Textiles

Machines, Mechanisms & Makers
doing
Knitting, Weaving & Braiding

Announcements

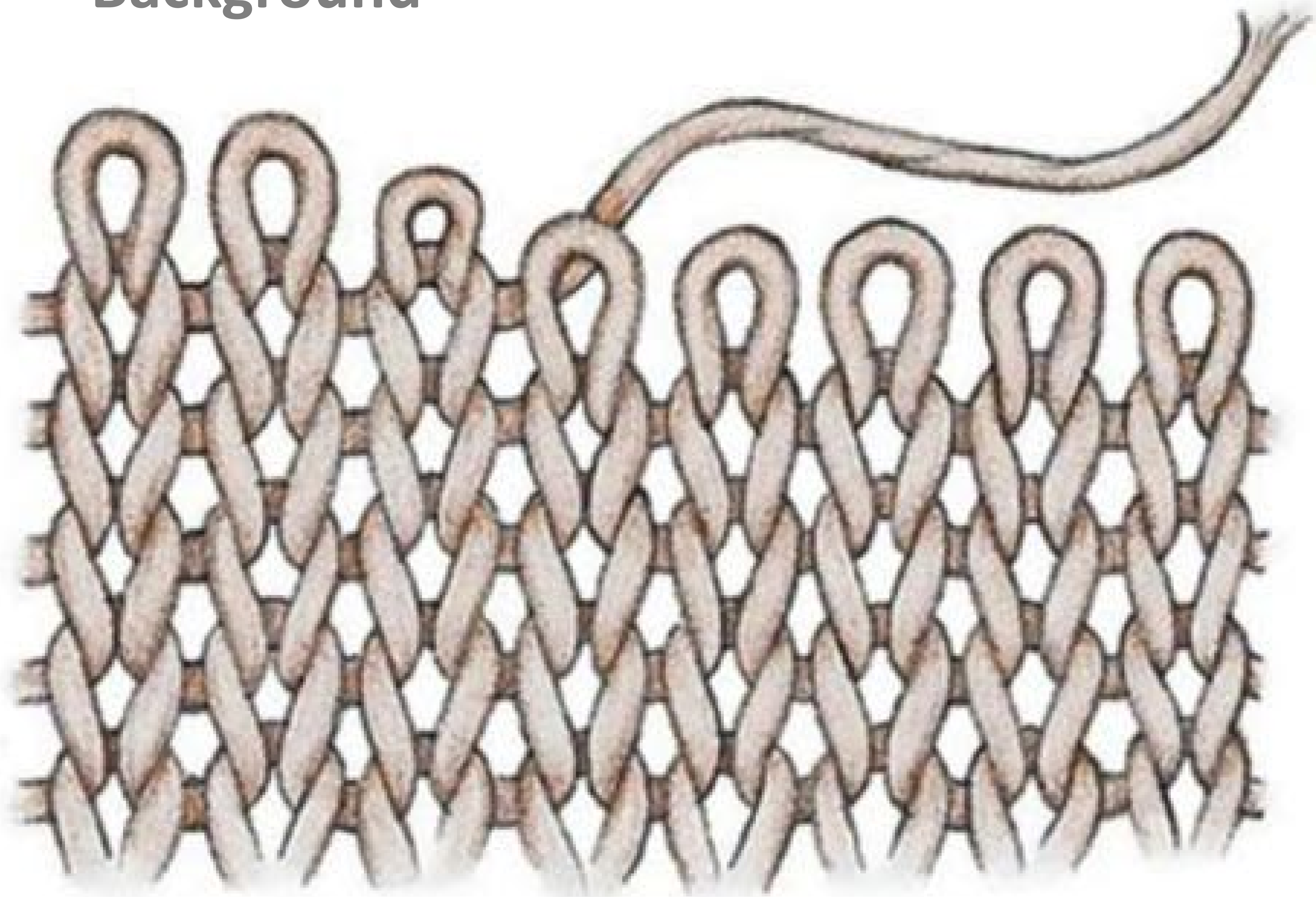
- **Wednesday, May 15: HCI Seminar**
- **Thursday, May 16: Ilan**
  - **Read "Shaper" paper**

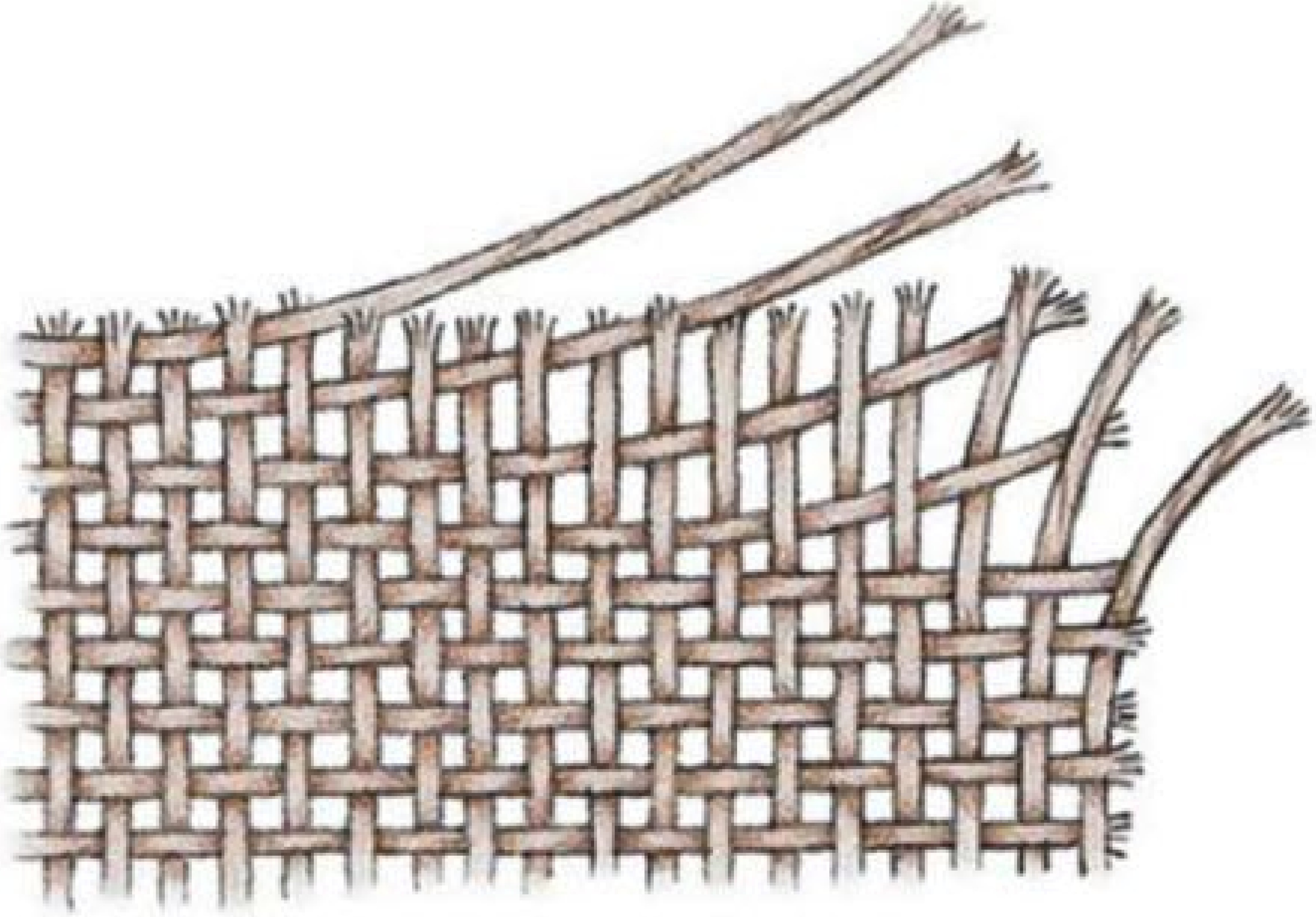
Alec Rivers, Ilan E. Moyer and Frédo Durand, **Position-Correcting Tools for 2D Digital Fabrication**, *SIGGRAPH 2012*

- **Paper** (PDF, 6MB)
- **Project page** (with video)
- **"For the Home Workshop, a GPS for Power Tools"**, New York Times article

Clothes can be knit or woven

Background





Knit Material

Woven Material

Jon Leaf

Which came first, knitting or weaving?

https://en.wikipedia.org/wiki/Timeline_of_clothing_and_textiles_technology

http://www.historyofclothing.com/making-clothing/

Timeline: Weaving

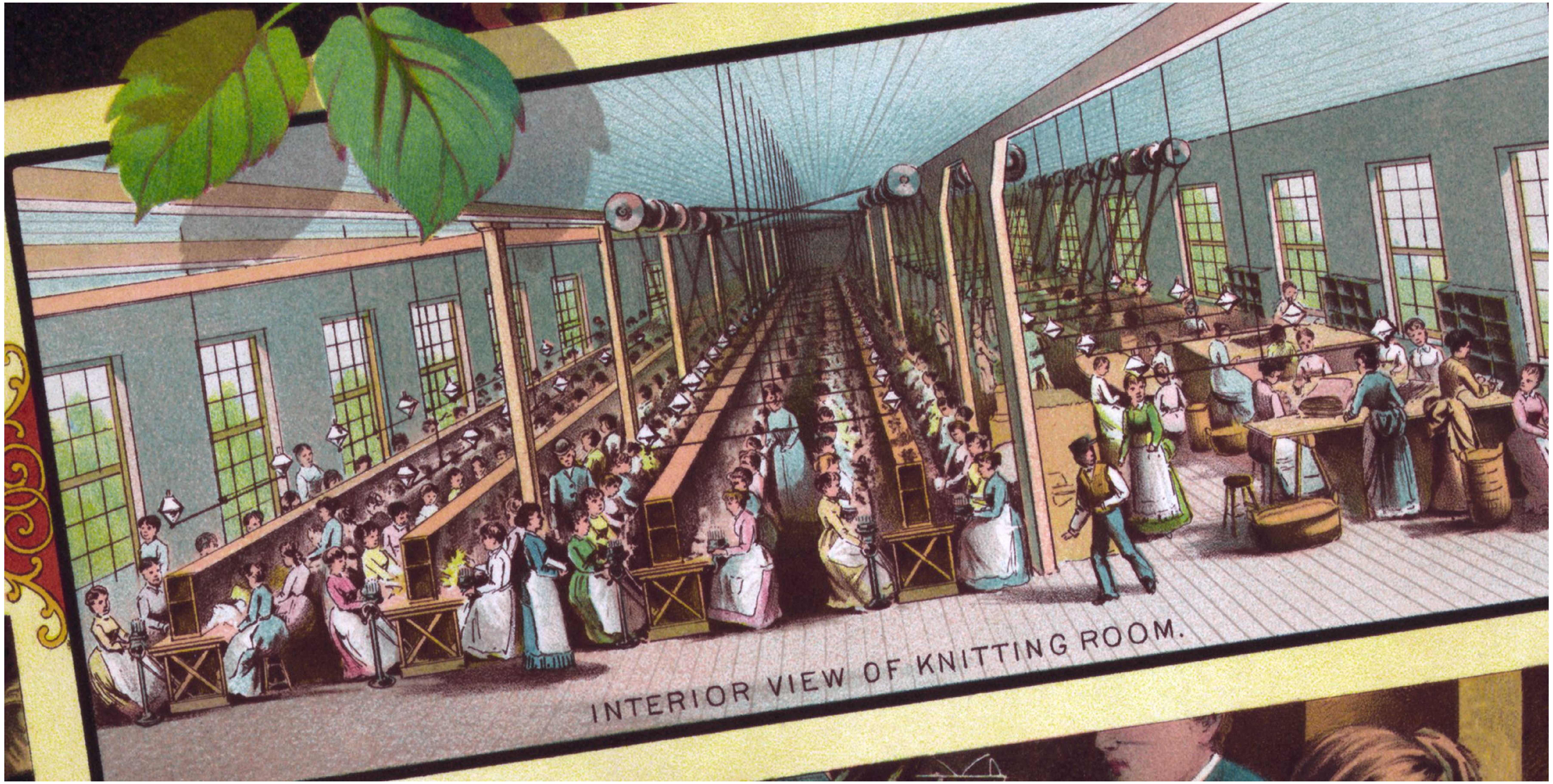
- Known since Paleolithic era (early phase of Stone Age, lasting about 2.5 million years)
- Widely known in all great civilizations
- ~5000 BC: Flax weavings found in Fayum, Egypt
- ~2000 BC: Wool replaces flax
- Bible: refers to loom and weaving in many places
- 700 AD: Horizontal and vertical looms found in Asia, Africa & Europe
  - Pit-treadle loom (with pedals for operating heddles) appears in Syria, Iran and Islamic parts of East Africa
  - Faithful required by Islam to be covered from head to foot, increasing demand for cloth.
- By 1177, loom improved in Moorish Spain with higher, stronger frame, freeing hands to pass the shuttle, and operate heddles with feet. Becomes standard in Europe.
- 1733: John Kay invents the *flying shuttle*, enabling weaving of a wider range of fabrics.
- 1785: First weaving factories appear
- ~1803: Jacquard loom invented. Programmable with punch cards. Enables faster and more complex weaving.

http://www.historyofclothing.com/making-clothing/history-of-weaving/

Timeline: Knitting

- Between 11th & 14th centuries AD: Oldest known knitted items in Egypt
- 14th century:
  - Spanish Christian royal families employed Muslim knitters. Earliest known knitted items in Europe, e.g., cushion covers and gloves.
  - Becomes widespread throughout 14th century Europe.
- 16th century: Knitting spreads to Britain.
- 17th-18th centuries: Preoccupies many in the Scottish Isles. Important source of income, e.g., entire families employed.
  - Sweaters are major items, useful to local fisherman.
- Before industrial revolution, mechanical ideas for faster knitting not widespread
- After industrial revolution, it takes off.

http://www.historyofclothing.com/making-clothing/history-of-knitting/



Advertisement for a late 19th-century hosiery firm that depicts its factory floor with workers using knitting machines. Published 1886.

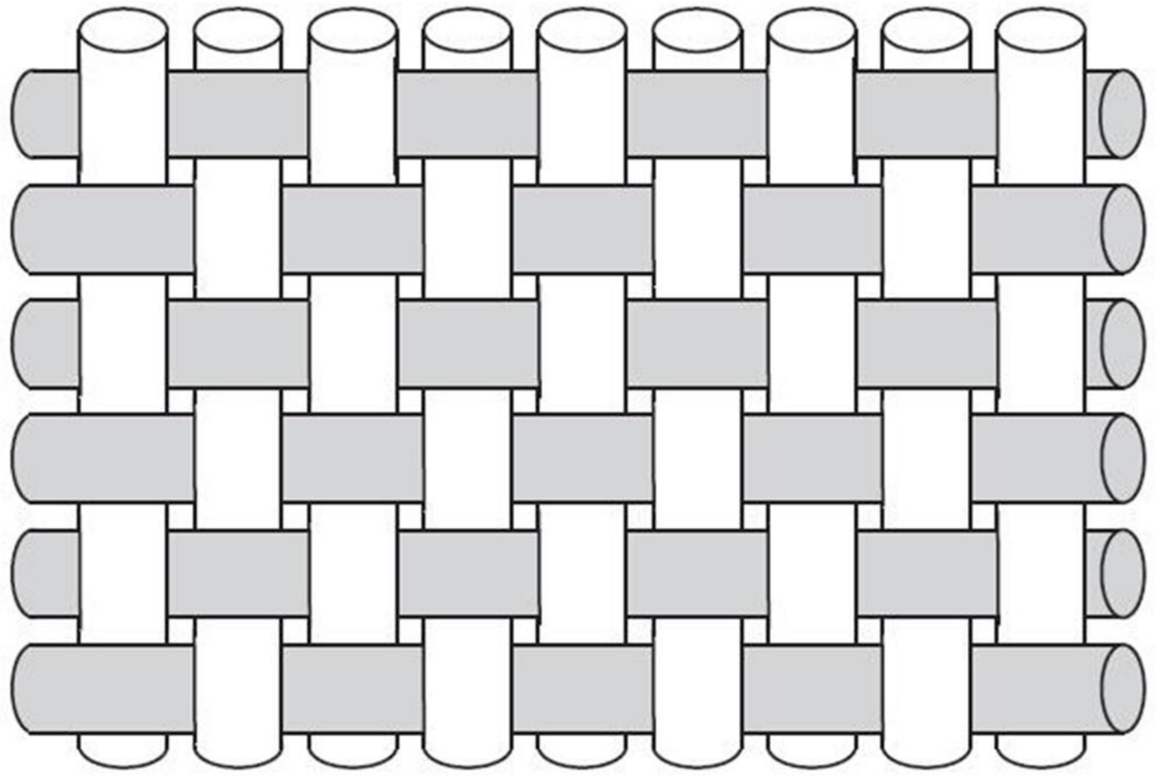
https://en.wikipedia.org/wiki/Knitting_machine

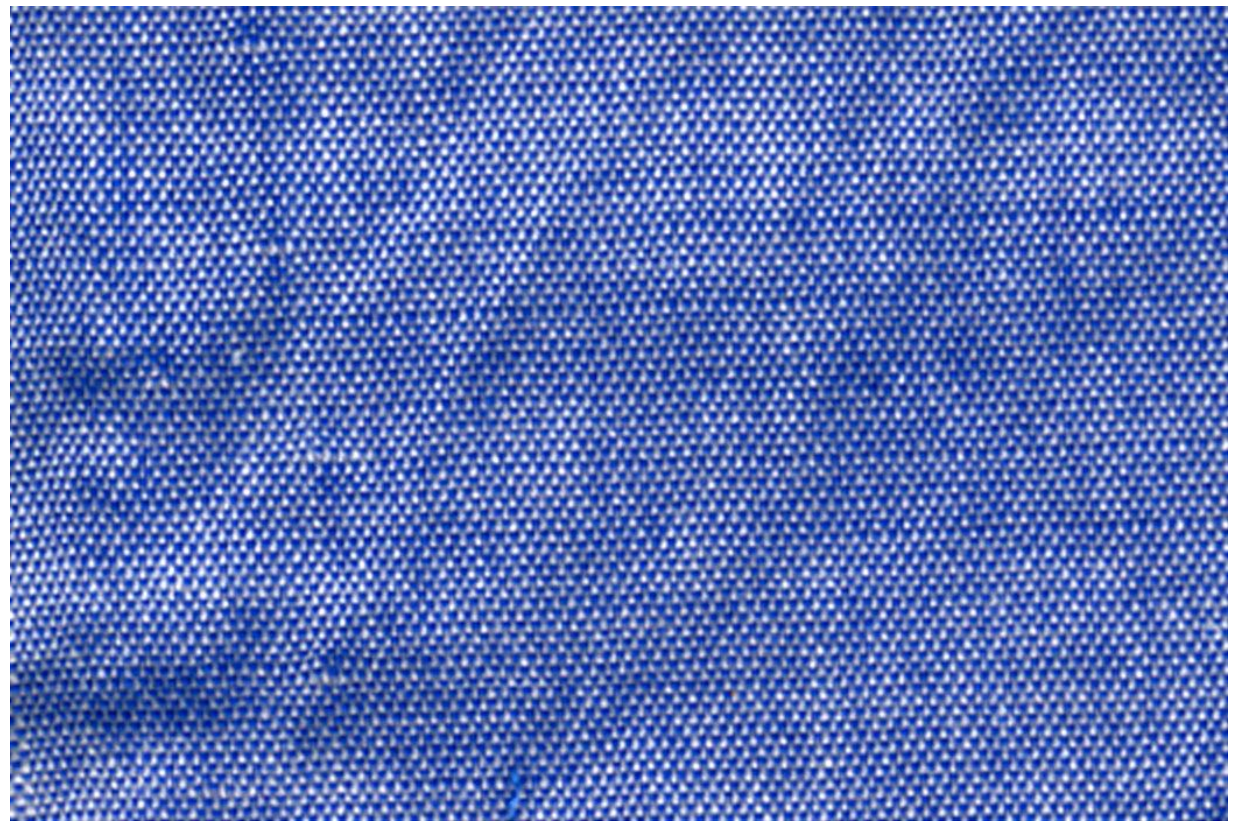
Weaving

Basic Loom Weaving

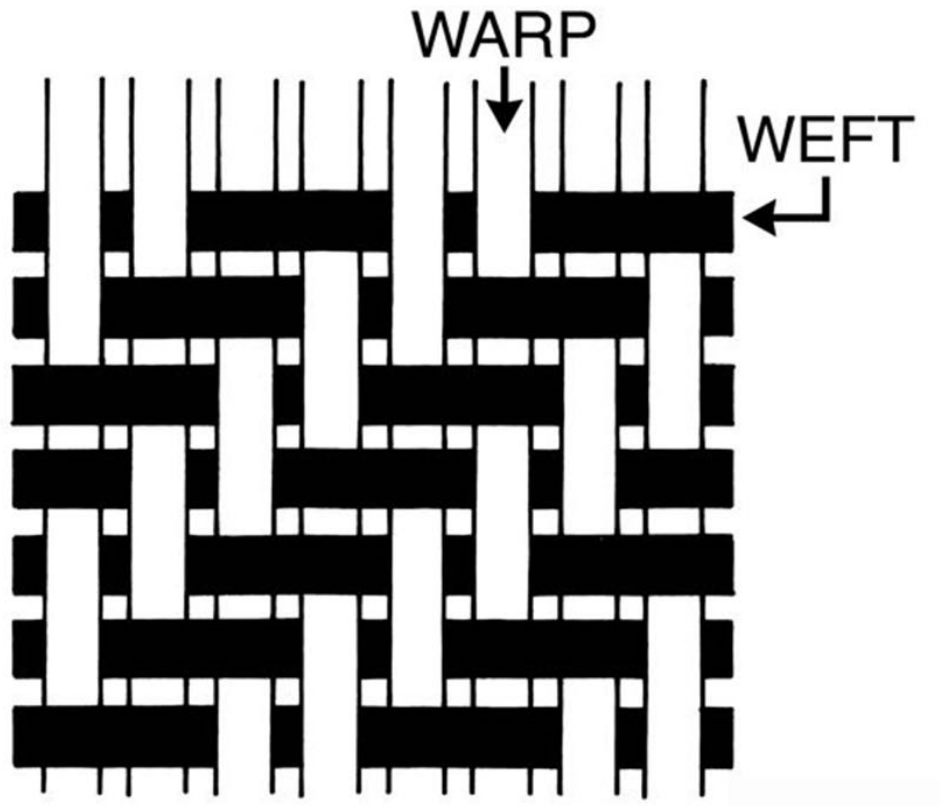
https://www.joann.com/melissa-doug-wooden-multi-craft-weaving-loom-kit/16145146.html

