# From Fabrics to Computers: A History of Cloth and Binary Code

by Deborah Semel Bingham

**The text and images are provided courtesy of the International Quilt Museum, University of Nebraska-Lincoln.**

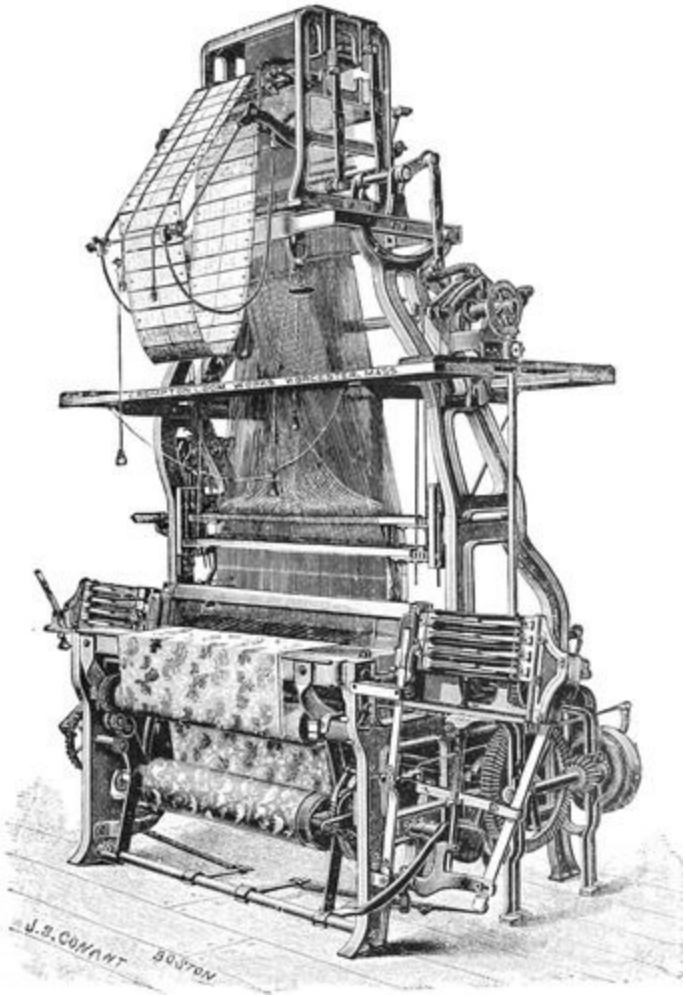
Did you know that modern computer coding was inspired by an 1804 invention for weaving fabric?

Before the 1800s, weaving patterned fabric was very expensive and time-consuming, because it had to be done entirely by hand. In order to produce such fabrics, master weavers employed trained apprentices to painstakingly lift a different selection of warp threads for each and every row of weaving. The result of this work was an array of fashionable and sought-after patterned fabrics. However, the time and expertise that went into these fabrics made them so expensive that only the wealthiest people could afford them. Most people wore clothing made from simple, single-color fabric.

To create a pattern, the weaver selects specific threads and holds them up, then passes the colored pattern thread through the opening. Each part of the pattern requires lifting different threads and using different colors.
*Image by Kwameghana on Wikimedia*

Then, in 1804, a French silk weaver named Joseph-Marie Jacquard invented a machine to automate the weaving of patterns in cloth. The machine used a series of "punch cards" that were encoded with the information for weaving a pattern. This eliminated the need for a separate person to manually lift threads and create the design. Each punch card had holes that corresponded to the threads that needed to be lifted in a row of weaving. Thousands of punch cards were strung together in order into a set and then fed through Jacquard's machine. The machine was attached to the top of a weaving loom. A set of hooks on the machine would "read" the punch cards: where there was a hole, a hook

would pass through and lift the correct thread; if there was no hole, the corresponding hook would be stopped and the thread would remain in its original position. The punch cards used a kind of code called binary code. The code was binary because the machine was responding to only two commands - either *punched hole* or *no punched hole*.



