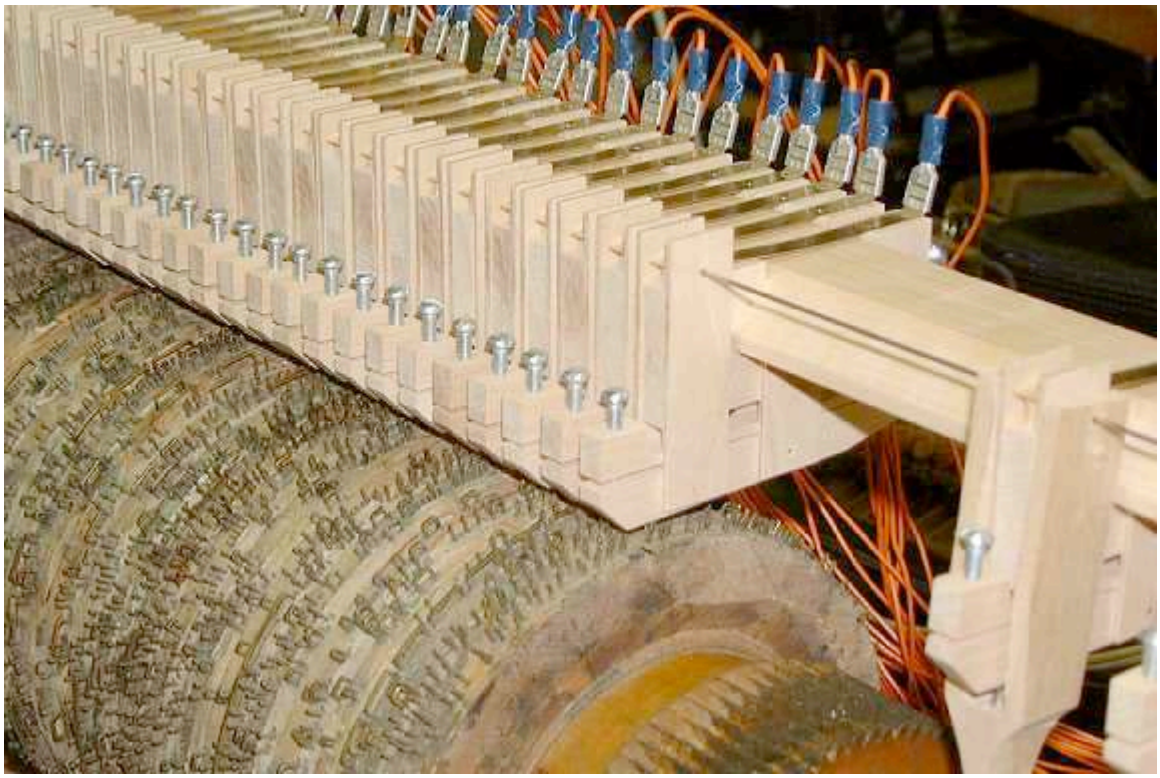

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- Reproducing and player pianos were by far the most widespread musical automata

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- Some player pianos encouraged human interaction and intervention in the performance

20.18. Weinberg: Haile

- Robotic percussionist that listens and performs with live players

- Developed by Gil Weinberg at Georgia Tech (2006)
- Haile videos at http://www.cc.gatech.edu/~gilwein/Haile.htm - CNN, Jam'aa Odense Outdoor

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