Basic weave patterns

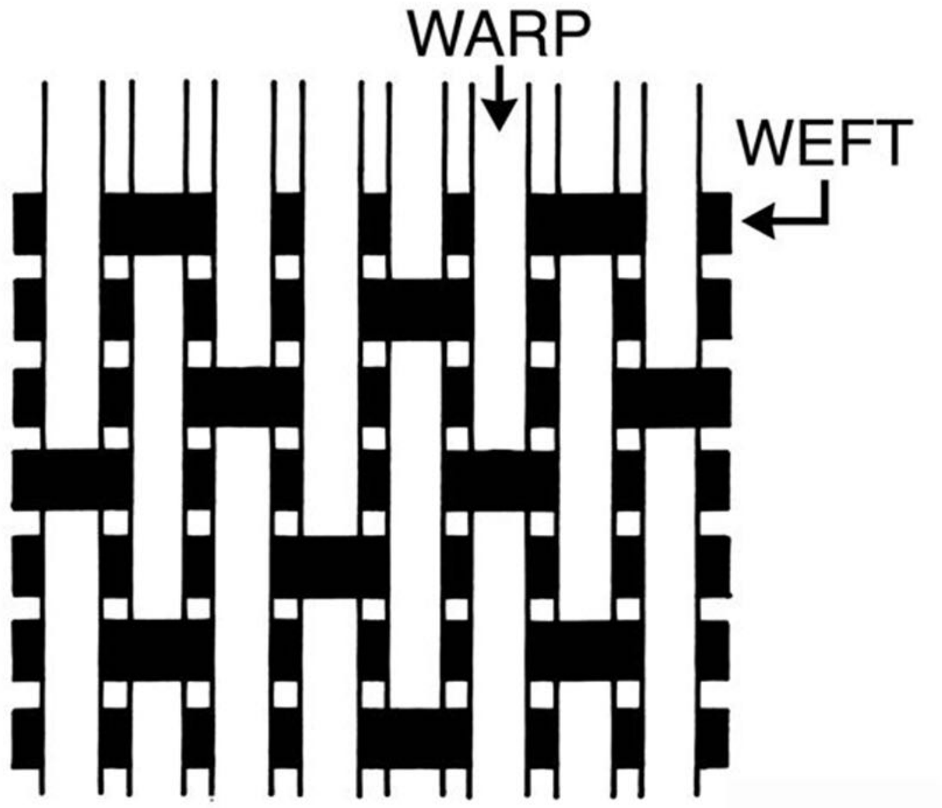


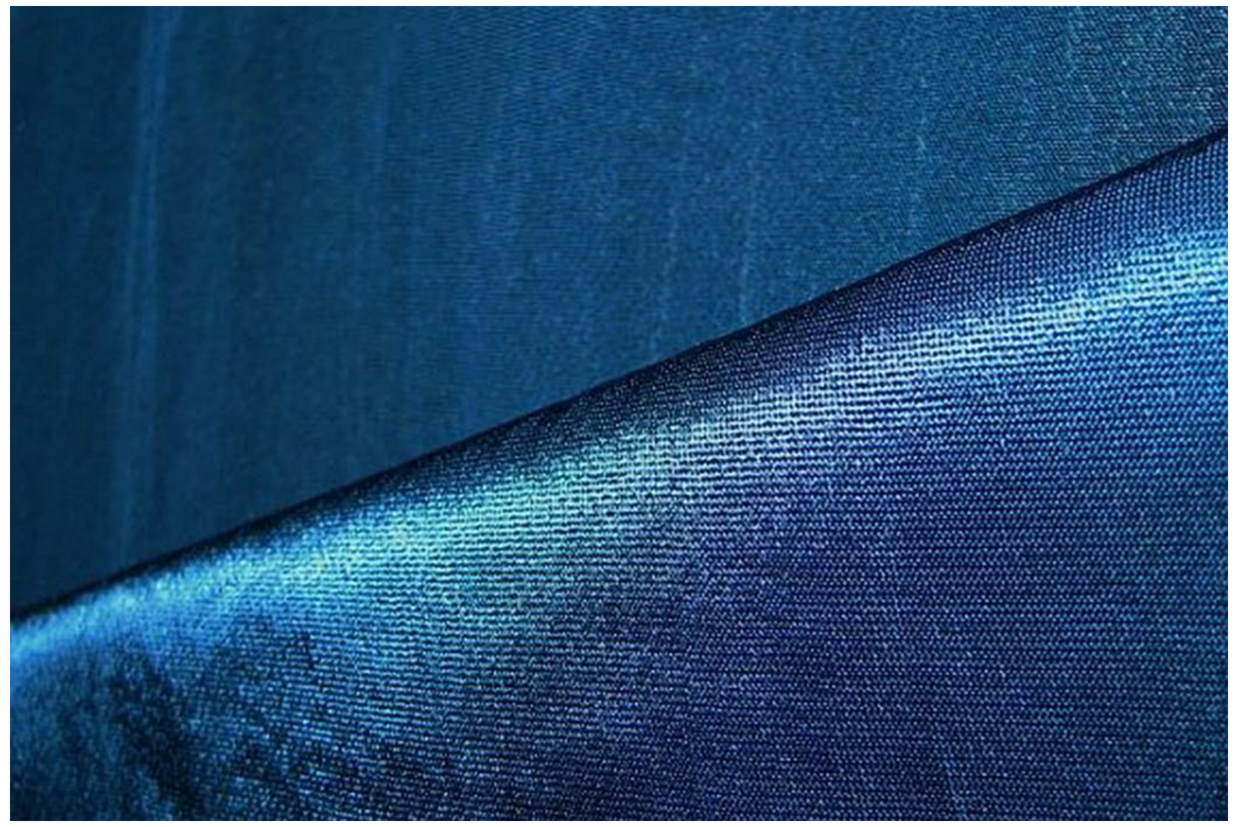


Plain

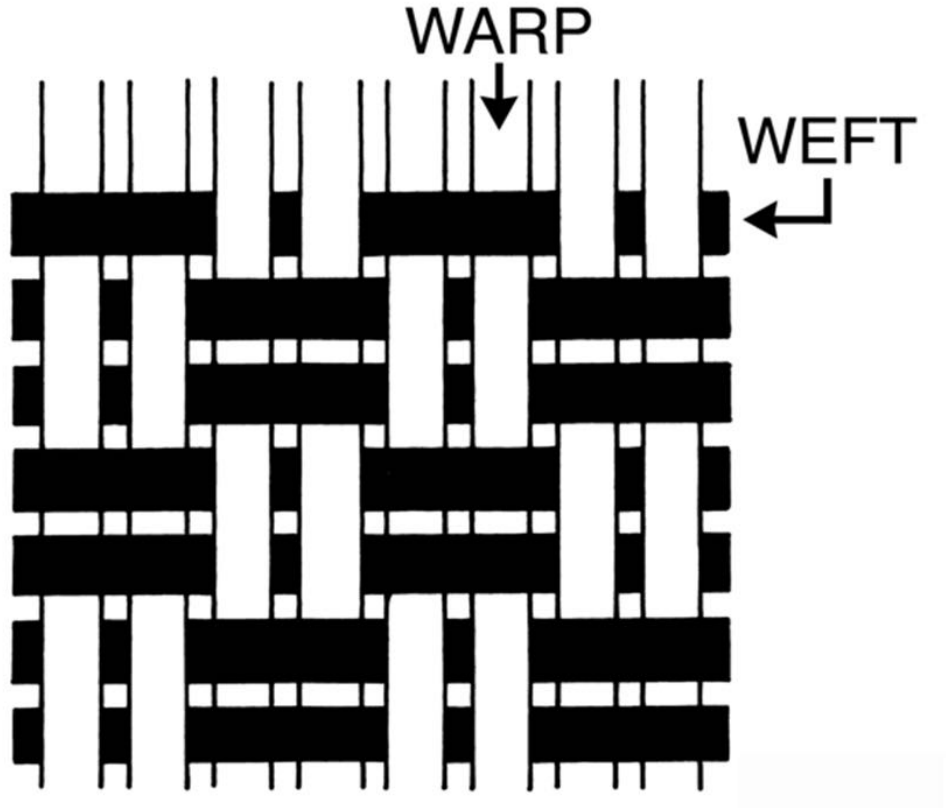


Twill





Satin

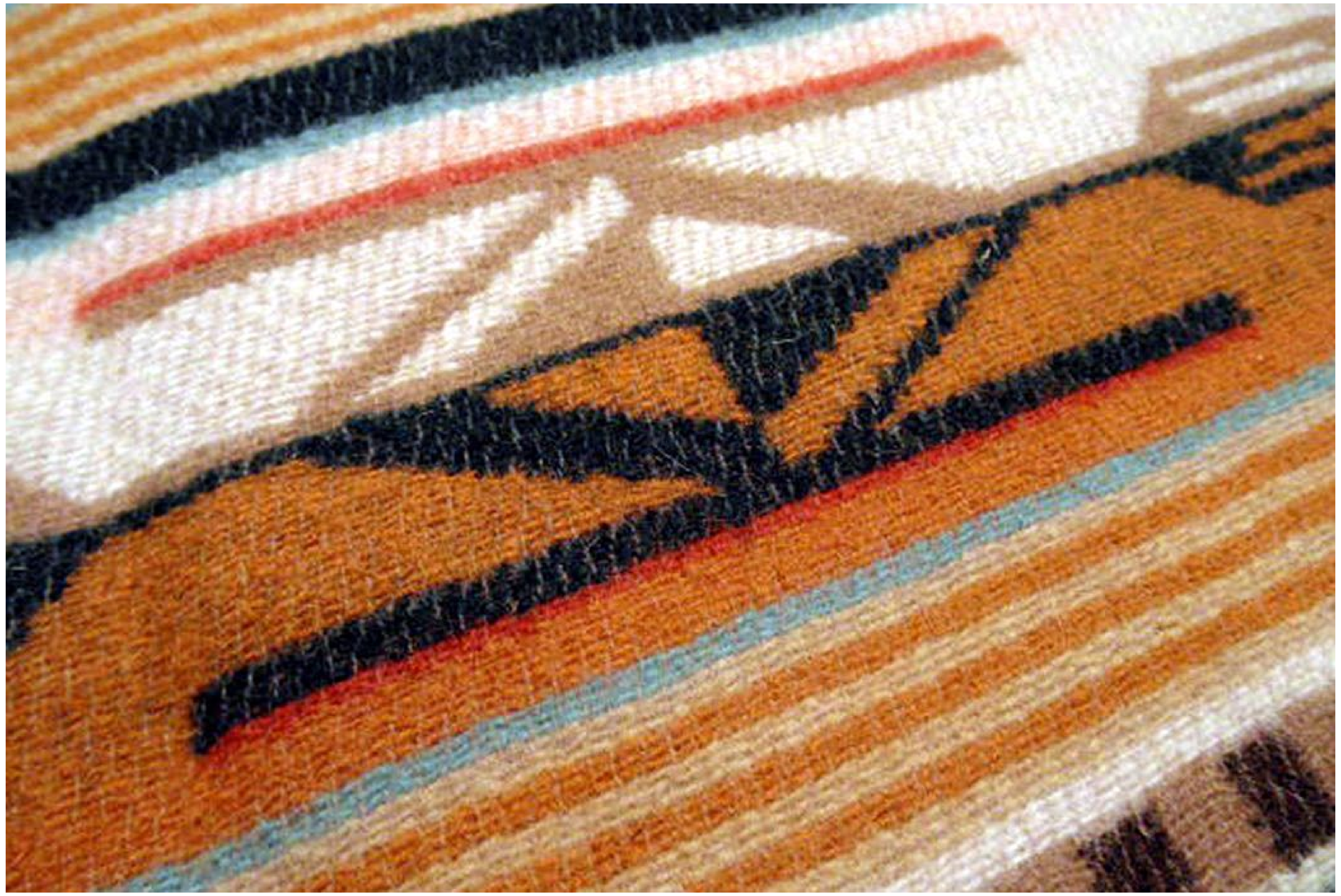


Basketweave

https://www.heddels.com/2017/12/7-weave-patterns-to-know-twill-basketweave-satin-and-more/

More complex weave patterns

Dobby



Jacquard

https://www.heddels.com/2017/12/7-weave-patterns-to-know-twill-basketweave-satin-and-more/

Handweaving.net Drafts Docs Store About Help Account

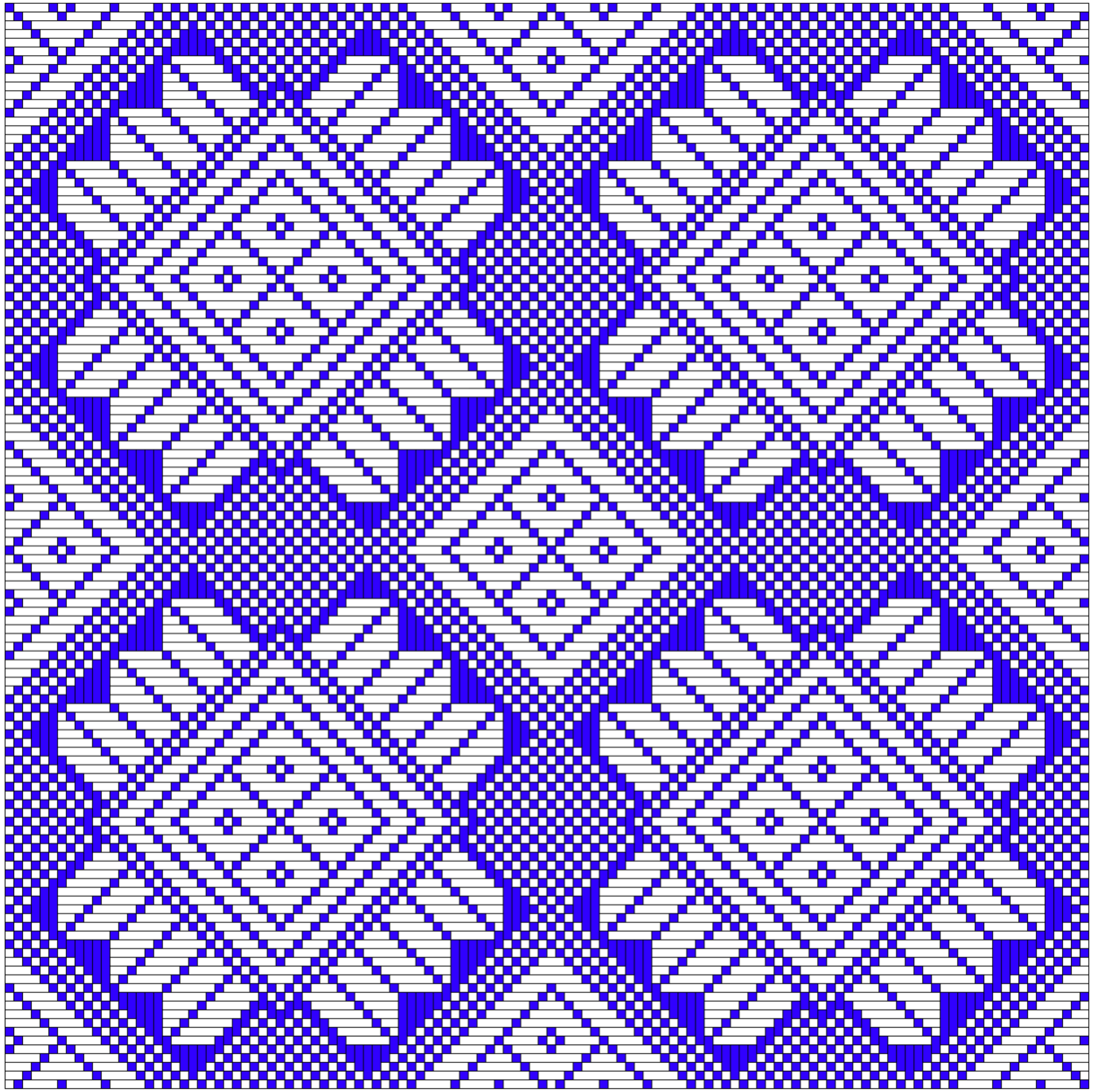
Weaving Draft: N. 35-4, Weber Kunst und Bild Buch, Marx Ziegler, Ulm, Germany, 1677, #56163

Subscribe to see full drafts and features when signed in! Learn More » Sign In »

« Prev Next » Collection » Same Threading (13 drafts) »

https://handweaving.net

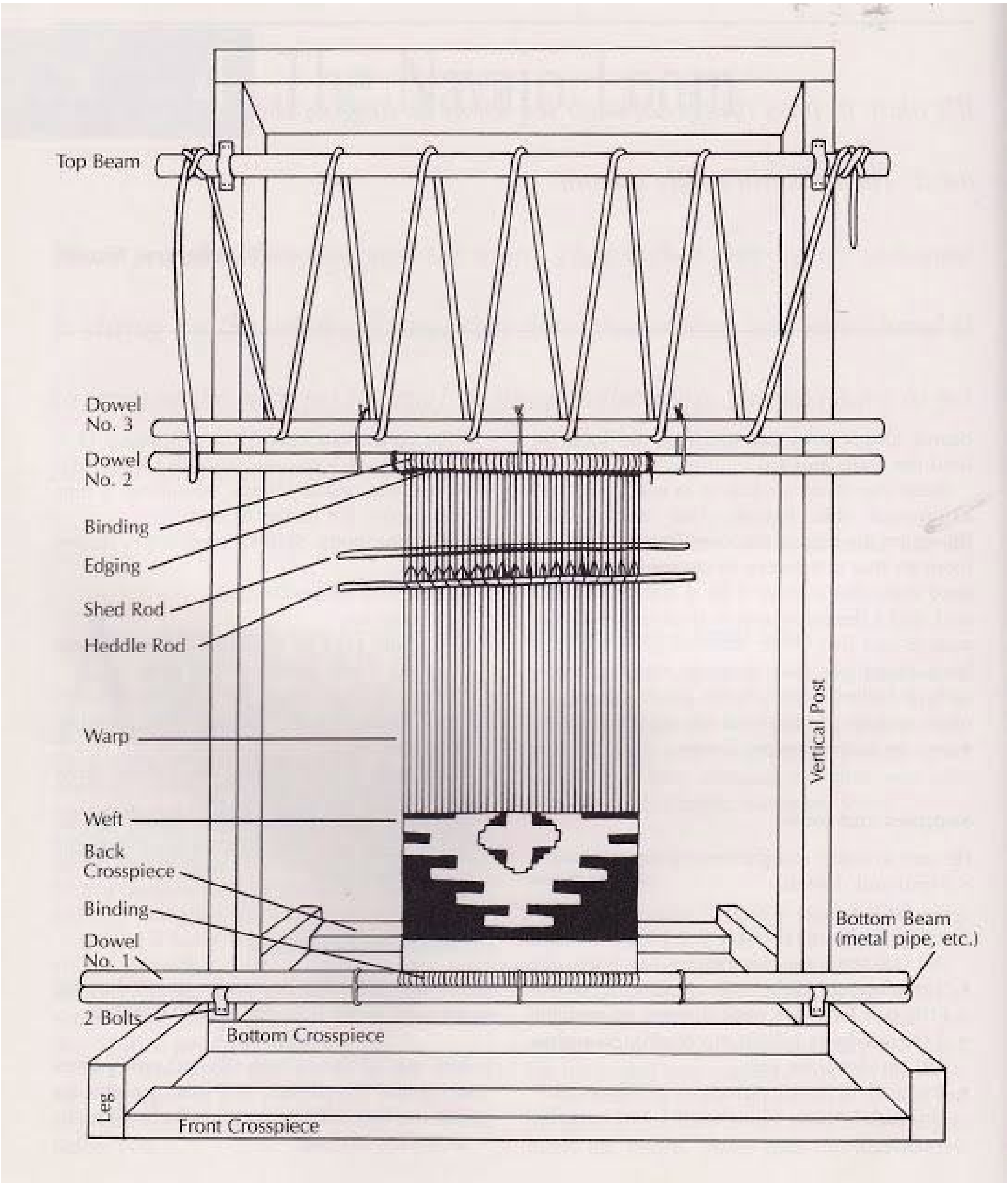
32 Shafts, 32 Treadles



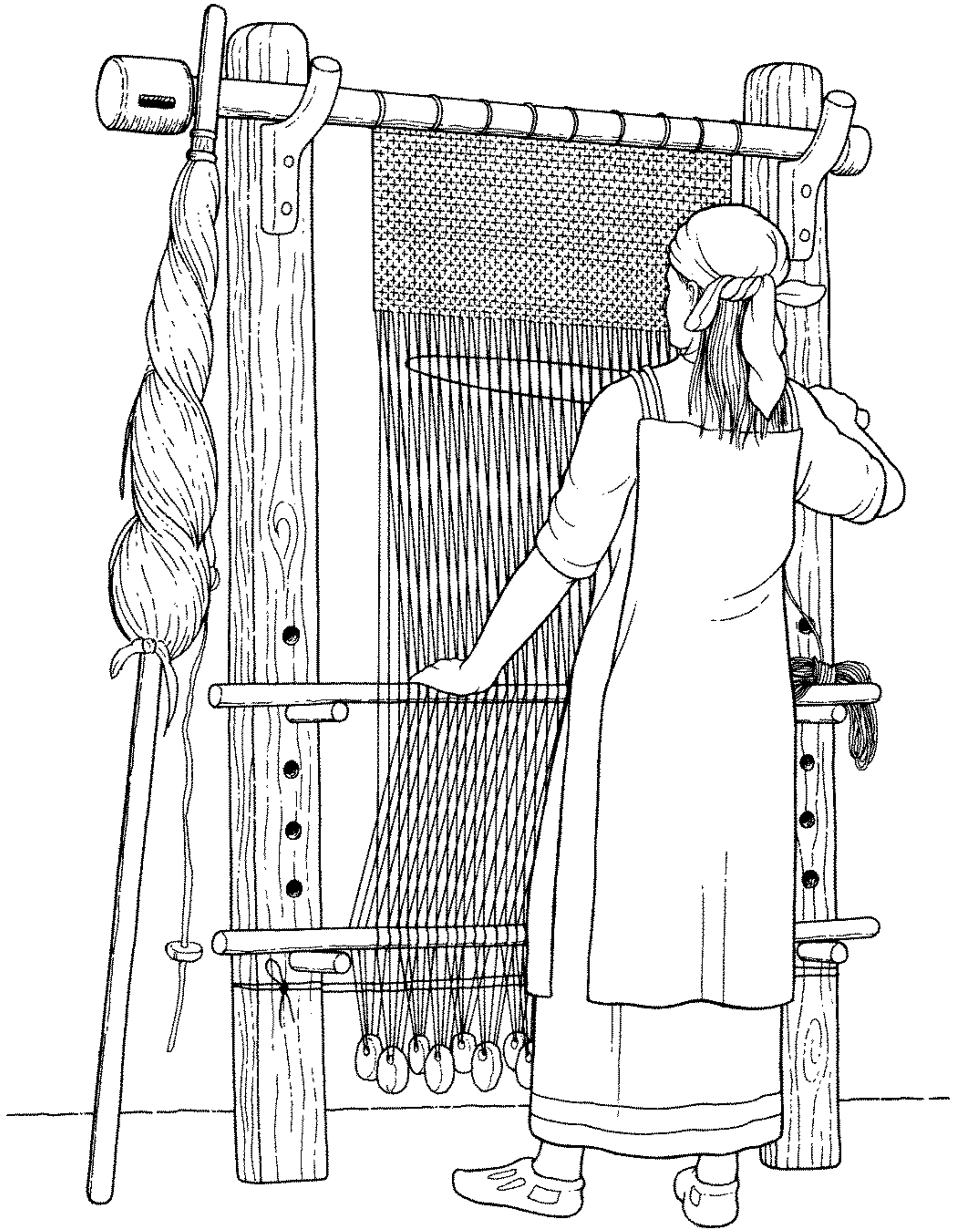
Handweaving.net #56163

Here is some gorgeous cloth woven by Sarah Bolante of Carry Om Handwovens with a painted warp on an AVL K-Series loom!
She chose a 32-shaft draft from a book dated 1677: Weber Kunst und Bild Buch by Marx Ziegler.
You can find the original draft on Handweaving.net here:https://handweaving.net/…/n-35-4-weber-kunst-und-bild-buch-…
Thank you to Sarah and to everyone else providing photos of their beautiful work for us to share here to inspire others!
https://www.facebook.com/Handweaving.net