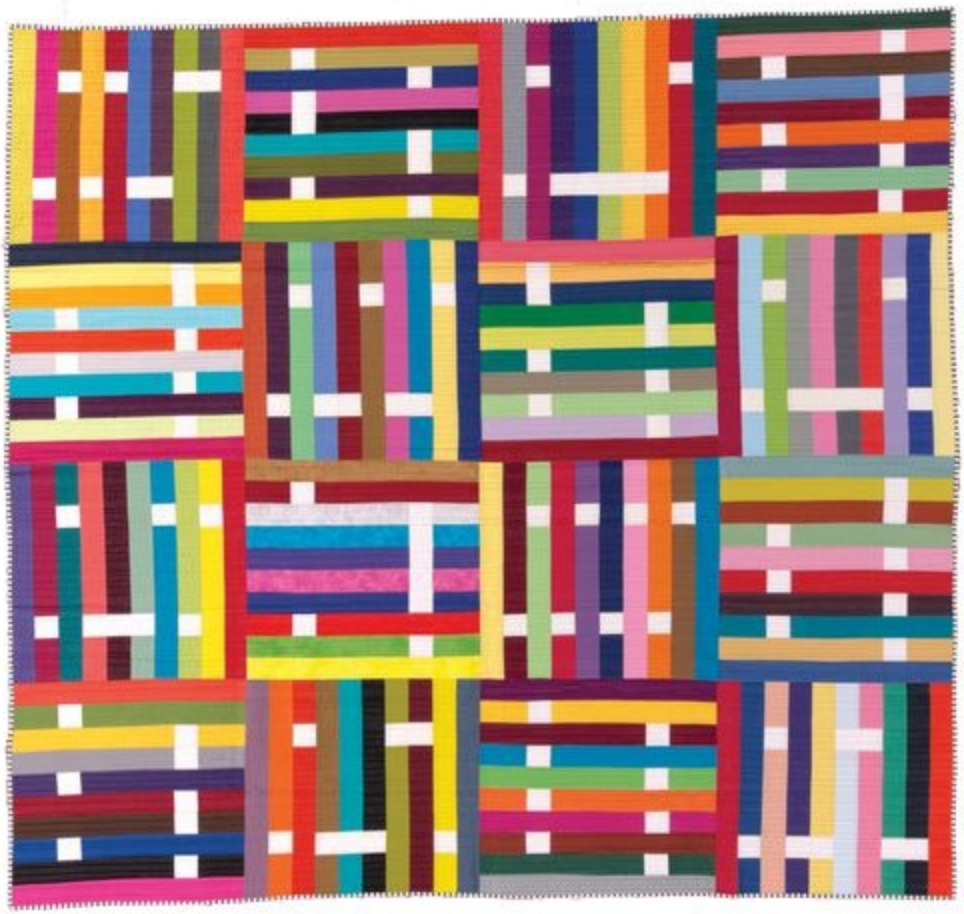

a drawing of a lJacquard loom
*Popular Science Monthly, Volume 39*

By using binary code to automate looms - allowing people to program machines to execute actions - the Jacquard machine represented a fundamental change in how humans interacted with machines. It enabled weaving looms to be operated by less-skilled factory workers and the fabric to be woven more than 20 times faster. The invention revolutionized fabric weaving and made a wider variety of fashionable fabrics available to more people. It had ripple effects across the world economy, from fashion to factories to shipping. By the 1830s there were more than 7,000 Jacquard machines operating in England alone! Simply by changing the sets of punch cards, a Jacquard loom could produce an unlimited number of different fabric patterns. The card sets were so valuable that there were even incidents of them being stolen by competing companies.