Many types of looms



Navajo

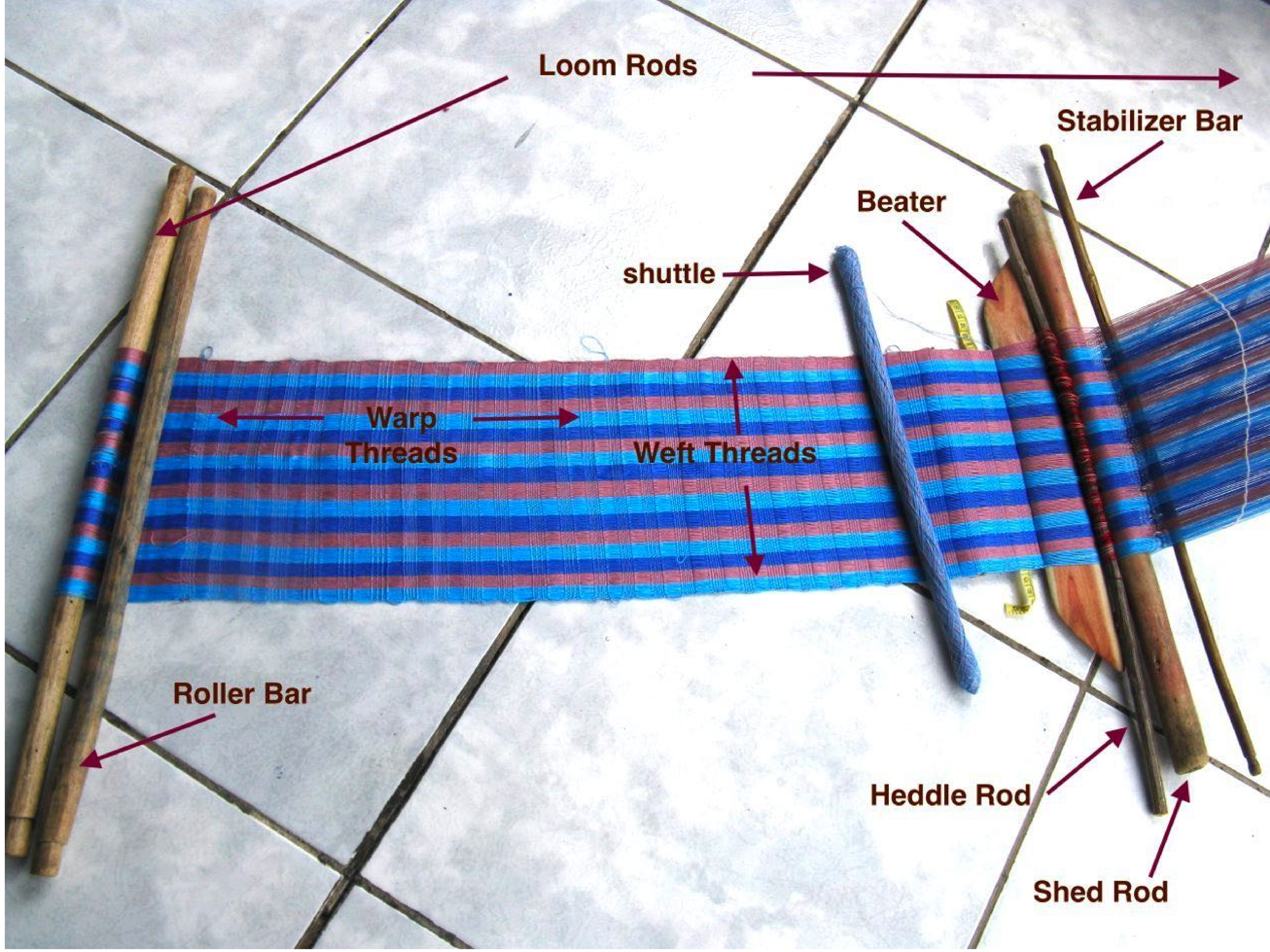


Viking

Many types of looms

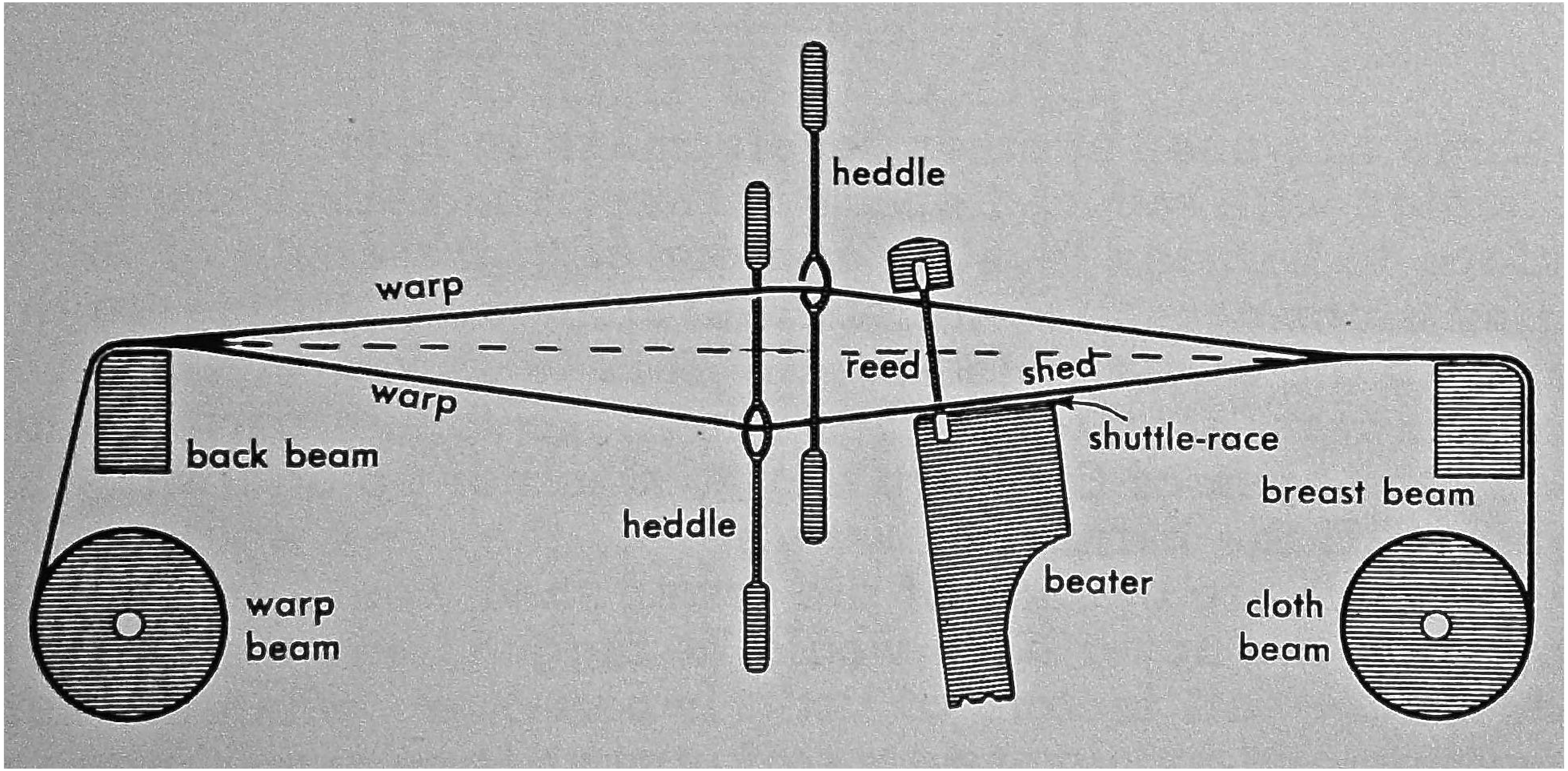
Backstrap loom weaving

https://mayaweavings.com/pages/what-is-backstrap-weaving



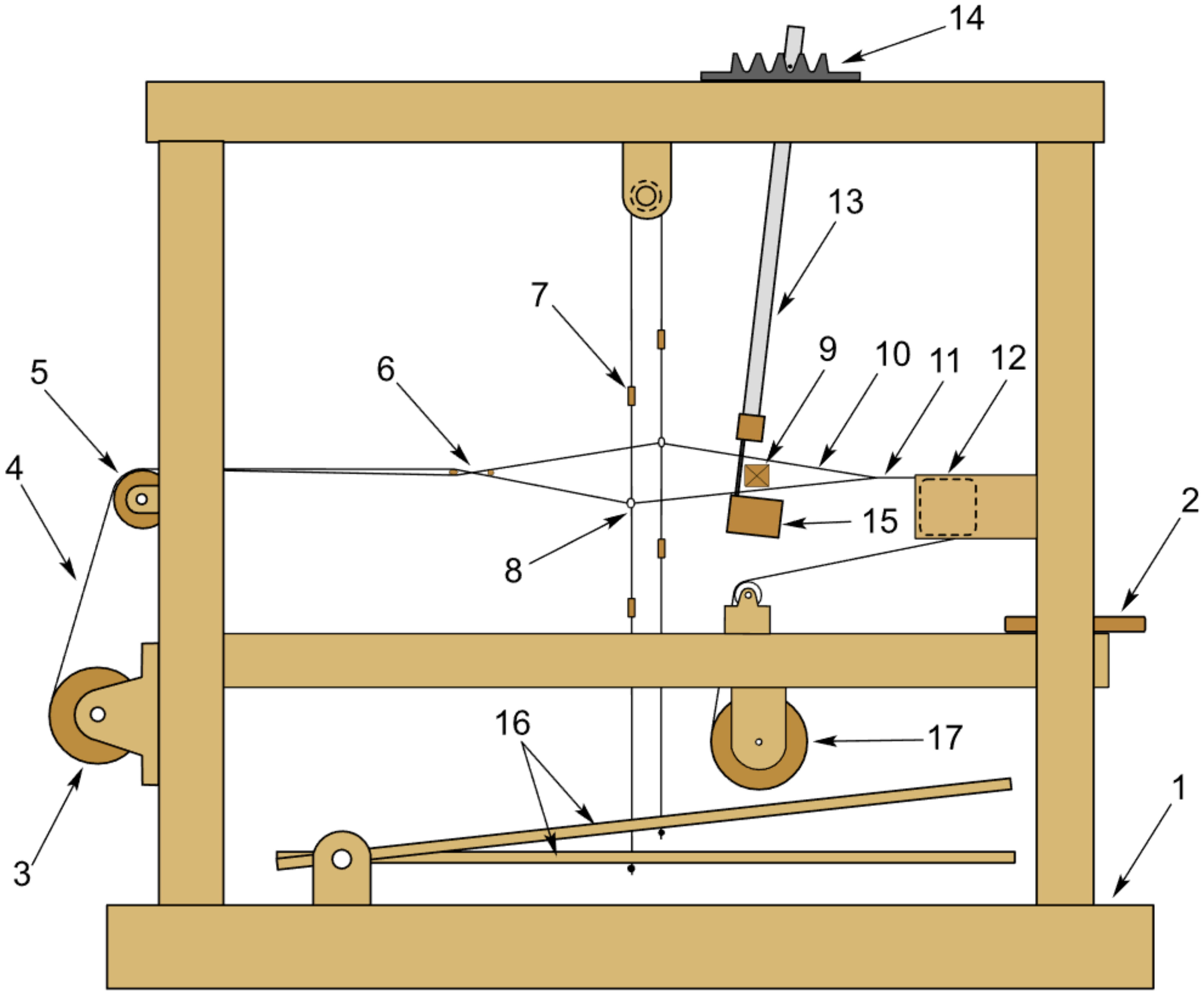
Woman weaving a silk rebozo on a backstrap loom at the Taller Escuela de Rebocería in Santa Maria del Rio, San Luis Potosí

Loom diagram



https://borealweaver.wordpress.com/tag/loom-diagram/

A Mechanical Loom



1. Wood frame
2. Seat for weaver
3. Warp beam- let off
4. Warp threads
5. Back beam or platen
6. Rods – used to make a shed
7. Heddle frame - heald frame - harness
8. Heddle- heald - the eye
9. Shuttle with weft yarn
10. Shed
11. Completed fabric
12. Breast beam
13. Batten with reed comb
14. Batten adjustment
15. Lathe
16. Treadles
17. Cloth roll- takeup

https://en.wikipedia.org/wiki/Loom

Shuttle looms

https://en.wikipedia.org/wiki/Power_loom

The main components of the loom are the warp beam, heddles, harnesses, shuttle, reed, and takeup roll. In the loom, yarn processing includes shedding, picking, battening and taking-up operations.

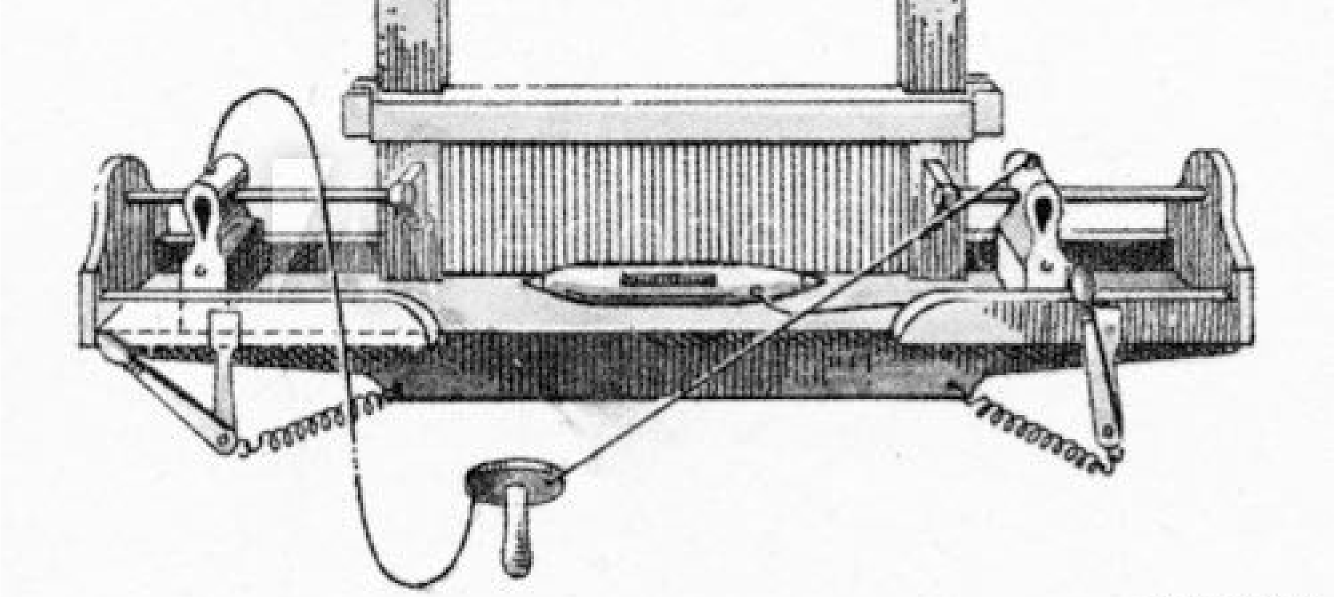
- ***Shedding***. Shedding is the raising of the warp yarns to form a loop through which the filling yarn, carried by the shuttle, can be inserted. The shed is the vertical space between the raised and unraised warp yarns. On the modern loom, simple and intricate shedding operations are performed automatically by the heddle or heald frame, also known as a harness. This is a rectangular frame to which a series of wires, called heddles or healds, are attached. The yarns are passed through the eye holes of the heddles, which hang vertically from the harnesses. The weave pattern determines which harness controls which warp yarns, and the number of harnesses used depends on the complexity of the weave. Two common methods of controlling the heddles are dobbies and a Jacquard Head.
- ***Picking***. As the harnesses raise the heddles or healds, which raise the warp yarns, the shed is created. The filling yarn is inserted through the shed by a small carrier device called a shuttle. The shuttle is normally pointed at each end to allow passage through the shed. In a traditional shuttle loom, the filling yarn is wound onto a quill, which in turn is mounted in the shuttle. The filling yarn emerges through a hole in the shuttle as it moves across the loom. A single crossing of the shuttle from one side of the loom to the other is known as a pick. As the shuttle moves back and forth across the shed, it weaves an edge, or selvage, on each side of the fabric to prevent the fabric from raveling.
- ***Battening***. As the shuttle moves across the loom laying down the fill yarn, it also passes through openings in another frame called a reed (which resembles a comb). With each picking operation, the reed presses or battens each filling yarn against the portion of the fabric that has already been formed. The point where the fabric is formed is called the fell. Conventional shuttle looms can operate at speeds of about 150 to 200 picks per minute

Shuttle with pirn

Shuttle loom operations: shedding, picking and battening

Re: Picking Mechanisms

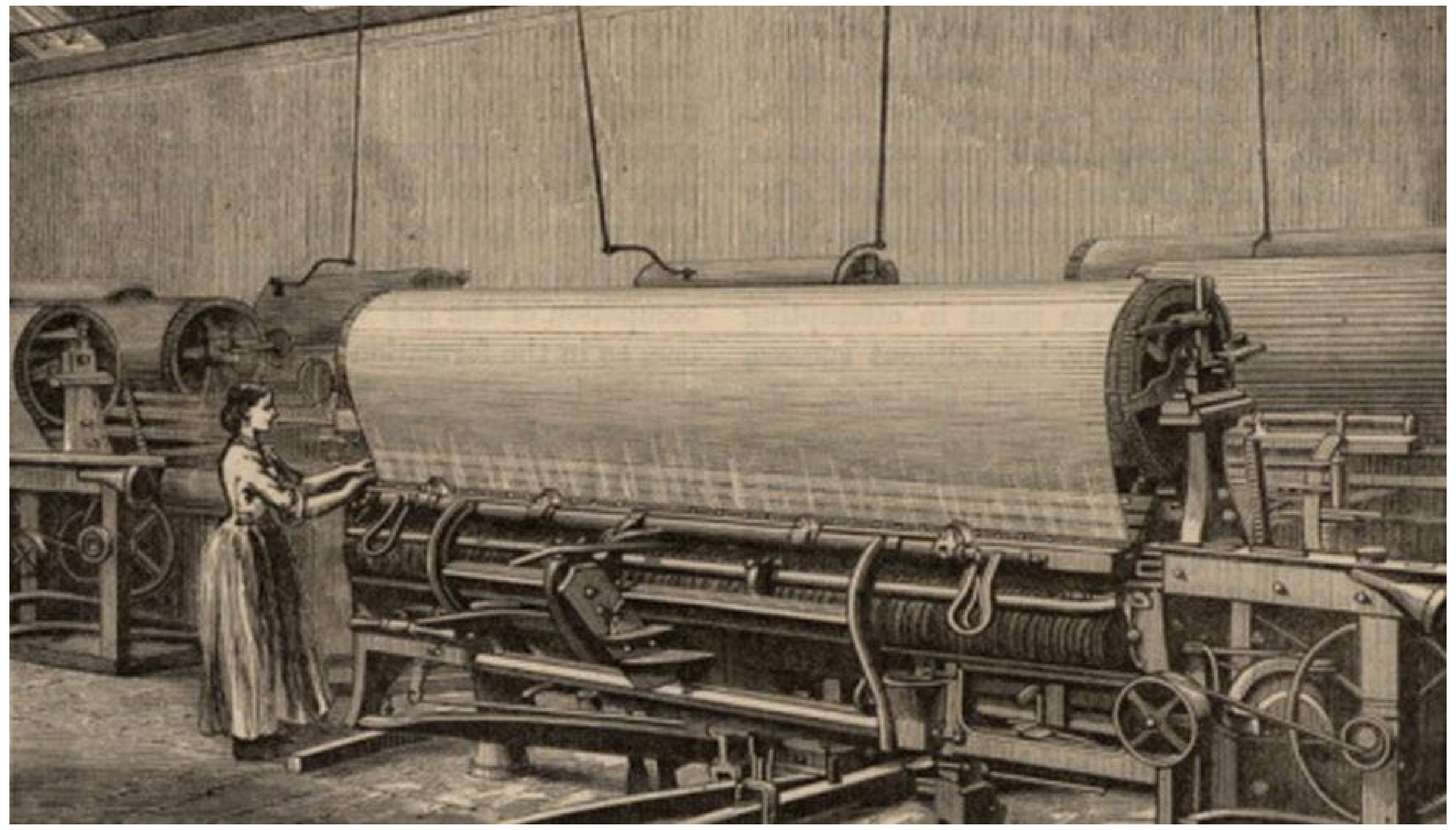
Flying Shuttle



- Invented in 1733 by John Kay (England)
- Lever-operated hammer that hit shuttle through shed
- "The shuttle, with the weft wound onto it, was placed in a wooden box which contained a sliding hammer, which in turn was attached to a cord. The weaver pulled the cord and the hammer slammed into the shuttle shooting it across the waft at a terrific speed (imagine hitting an ice puck). To make the shuttle move even faster. a small modified roller was attached to the shuttle and the shape was made more aerodynamic and capped with metal ends." https://www.intriguing-history.com/flying-shuttle
- Allowed single-operator weaving on large machines
- Human and social costs

The box that contained the flying shuttle

https://en.wikipedia.org/wiki/Flying_shuttle



https://sciencing.com/description-of-a-flying-shuttle-12556508.html

https://www.youtube.com/watch?v=kNqHgY4TQwM

Flying Shuttle Demonstration

https://www.youtube.com/watch?v=khiEAEqdkZY

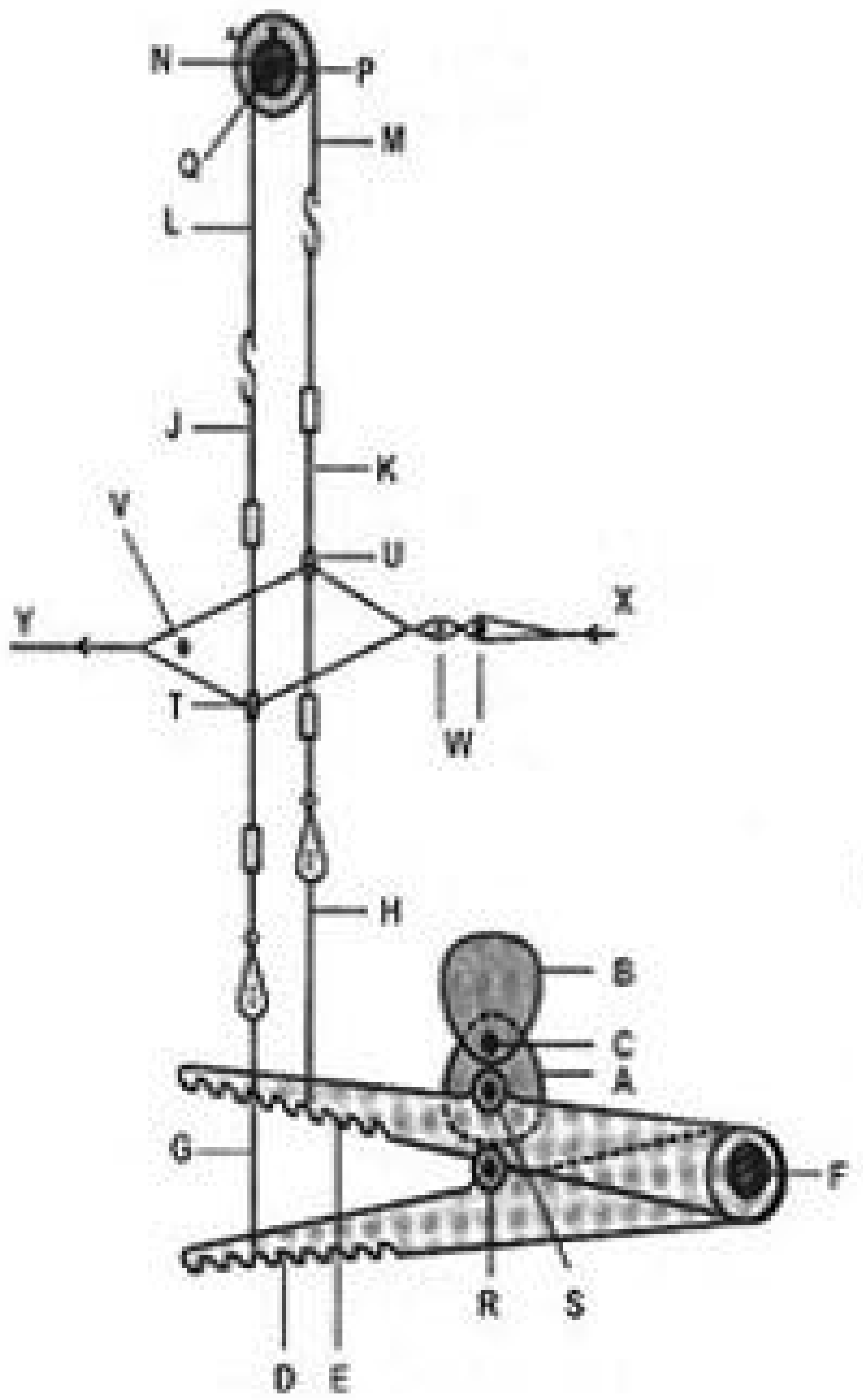
Shedding Mechanisms

Three types of shedding (opening) motions:

- **Tappet** shedding:
  - Uses a cam-follower system that drives a small number of treadles, e.g., <15
- **Dobby** shedding:
  - Control many shafts / heald frames, e.g., 12, 16, 20, 24, 28, 30
  - Positive (negative) dobby shedding mechanisms raise/lower (raise) shafts
- **Jacquard** shedding:
  - Controls every warp yarn individually
  - Can achieve the most complex designs

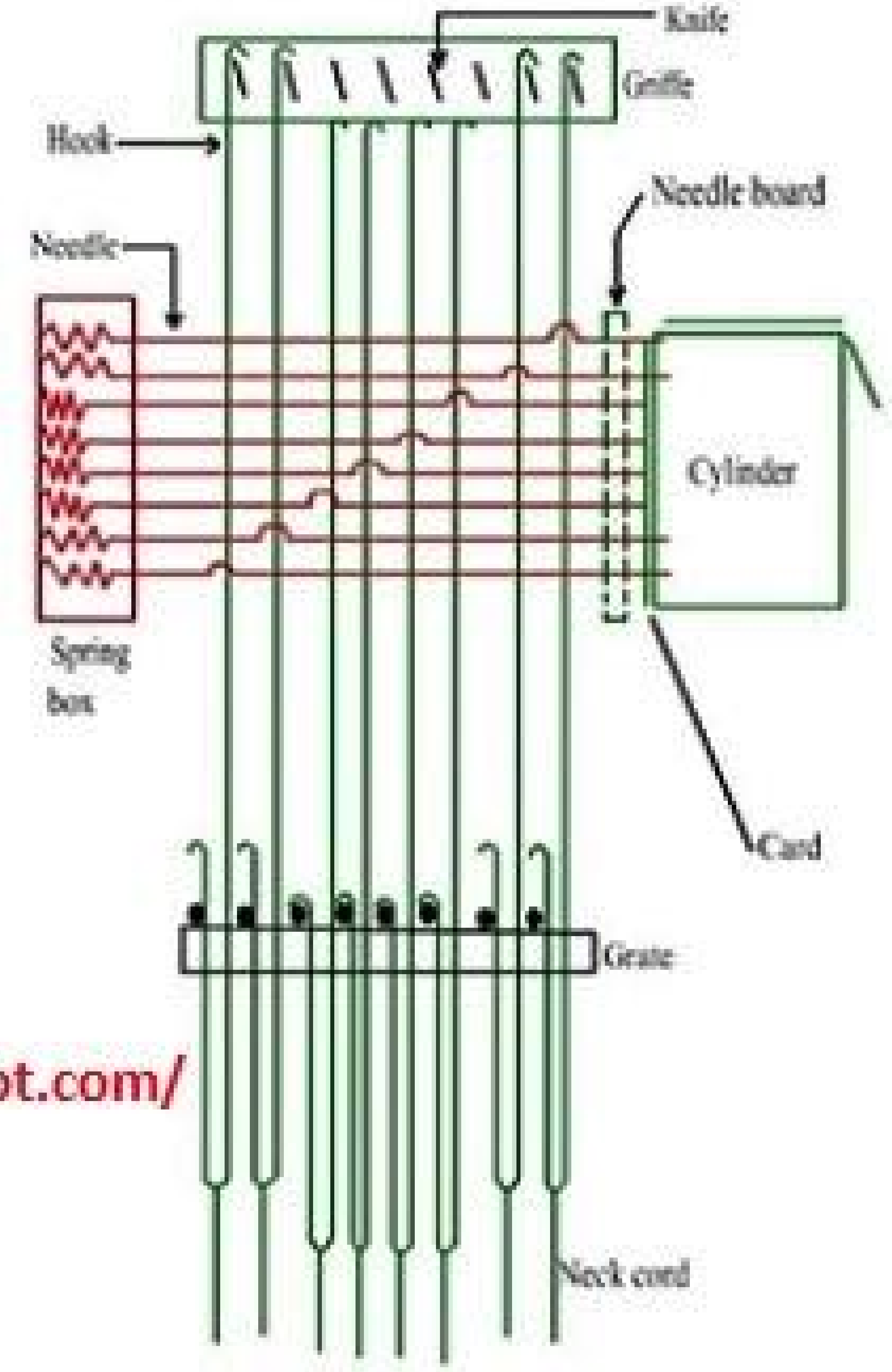
Shedding Mechanisms

Tappet Shedding



Dobby Shedding

Jacquard Shedding

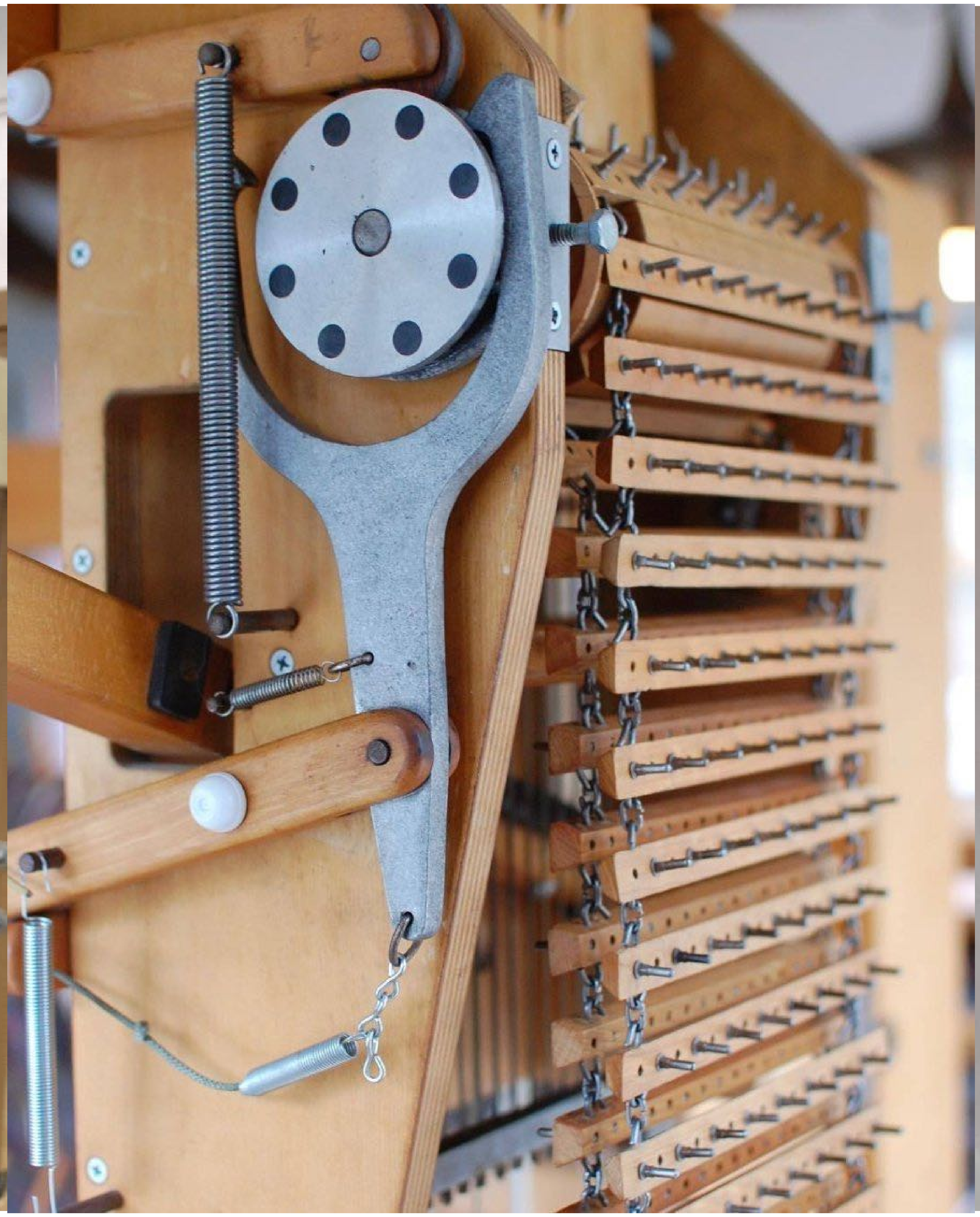


Shedding Mechanisms

Tappet Shedding	Dobby Shedding	Jacquard Shedding
Simplest design capacity.	Medium i.e. complex design capacity.	Elaborate i.e. very complex design capacity.
Most costly weaving loom.	Less costly weaving loom.	Very less costly loom.
Loom speed is very high.	Loom speed is medium to high.	Loom speed is slow.
Max. No. of heald shafts is 14.	Theoretically it can control max. 48 heald frames. In case of wool, particularly 36 heald and in cotton-24	Theoretically it can control any no. of warp thread individually.
Tappet is placed generally below the loom.	Dobby is placed generally above the loom.	Jacquard is placed normally above the **loom**.
Lowest cost of production.	Lower **production cost**.	Cost of production is low.
Different tappets are fitted to bottom shaft for different designs.	For different designs, different designs of pegging legs are placed on pattern drum or cylinder.	Different designed pinches cards are placed on cylinder for different designs.
Production is more than dobby.	Less production.	Less production.

https://www.fiber2apparel.com/2018/06/tappet-dobby-jacquard-shedding-difference-textile-weaving.html

Mechanical Dobby Bars



https://avllooms.com/collections/mechanical-dobby/products/mechanical-dobby-bars

Dobby Loom

Harnesses ready to go into a dobby loom

http://blog.guilfordofmaine.com/dobby-vs-jacquard-a-tale-of-two-looms/

AVL Industrial Dobby Loom

https://avllooms.com/collections/looms/products/industrial-dobby-loom

Jacquard Loom

https://www.youtube.com/watch?v=MQzpLLhN0fY

Interesting Connections

James Burke's "Connections" on PBS
Excerpt: https://www.youtube.com/watch?v=itd-4lMoXgI

Watch this one!

James Burke
Connections,
Ep. 4 "Faith in Numbers"
https://www.youtube.com/watch?v=z6yL0_sDnX0

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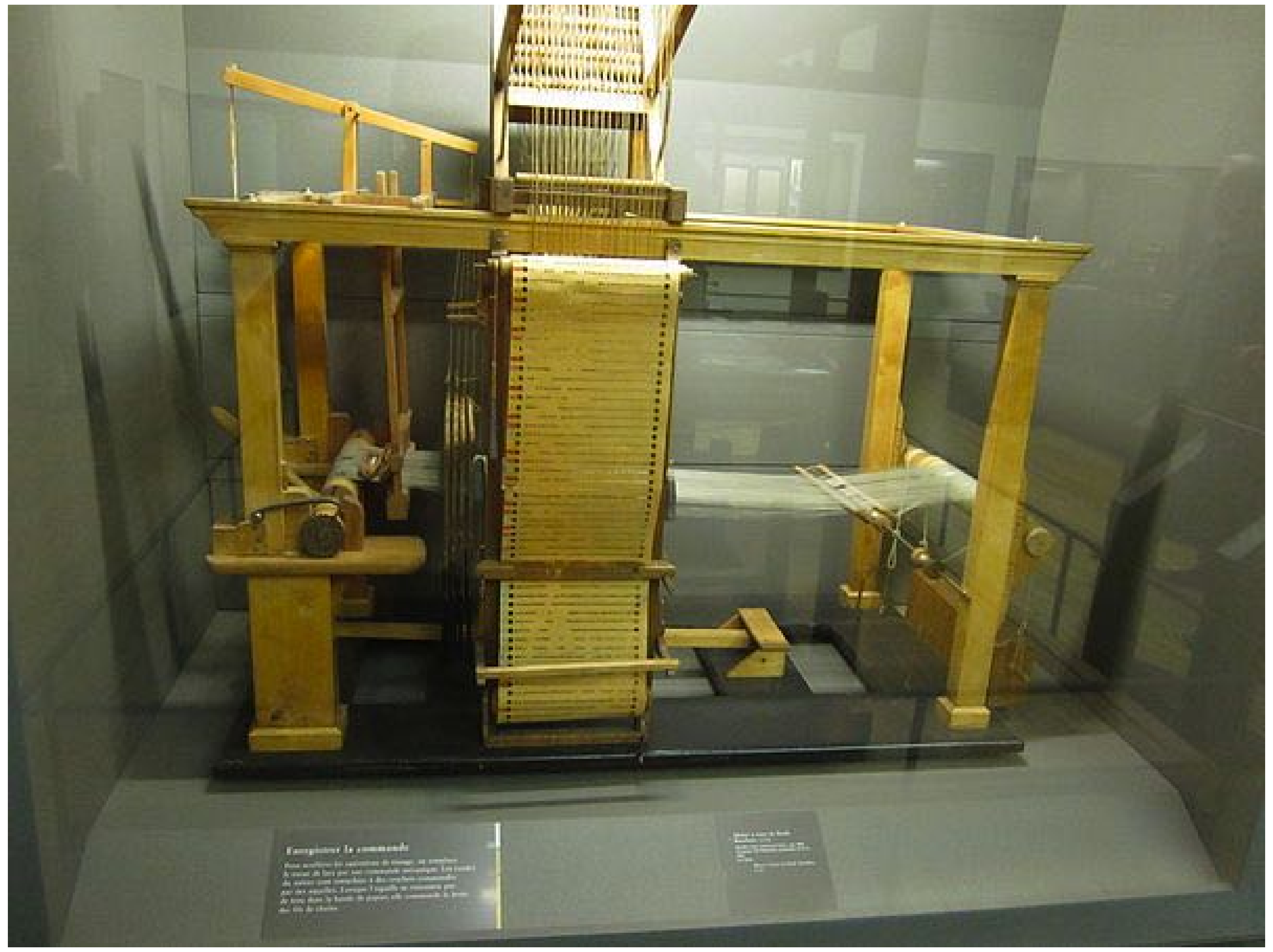


Basile Bouchon: Invented way to control loom using perforated paper tape in 1725.
https://en.wikipedia.org/wiki/Basile_Bouchon

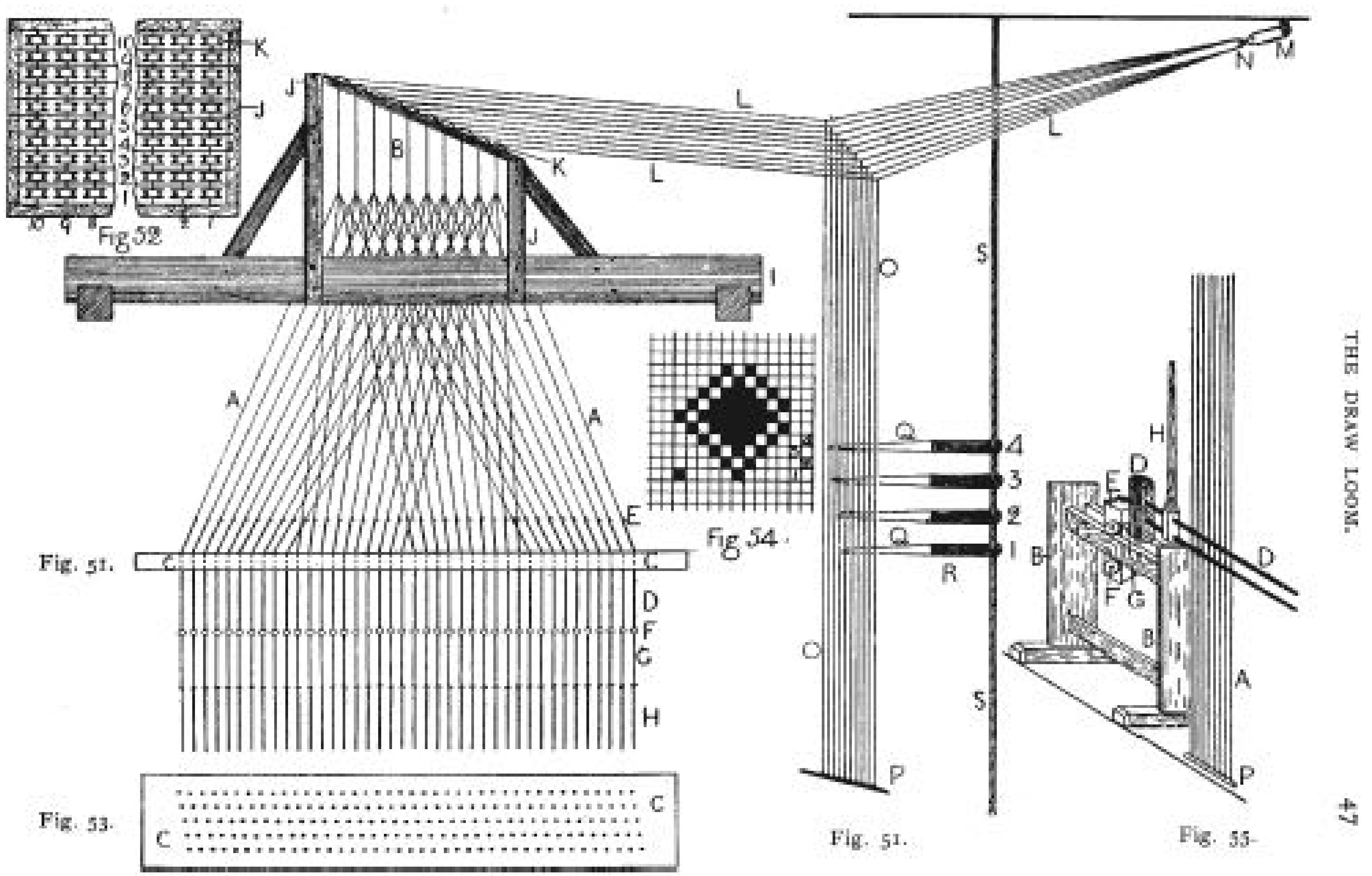
Jean-Baptiste Falcon: In 1728, replaced paper tape with cards connected to form an endless chain.
https://history-computer.com/Dreamers/Bouchon.html

Jacques de Vaucanson: Automated Bouchon's paper-tape loom in 1745.
https://en.wikipedia.org/wiki/Jacques_de_Vaucanson

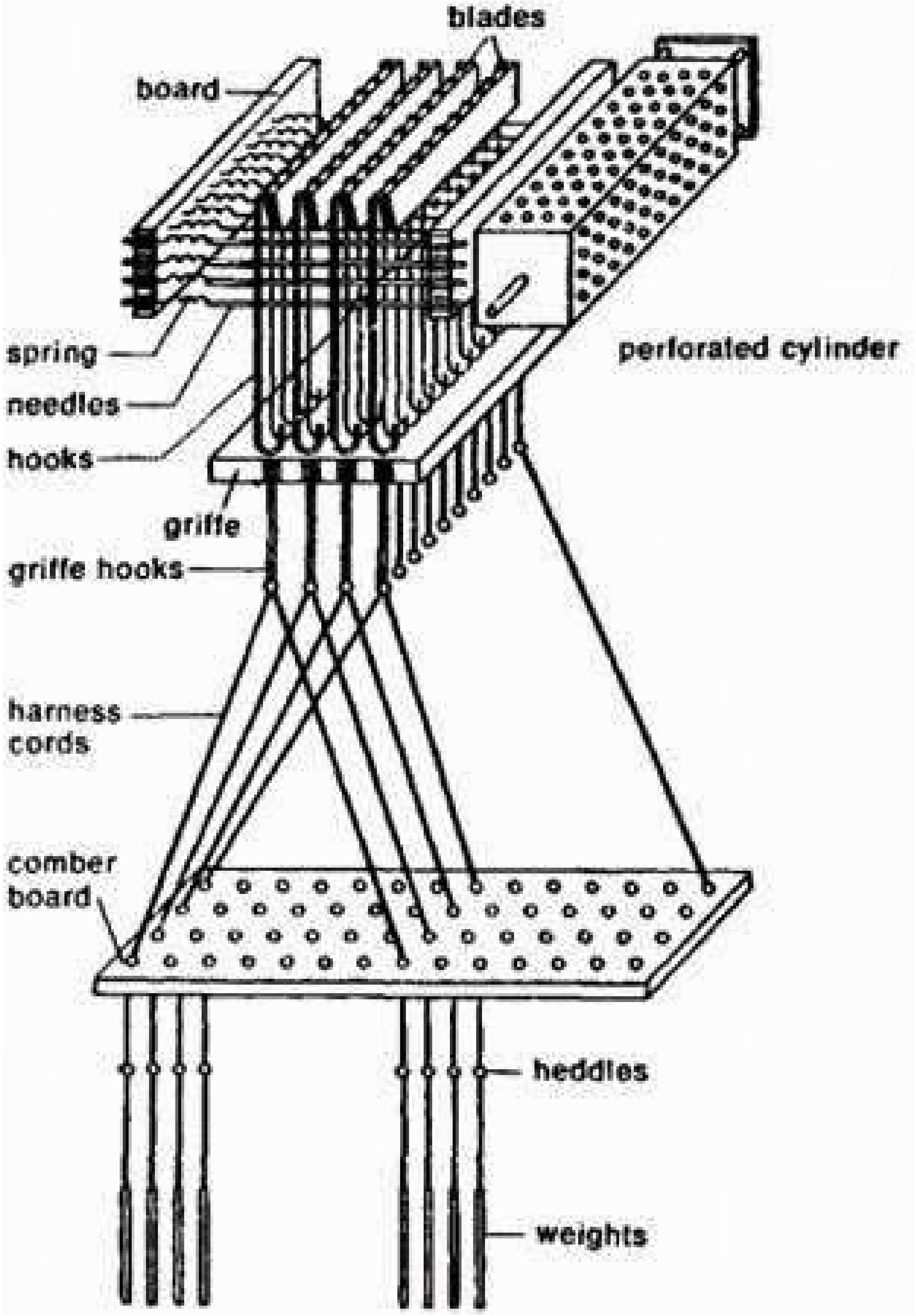
Joseph Marie Jacquard: Automated Falcon's card-controlled loom in 1804.
https://en.wikipedia.org/wiki/Jacques_de_Vaucanson

Jacquard Loom

- Invented by Joseph Marie Jacquard in 1804.
- The Jacquard machine is a device fitted to a power loom that simplifies the process of manufacturing textiles with such complex patterns as brocade, damask and matelassé.