In the 1830s, British mathematician Charles Babbage was fascinated by the binary code in Jacquard's punch cards. (He even kept a woven portrait of Jacquard at home, a design woven with a set of 24,000 punch cards.) He believed a punch card system could be used to make mathematical tables (needed for engineering, navigation, and science). He began working on a machine that would

do this, calling it an Analytical Engine. His friend, Ada Lovelace went even further, observing that such an analytical engine could be used not only for mathematics, but for automating and manipulating *any* data. She proposed that combinations of the two numbers in a binary code could be used to represent other variables, such as letters, symbols, or even musical notes! Their combined vision of how the tasks a machine performed could be changed by using different sets of punch cards served as a cornerstone in the development of computers over the next century.

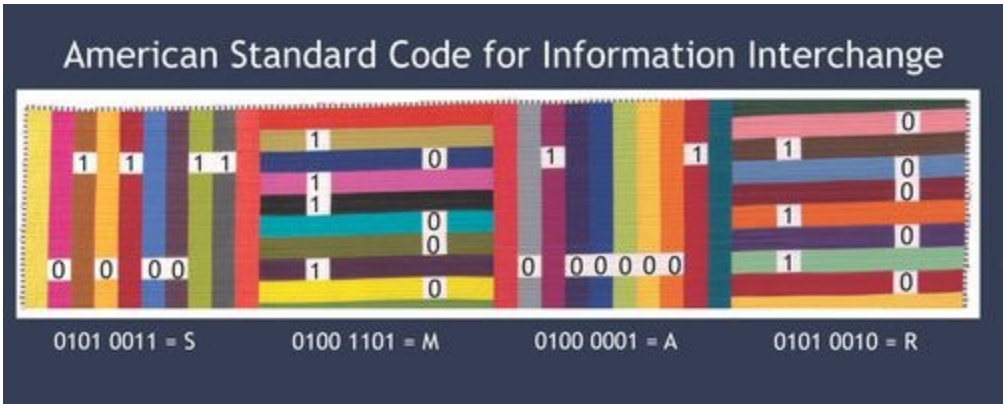
Punch cards were used in several fields of data processing over the next several decades, including government processing of census data. Then, in the 1960s and 1970s, as data-encoding methods changed, the binary format came back in a new form, without punch cards. The American Standard Code for Information Interchange (ASCII) is a binary-based code that uses patterns of 0s and 1s to encode different characters. Because ASCII was standardized, different makes and models of computers were able to exchange information directly, instead of having to "translate" data into new formats at each new machine. ASCII soon became the coding basis for digital computers, and is still used today.



Smart is Beautiful #2 quilt by Thomas Knauer
*International Quilt Museum, University of Nebraska-Lincoln*

In the 2015 quilt shown here, Smart is Beautiful # 2 by Thomas Knauer, the history of patterned fabric is echoed by Knauer's use of binary code in his design. Quilts are textiles created by sewing together three layers of fabric. The top layer is often made of smaller pieces or blocks of fabric sewn together to form a larger design or pattern. Quilters often include messages and motifs in the design of a quilt's

top layer that have special meaning to them or to the person for whom the quilt is made. Knauer's quilt includes a secret message for the viewer, conveyed in binary code.




*International Quilt Museum, University of Nebraska-Lincoln*

In each quilt block, Knauer used squares of white fabric to represent alphabet letters in ASCII binary code. In the blocks with vertical stripes, such as the top left hand block, a white square in the top row stands for 1. A white square in the bottom row stands for 0. Thus, that block in the quilt corresponds to 0101-0011, which is the letter "S" in ASCII binary code. Each of the sixteen blocks in the quilt stands for a letter in the sentence "Smart is beautiful." Knauer encoded this message to his daughter in the quilt to communicate that intelligence is a more beautiful human quality than physical appearance. By communicating this message in cloth, Knauer's work connects modern, digital programming to the revolutionary work of inventors and mathematicians of the past.

What message would you hide in a quilt, and to whom would you give it?

**Name:** _____ **Date:** _____

**1.** What kind of machine did Joseph-Marie Jacquard invent in 1804?

A. a machine to automate the production of flour and other foods

B. a machine to automate the processing of data in math

C. a machine to automate the weaving of patterns in cloth

D. a machine to automate the processing of census data

**2.** What effect did the Jacquard loom have on fabric weaving?

A. It allowed fabric looms to be operated by less skilled workers and produced fabric faster, which made more types of fabric available to more people.

B. It caused a shipping delay in the fabric industry because it was creating too much fabric too quickly.

C. It caused many workers to leave their factory jobs because they had been replaced by the independent weaving machines.

D. It allowed fabric looms to be operated by highly skilled workers who knew how to create new punch cards.

**3.** Read the following sentences from the text.

"The [Jacquard loom] used a series of "punch cards" that were encoded with the information for weaving a pattern. This eliminated the need for a separate person to manually lift threads and create the design. Each punch card had holes that corresponded to the threads that needed to be lifted in a row of weaving...

[Babbage] believed a punch card system could be used to make mathematical tables (needed for engineering, navigation, and science). He began working on a machine that would do this, calling it an Analytical Engine. His friend, Ada Lovelace went even further, observing that such an analytical engine could be used not only for mathematics, but for automating and manipulating any data. She proposed that combinations of the two numbers in a binary code could be used to represent other variables, such as letters, symbols, or even musical notes!"

What can you conclude about the connection between the Jacquard loom and Babbage and Lovelace's ideas?

A. Instead of each hole in a punch card representing a row of thread, Babbage and Lovelace's design used holes in punch cards to represent colors in a painting palette.

B. Like the Jacquard loom, Babbage and Lovelace's ideas were mostly about how to make weaving faster and more efficient.

C. Instead of each hole in a punch card representing a row of thread, Babbage and Lovelace's design used holes in punch cards to represent other data.

D. Babbage and Lovelace created a new, faster Jacquard loom, and then used the punch card system to help them organize their taxes.

**4.** How is the punch card system for the Jacquard loom connected to the way that modern computers work?

A. The binary code system in the Jacquard loom's punch cards formed the language that modern computers use to communicate information to each other.

B. The punch card system used holes to communicate when hooks should be used, and modern computers use holes in their circuits to communicate information.

C. The binary code in the Jacquard loom's punch cards was used by by designers to create new computer keyboard models.

D. The punch card system for the Jacquard loom used holes to communicate information, and modern day computers process data through long wires with holes.

**5.** What is the main idea of this text?

A. The American Standard Code for Information Interchange (ASCII) was a binary-based code that created a shared language, where different combinations of 0s and 1s were used to create different characters.

B. Ada Lovelace and Charles Babbage worked together to design a system of punch cards that could be used to automate and manipulate any data because the 1 and 0 in the binary code could represent any two things.

C. Joseph-Marie Jacquard, a French silk weaver, thought that more people should have access to fabrics with patterns woven into them, so he created an automated machine to make the process of weaving faster and easier.

D. The creation of binary code started with the Jacquard automated weaving machine and progressed throughout the centuries to include automated data processing and, finally, a shared binary-based code that allows computers to exchange information.

**6.** Read the following sentences from the text.

"By using binary code to **automate** looms - allowing people to program machines to execute actions - the Jacquard machine represented a fundamental change in how humans interacted with machines."

What does the word **automate** most closely mean as it's used here?

A. make something digital by using ASCII to communicate

B. make something into an automatic or machine-driven process

C. create a new version of an old machine that requires more skill to operate

D. cool down machines using fans and other cooling devices

**7.** Choose the word that best completes the following sentence.

Charles Babbage was fascinated by the Jacquard loom, and _____ created a binary code system for processing data with Ada Lovelace.

A. eventually

B. however

C. first

D. therefore

**8.** What are quilts?

**9.** How did Thomas Knauer include words in his quilt, *Smart is Beautiful #2*?

**10.** Why is a quilt like Thomas Knauer's *Smart is Beautiful #2* a good way to explore the history of binary coding?