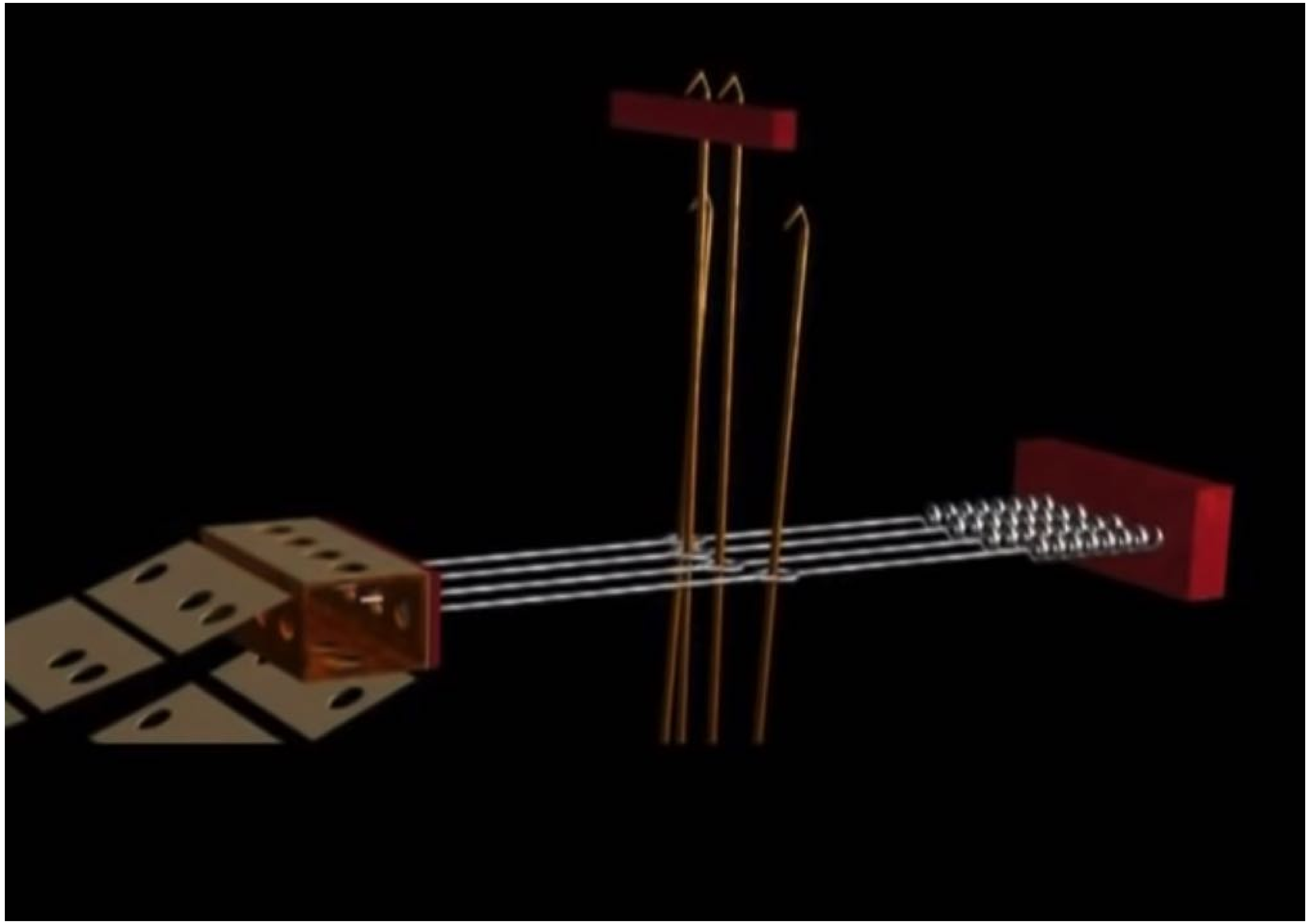


Bradbury, Fred. *Jacquard Mechanism and Harness Mounting*



This portrait of Jacquard was woven in silk on a Jacquard loom and required 24,000 punched cards to create (1839). It was only produced to order. Charles Babbage owned one of these portraits; it inspired him in using perforated cards in his analytical engine.[1] It is in the collection of the Science Museum in London, England.[2]

Jacquard Head Animation



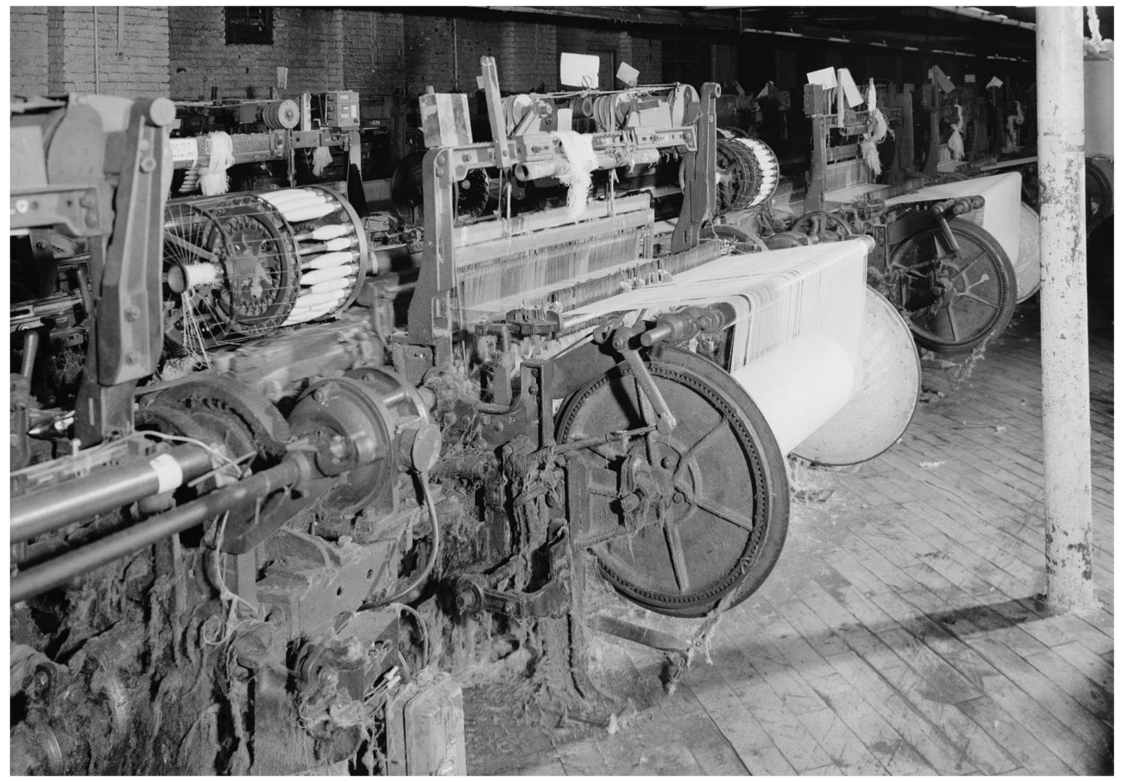
https://www.youtube.com/watch?v=K6NgMNvK52A

Power Looms

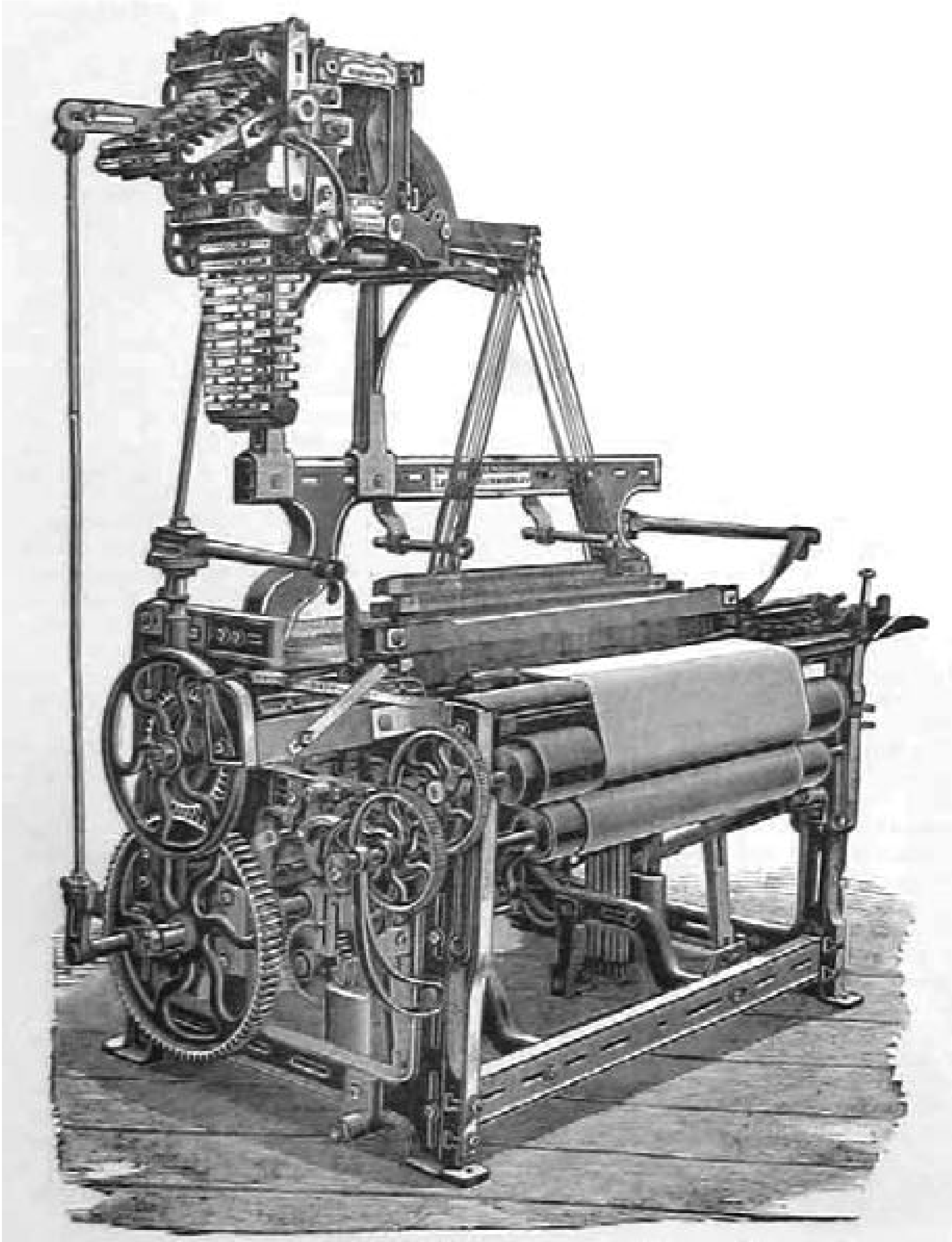
https://en.wikipedia.org/wiki/Power_loom

- Powered mechanical looms
- Edmund Cartwright:
  - 1784: First design
  - 1785: First built
  - Refined over next 47 years; many versions.
    - Primarily shuttle looms
- 1832: **Lancashire Loom**. Kenworthy & Bullough.
  - A completely automatic power loom
    - "a perfect machine"
  - Con: Has to stop to recharge shuttles
- 1895: **Northrop Loom**.
  - James Henry Northrop
    - Invented shuttle-charging mechanism.
  - Marketed by Draper and Sons.
  - Sold over 700,000 looms!
- Many related inventions
- Conventional shuttle looms operated at 150-200 picks/min

Two Lancashire looms



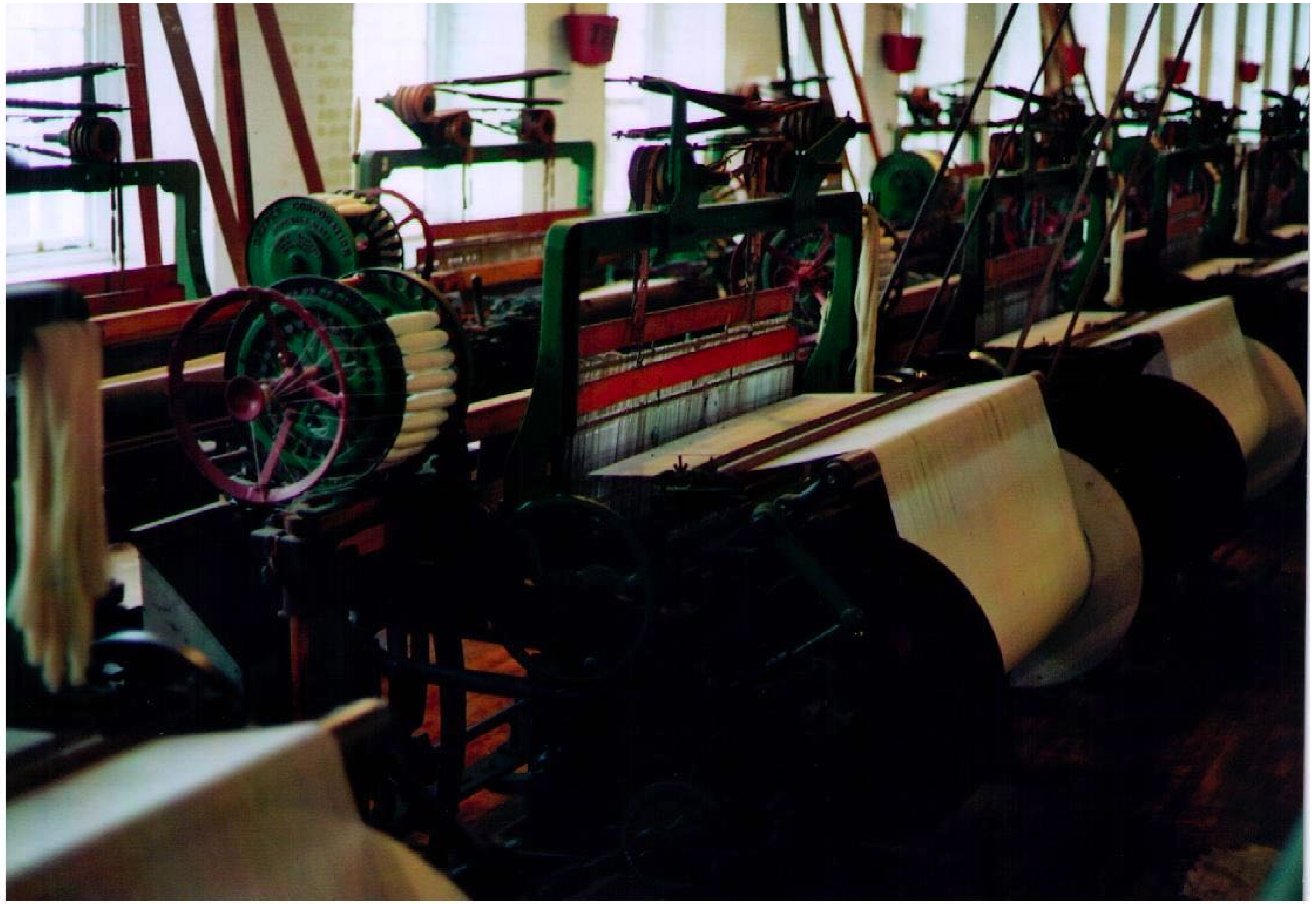
A Draper loom showing a Northrop filling-changing battery (the cylinder of pirns) in Bamberg, South Carolina



A loom from the 1890s with a dobby head.

Northrop Loom

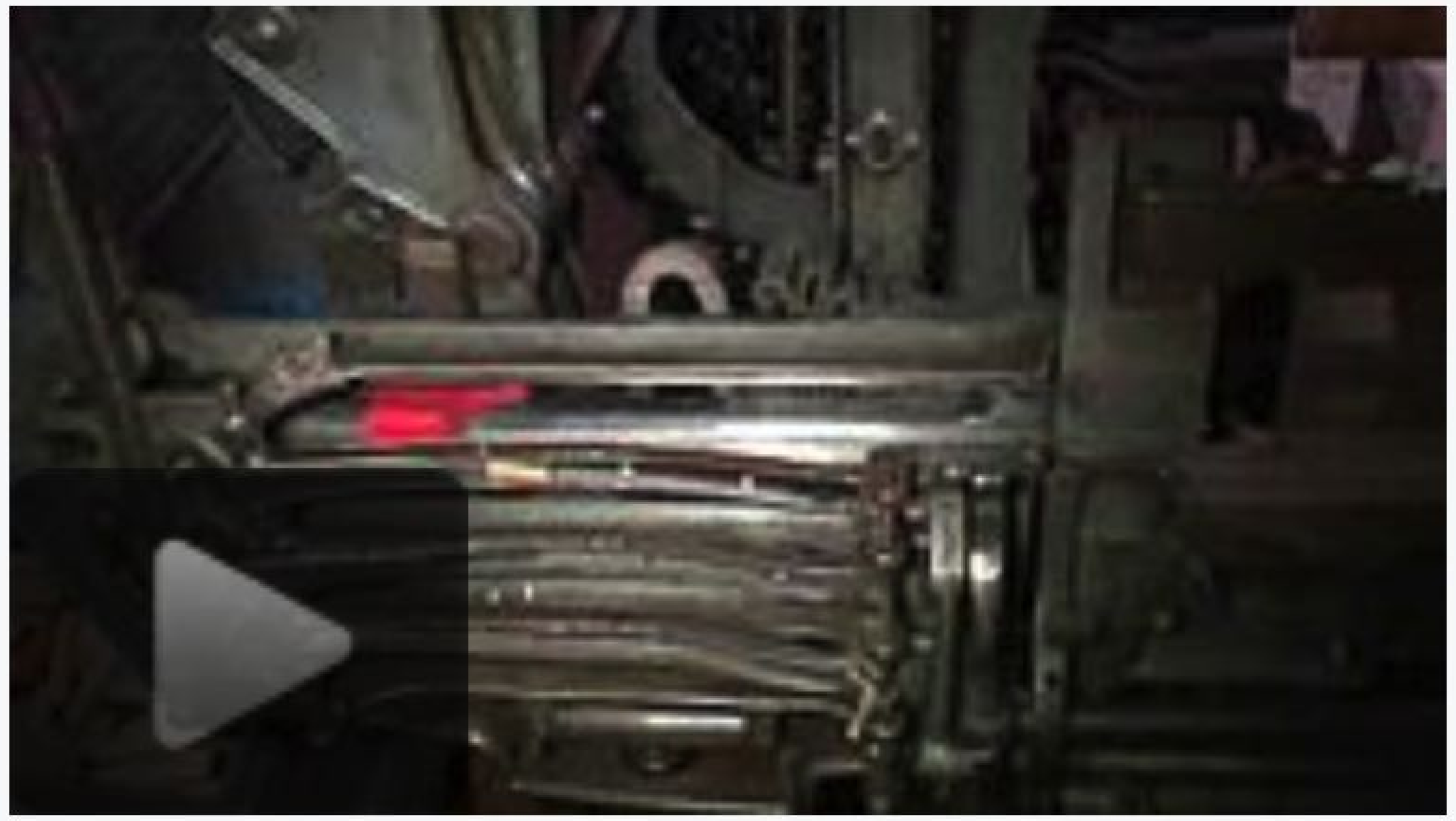
https://en.wikipedia.org/wiki/Northrop_Loom



Northrop Battery

Gratuitous Power-Loom Flying Shuttle Example

https://en.wikipedia.org/wiki/Loom

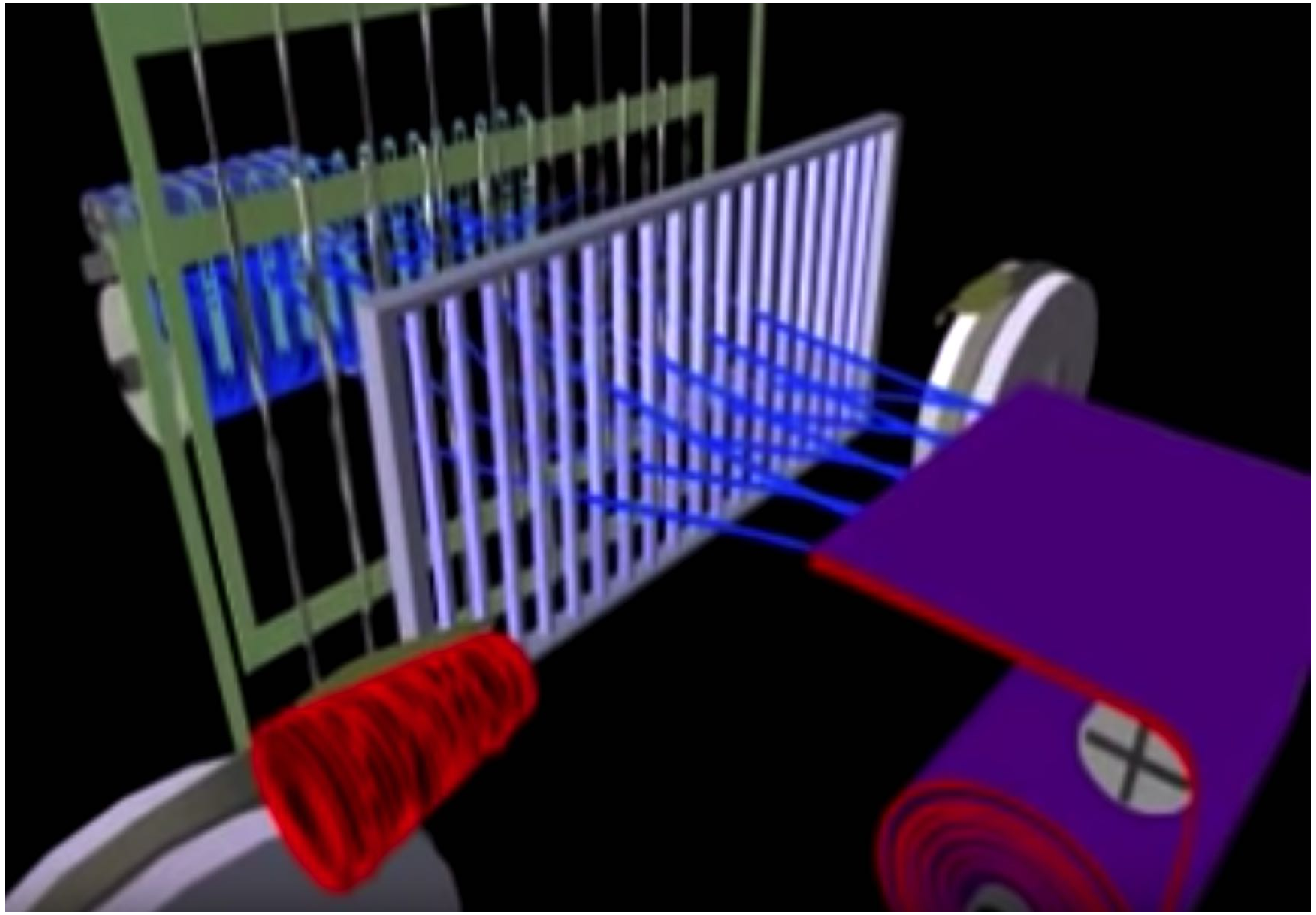


A 1939 loom working at the Mueller Cloth Mill museum in Euskirchen, Germany.

https://upload.wikimedia.org/wikipedia/commons/e/ef/Weben_in_der_Tuchfabrik_M%C3%BCller.ogv

Weft yarn insertion mechanisms

- Shuttle
- Rapier
- Projectile
- Air jet
- Water jet
- Multiphase loom

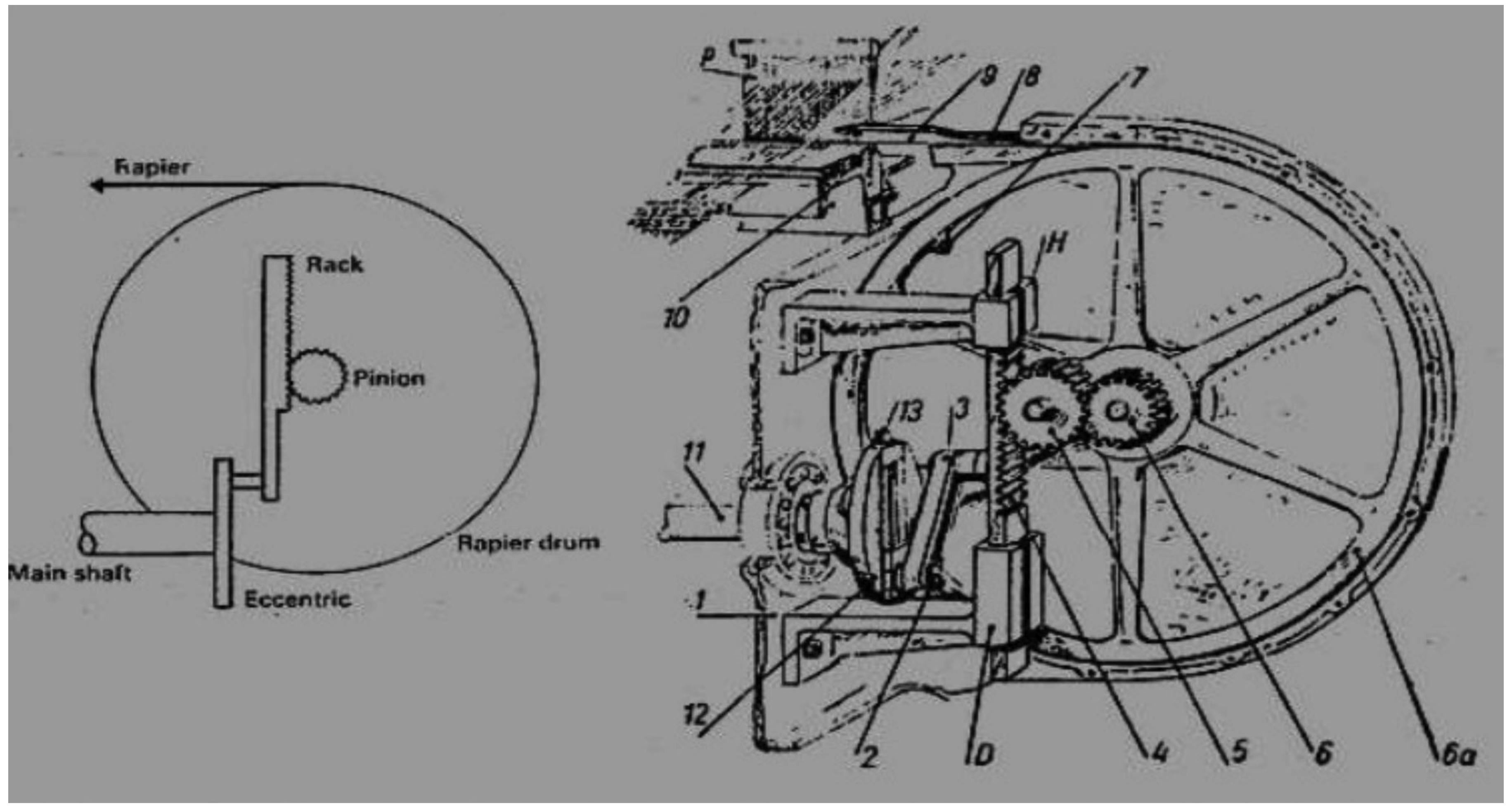


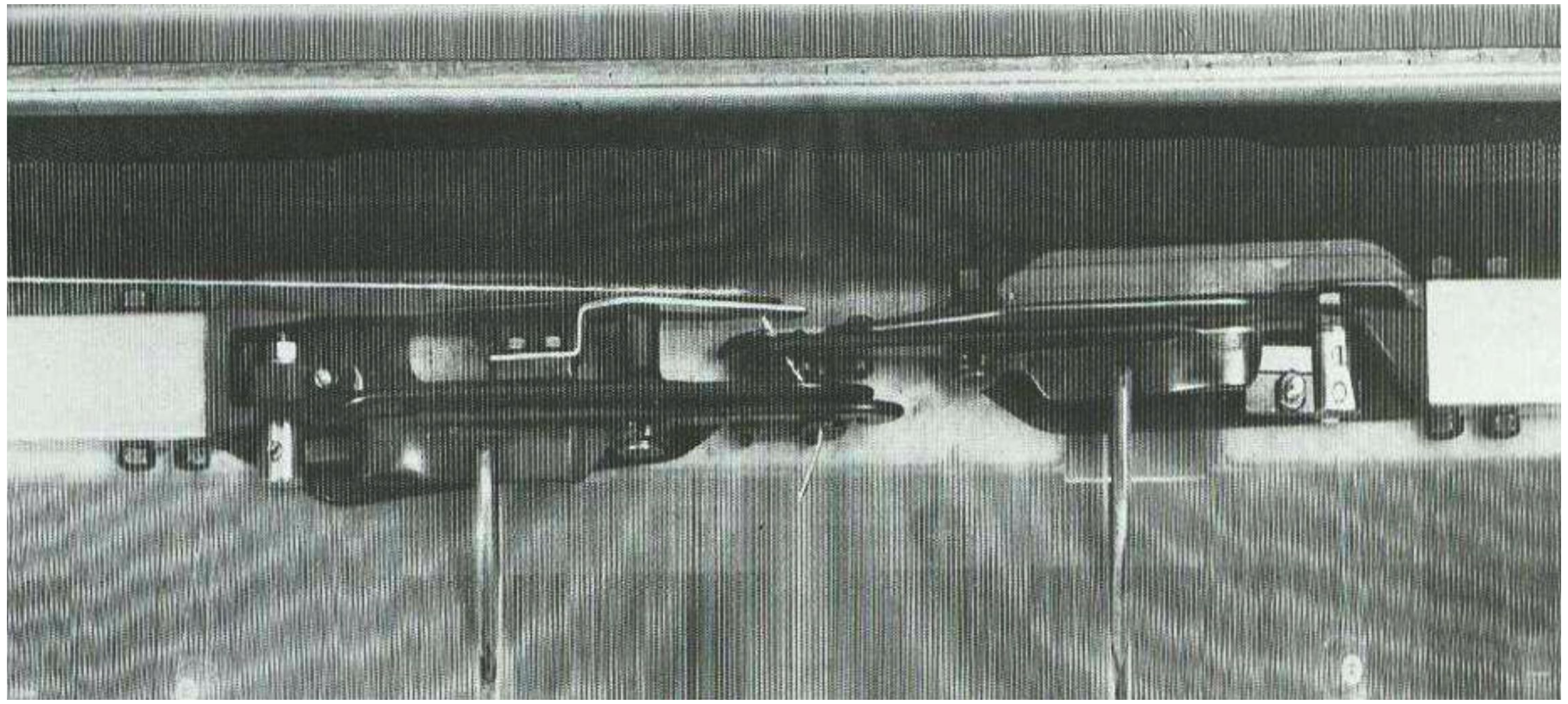
https://www.youtube.com/watch?v=s0W0iDj7_hc

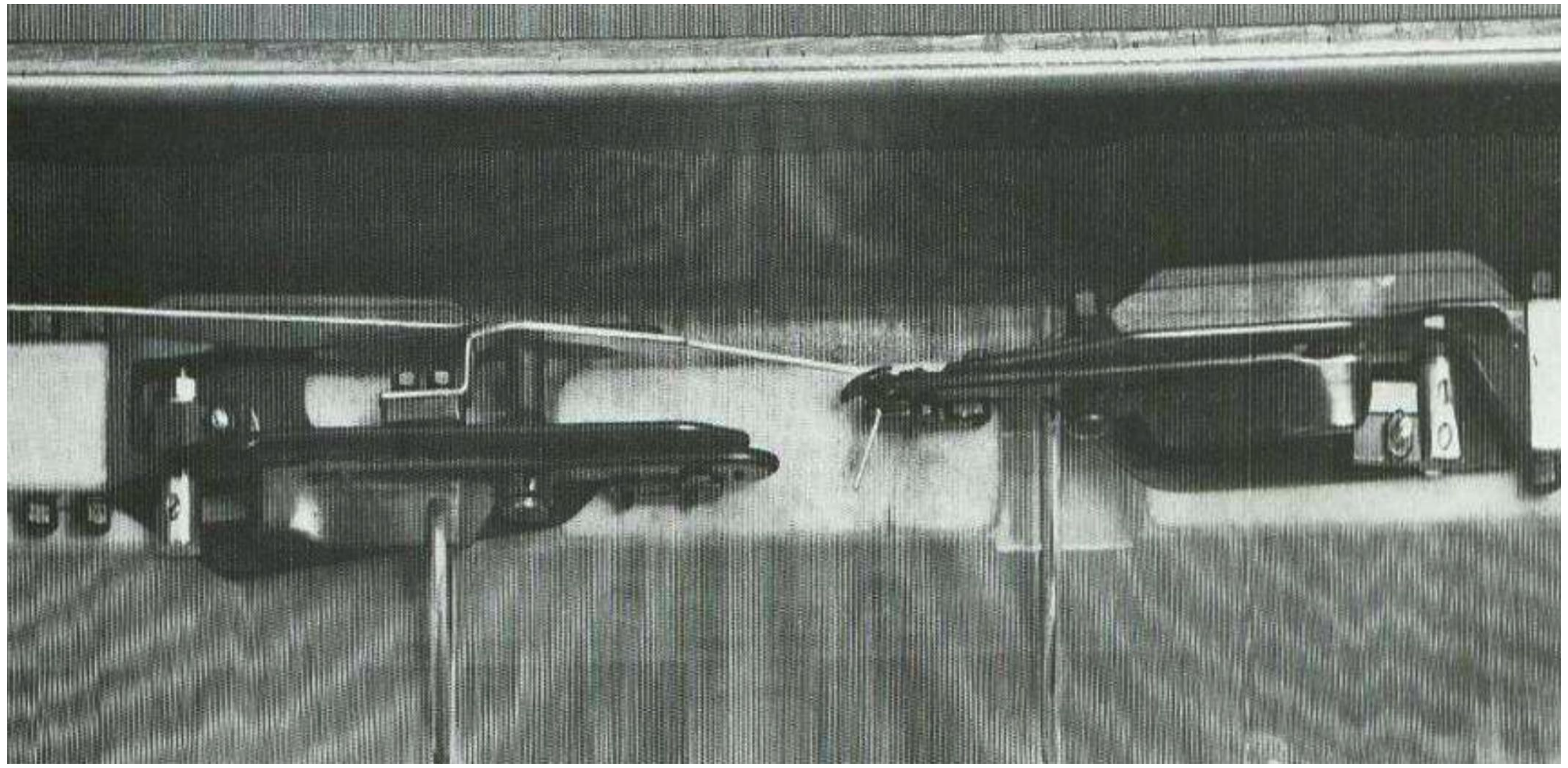
Rapier Loom

https://en.wikipedia.org/wiki/Rapier_loom

- 1844, John Smith of Salford
- A rapier loom is a shuttleless weaving loom in which the (weft) filling yarn is carried through the shed of warp yarns to the other side of the loom by finger-like carriers called rapiers.
- Many variations:
  - rigid vs flexible rapiers
  - single vs double rapiers
    - double has carrier & receiver rapiers

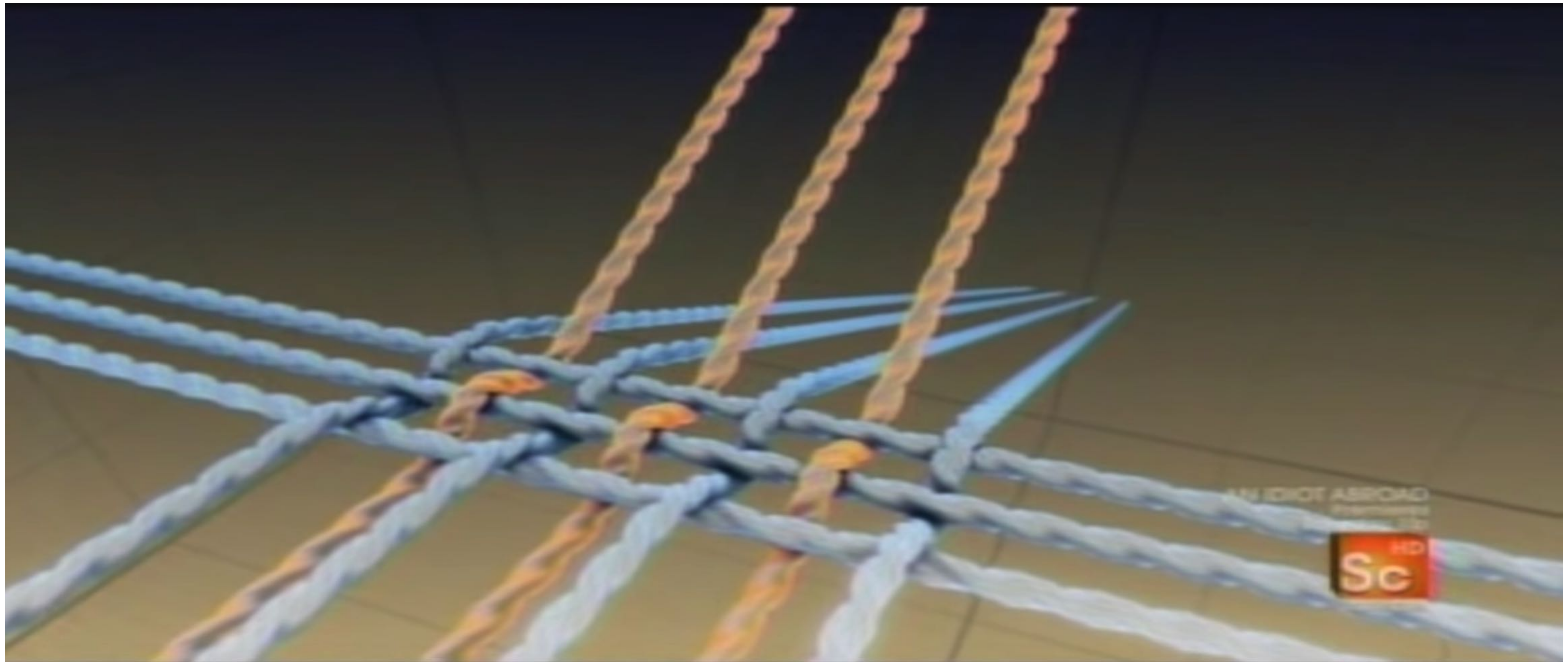






https://www.slideshare.net/amitbiswas420/rapier-loom-75352015?from_action=save

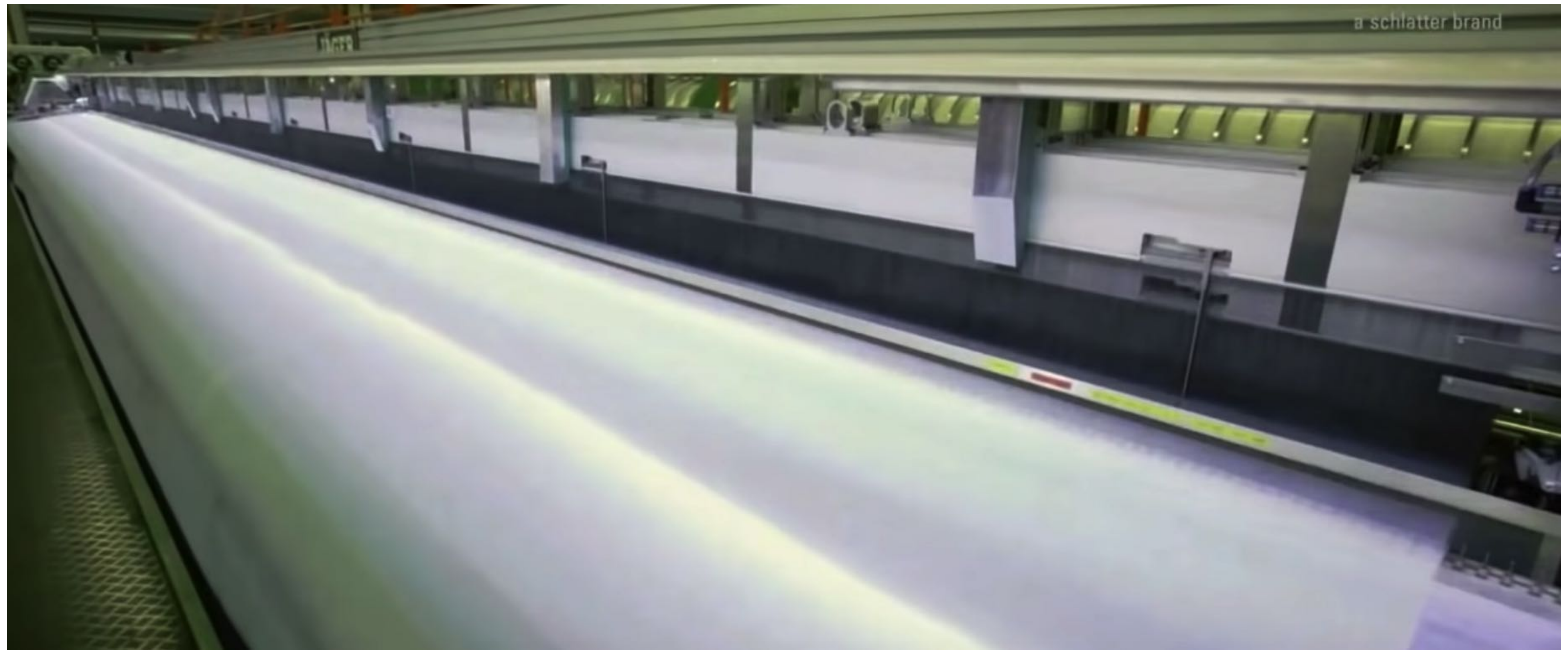
Industrial Loom Overview



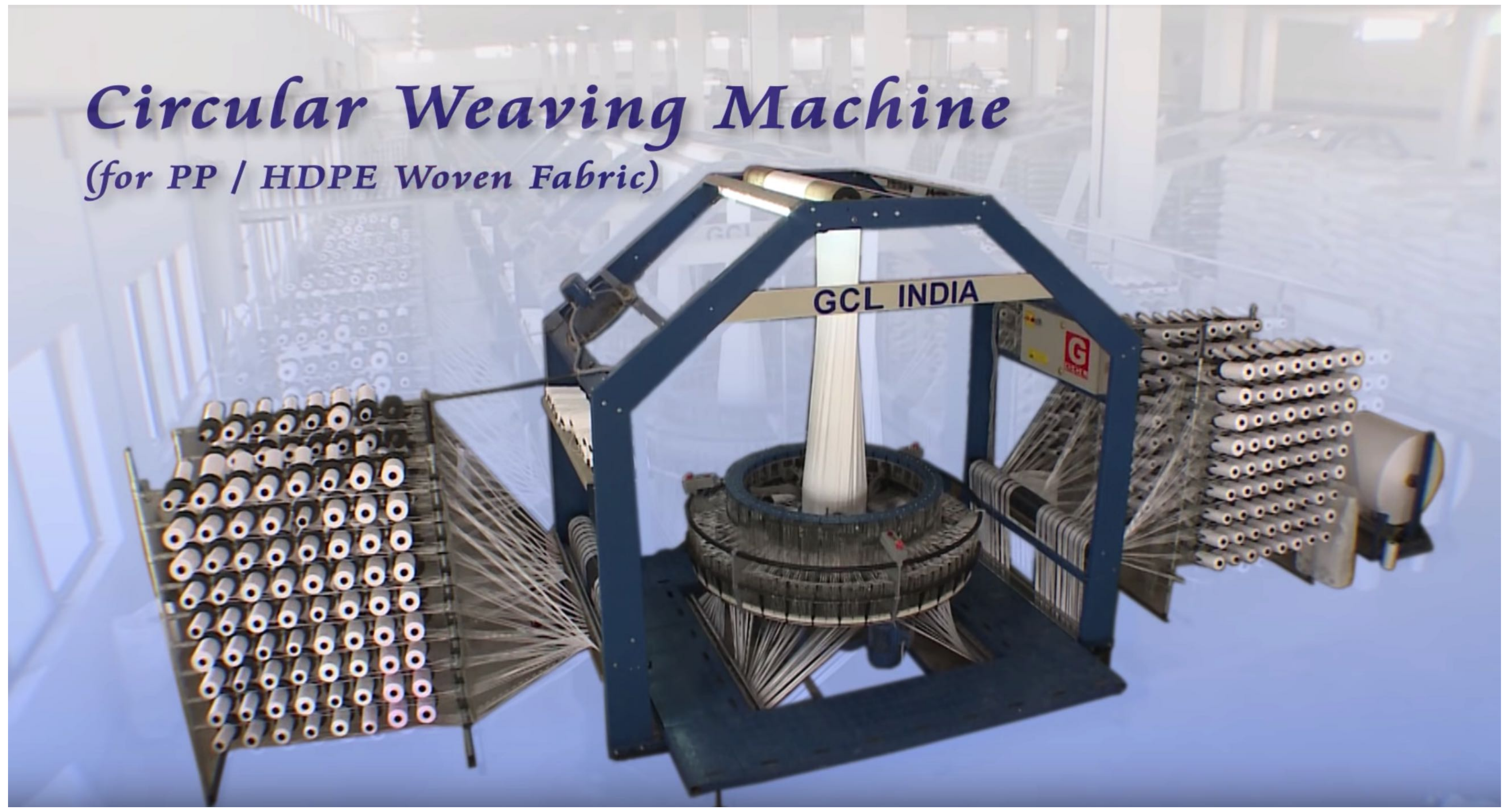
https://www.youtube.com/watch?v=TyhDkd8Iabs

How fast can you weave?

Large-scale weaving machines

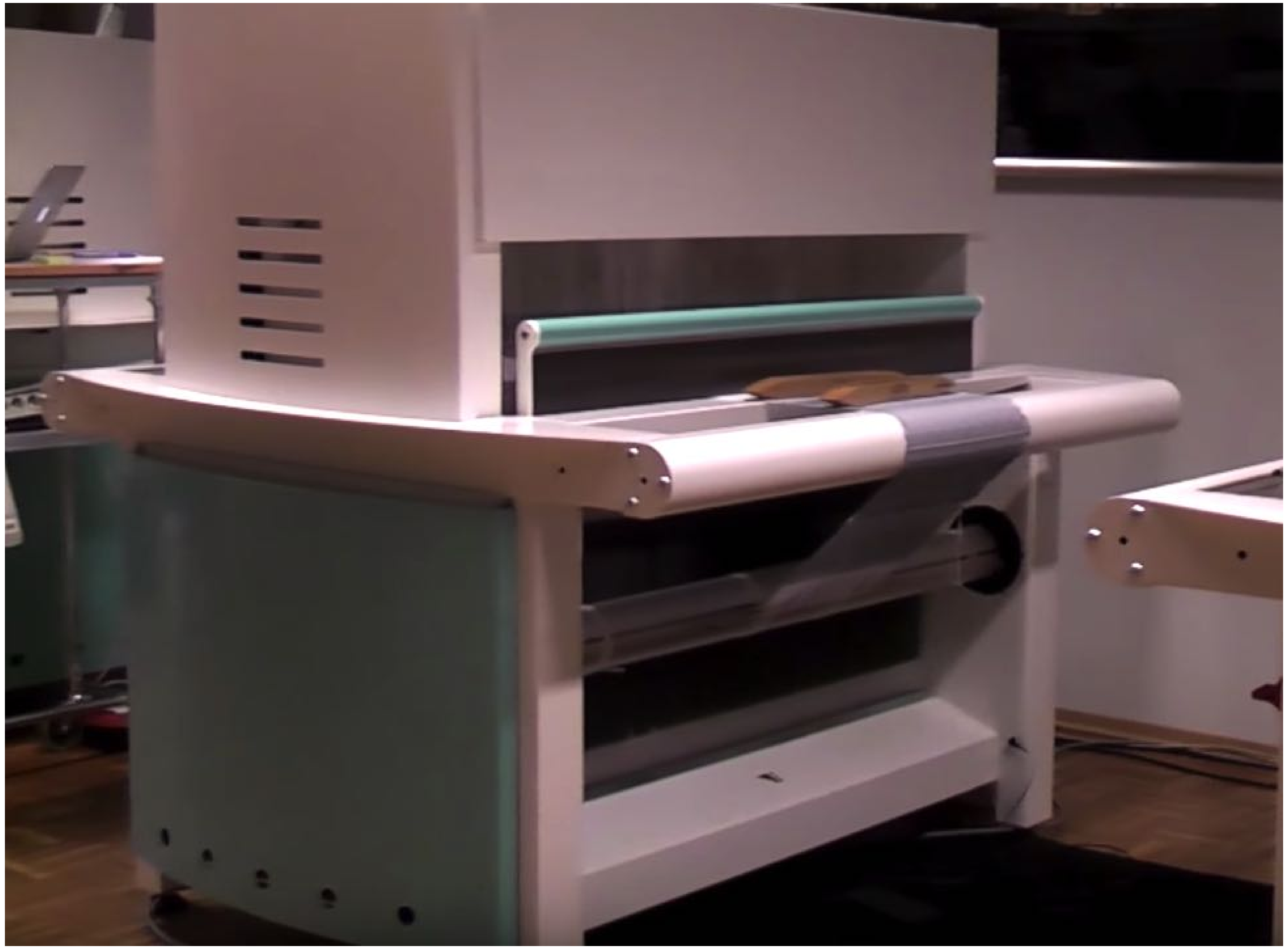


Example: Rapier weaving machine (Jager BK880)
https://www.youtube.com/watch?time_continue=23&v=6_BmENBObgo



GCL Circular Loom / Weaving Machine for PP Woven Bags/ Sacks
https://www.youtube.com/watch?v=VK5CV-kSUAY

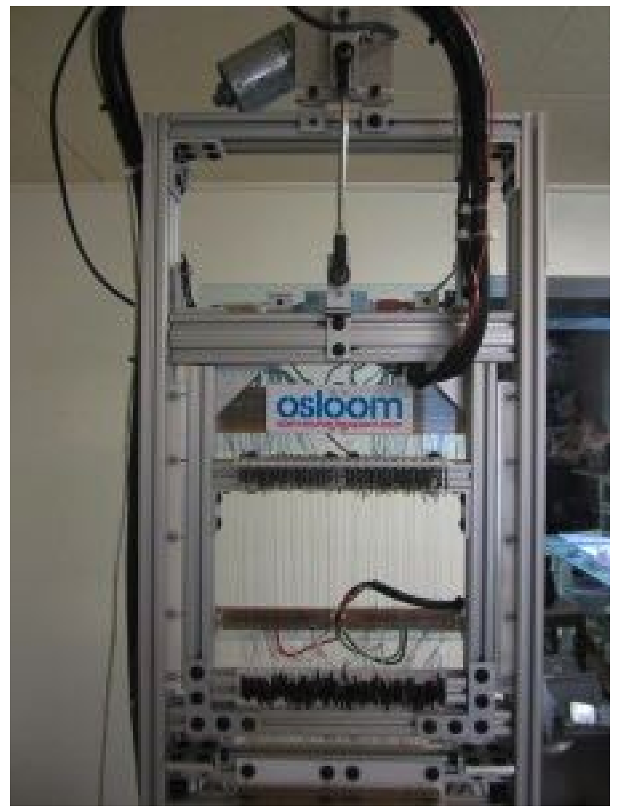
Digital Jacquard Looms



https://www.youtube.com/watch?v=UK6IqovdKLA

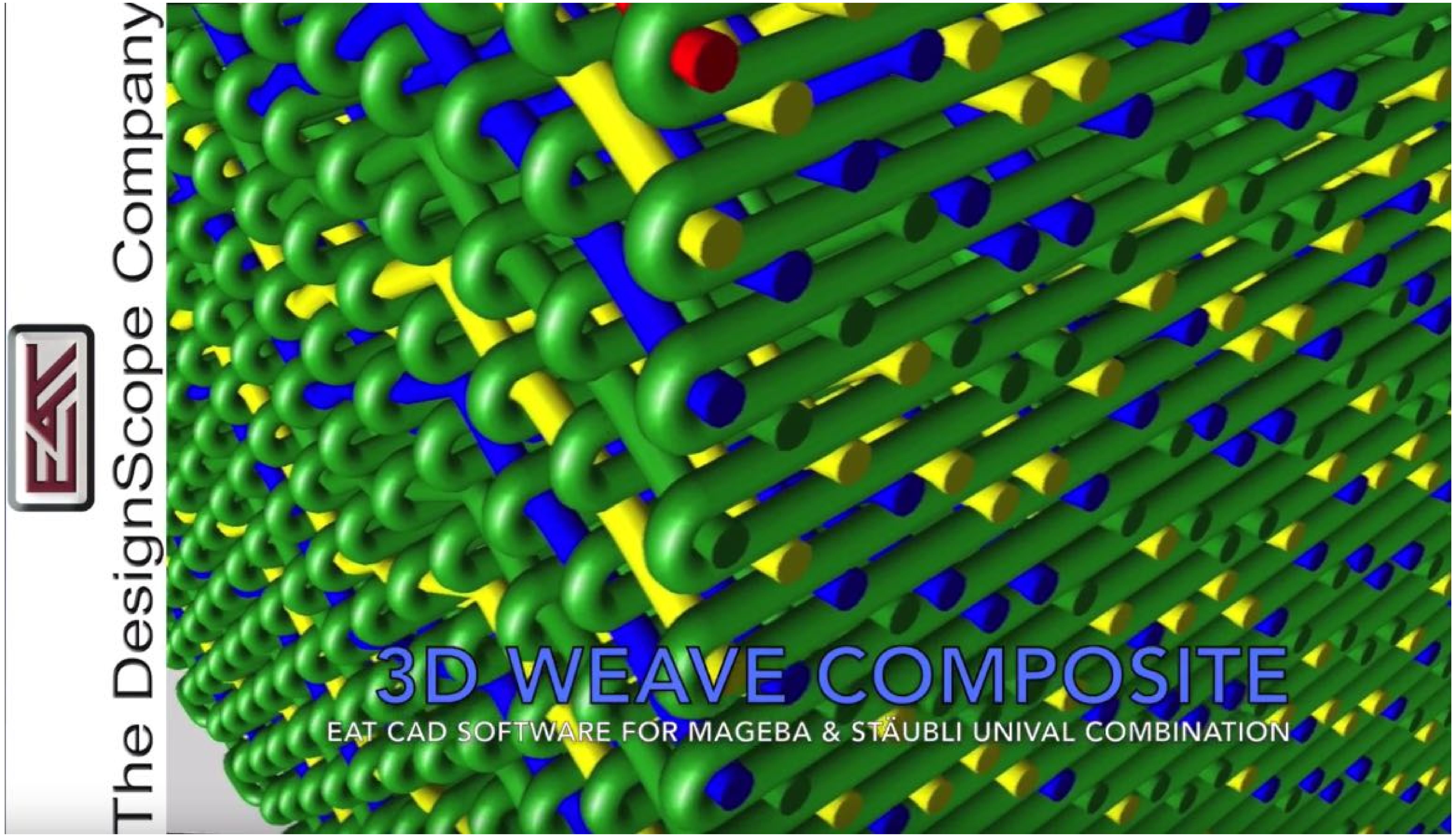
Weaving Software

- Mostly design
  - http://www.e-weaving.com/Links.html
  - E.g., ARAHWEAVE: Textile design software, for dobby and jacquard weaving.
    - https://www.arahne.si/products/arahweave
- Some control
  - OSLOOM: OPEN SOURCE LOOM, http://www.osloom.org/

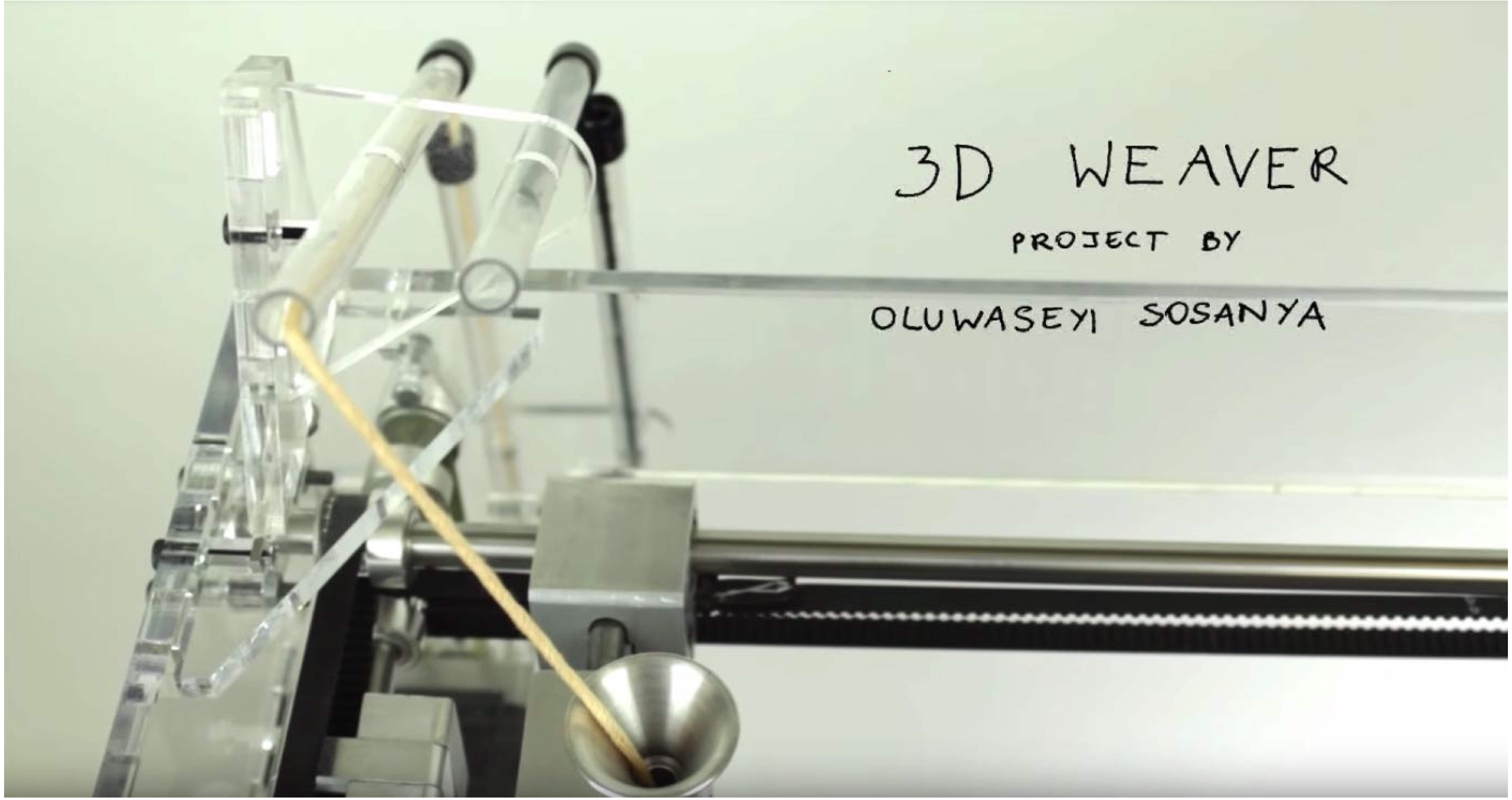


3D Weaving

Composites


The DesignScope Company
3D WEAVE COMPOSITE
EAT CAD SOFTWARE FOR MAGEBA & STÄUBLI UNIVAL COMBINATION

DIY 3D Weaving

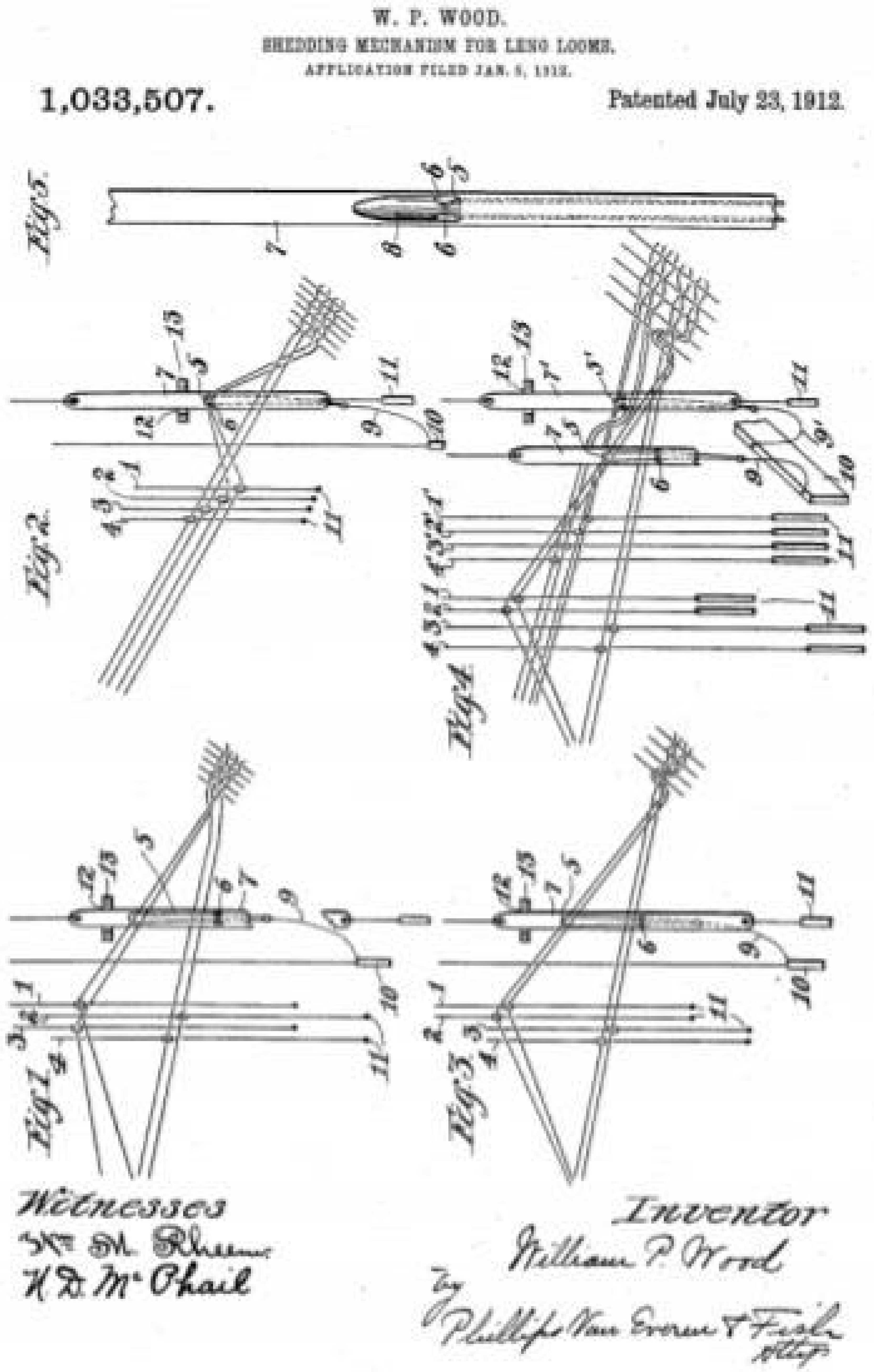


Some weaving materials from

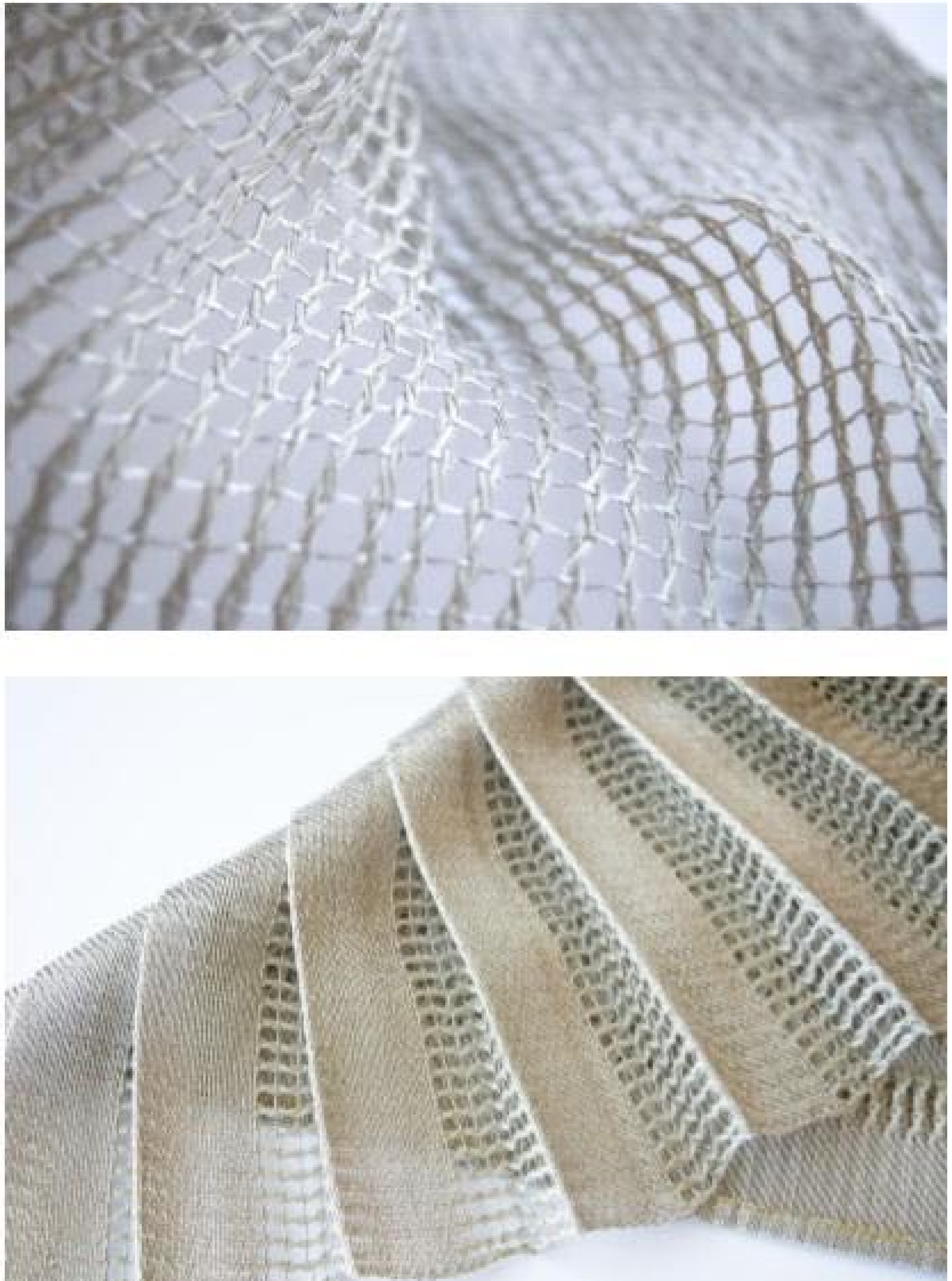
Brooks Hagan

(RISD: Rhode Island School of Design)

https://www.risd.edu/people/brooks-hagan/

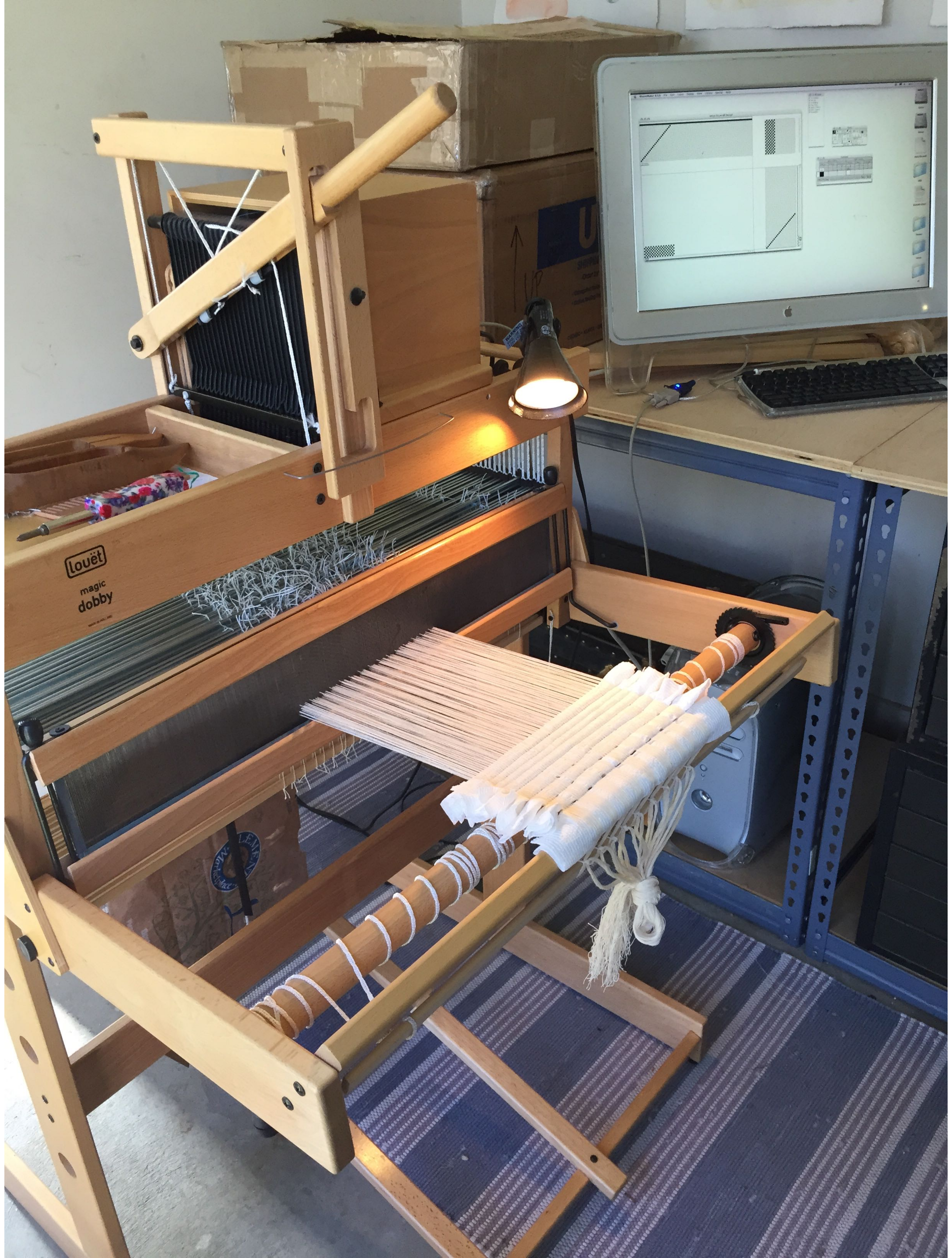

W. P. WOOD.
SHEDDING MECHANISM FOR LENO LOOMS.
APPLICATION FILED JAN. 5, 1912.
1,033,507.
Patented July 23, 1912.
Witnesses
Inventor
William P. Wood

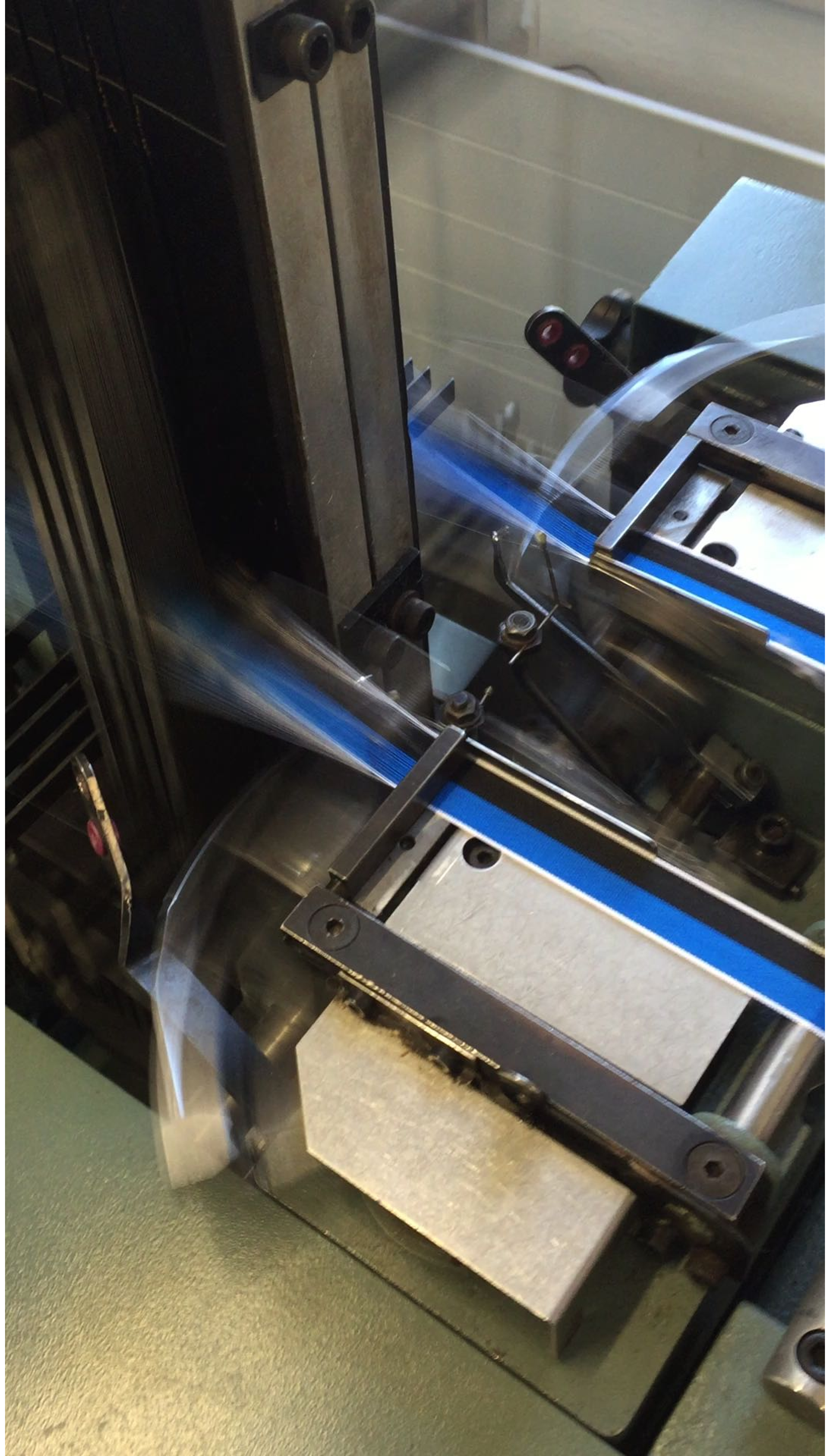
a.



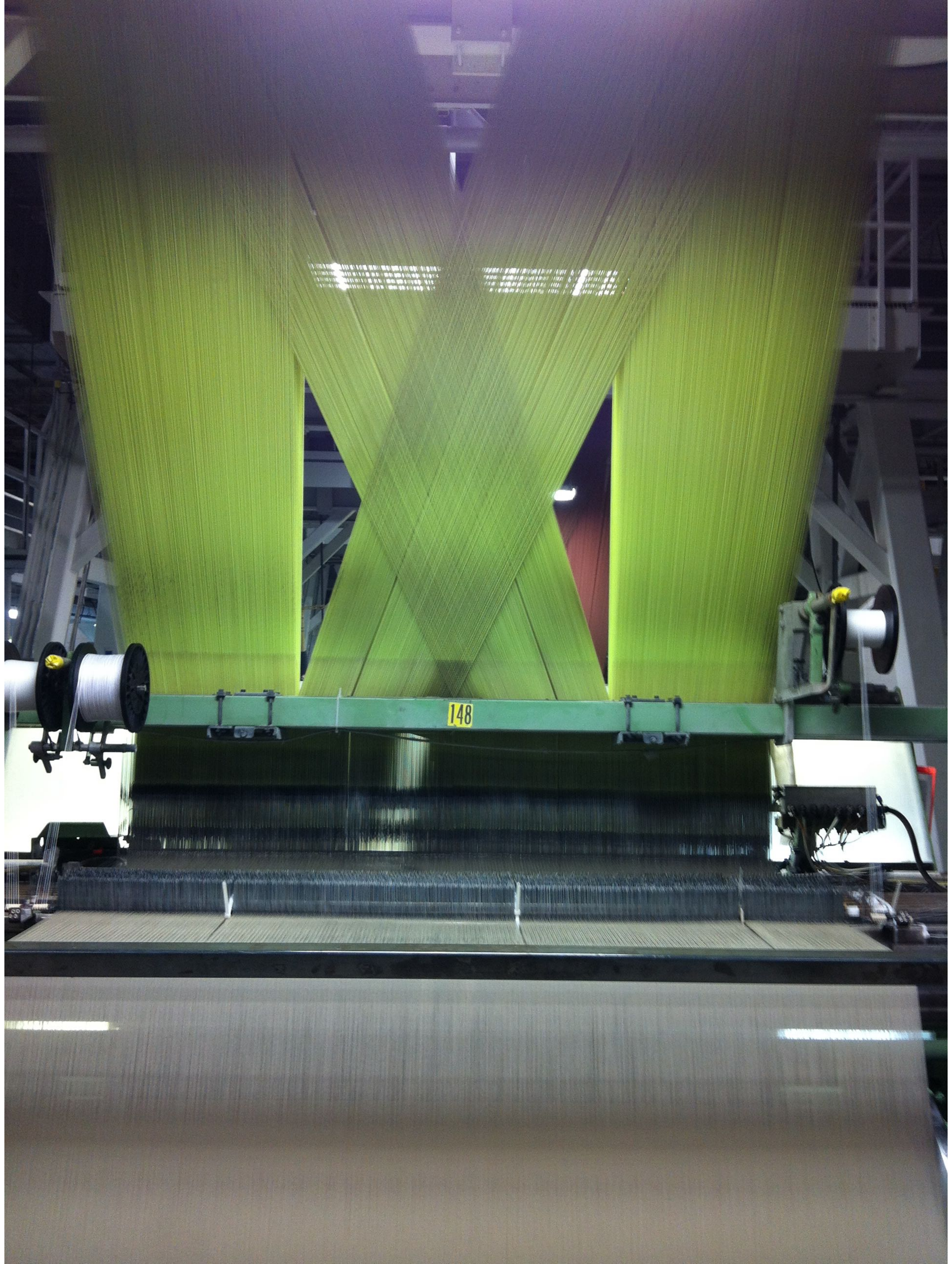
b.

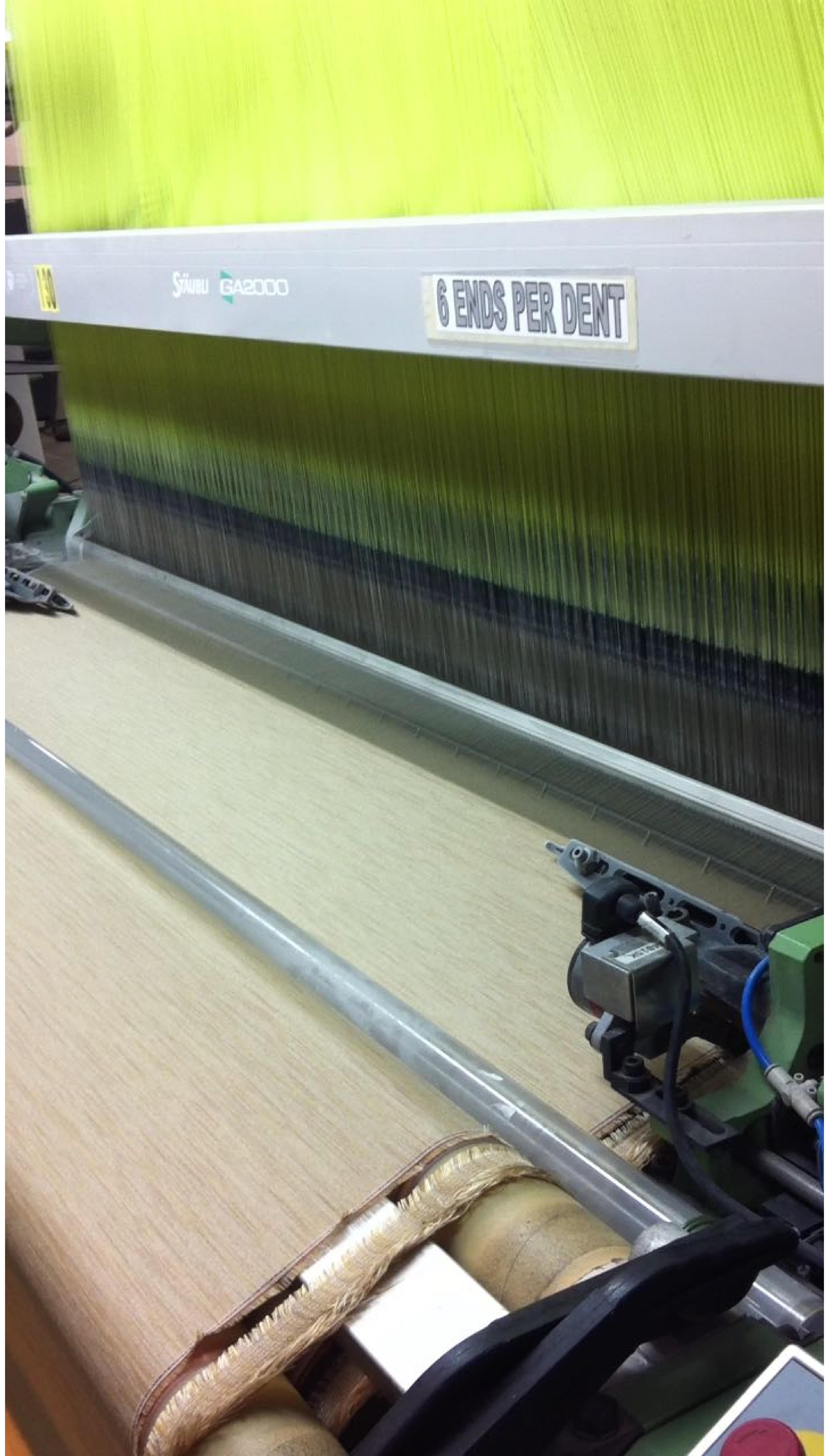

UP
5
4
3
2
1


louët
magic
dobby

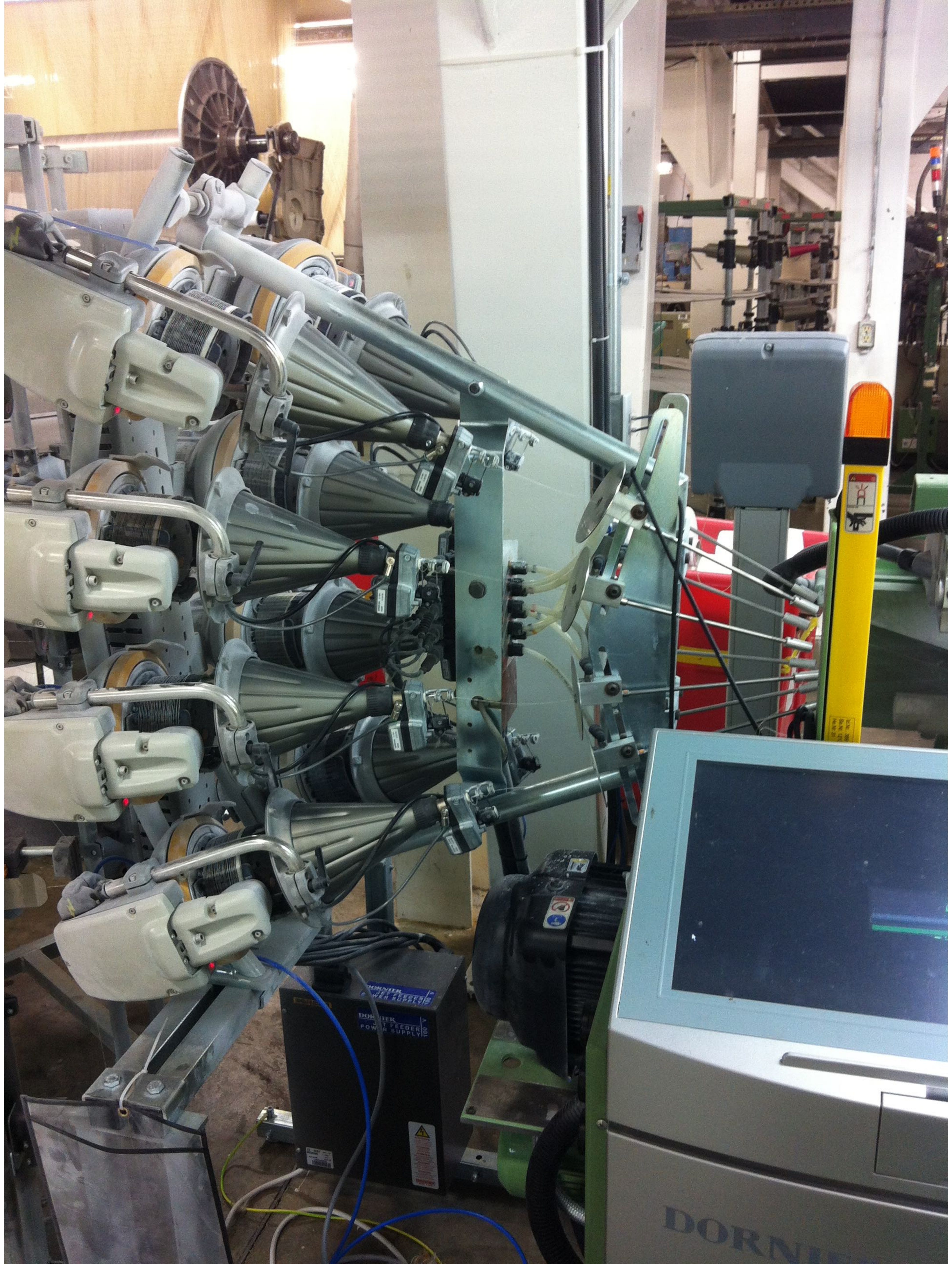



ÄUBLI®
5 ENDS PER DENT
45


148



6 ENDS PER DENT
GA2000




DORNIER
DORNIER
A1


142
142
142
DORNIER


PER DENT
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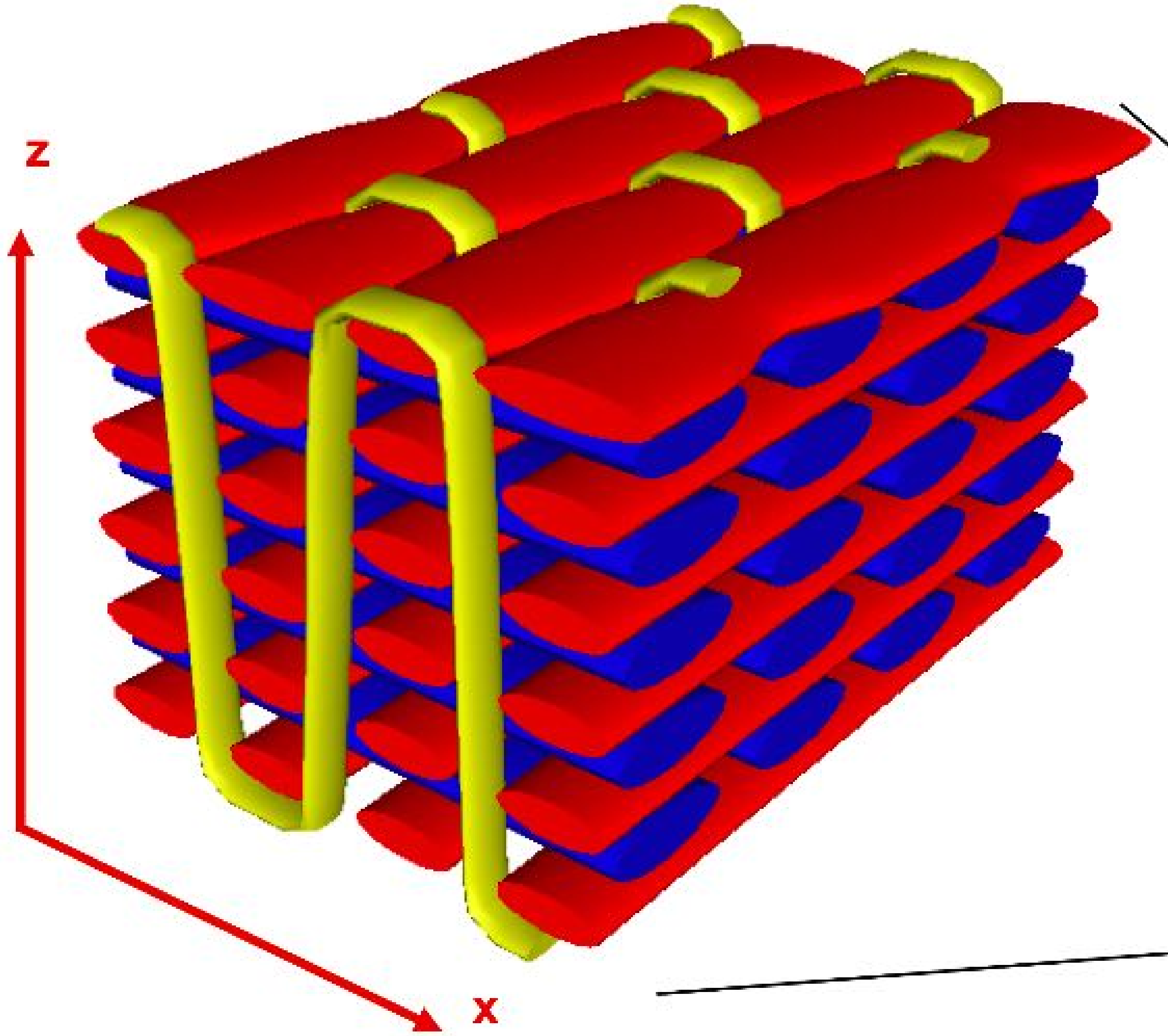
202

team

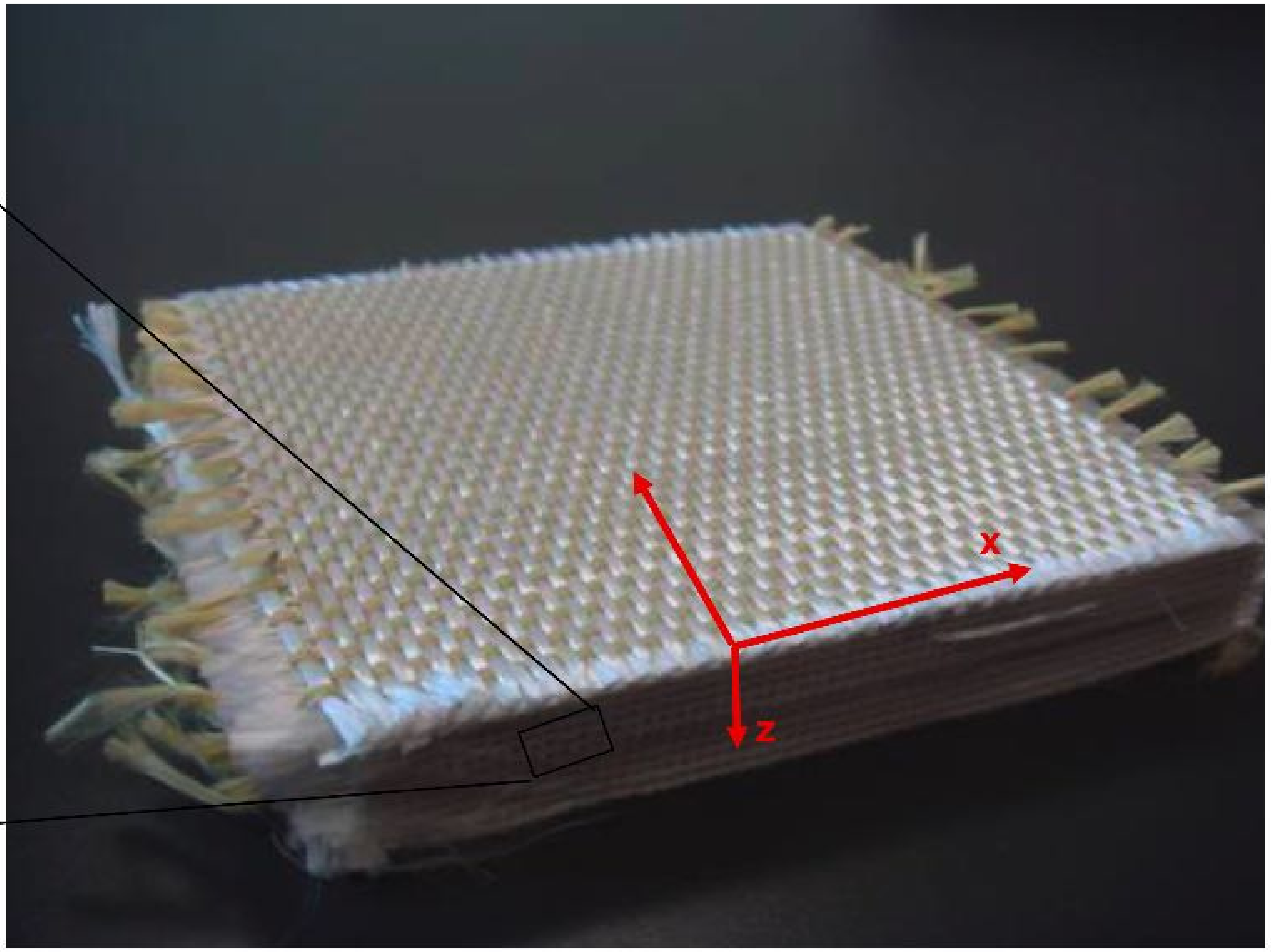
textile engineering & manufacturing

Generic Orthogonal Weave Architecture

Unit Cell

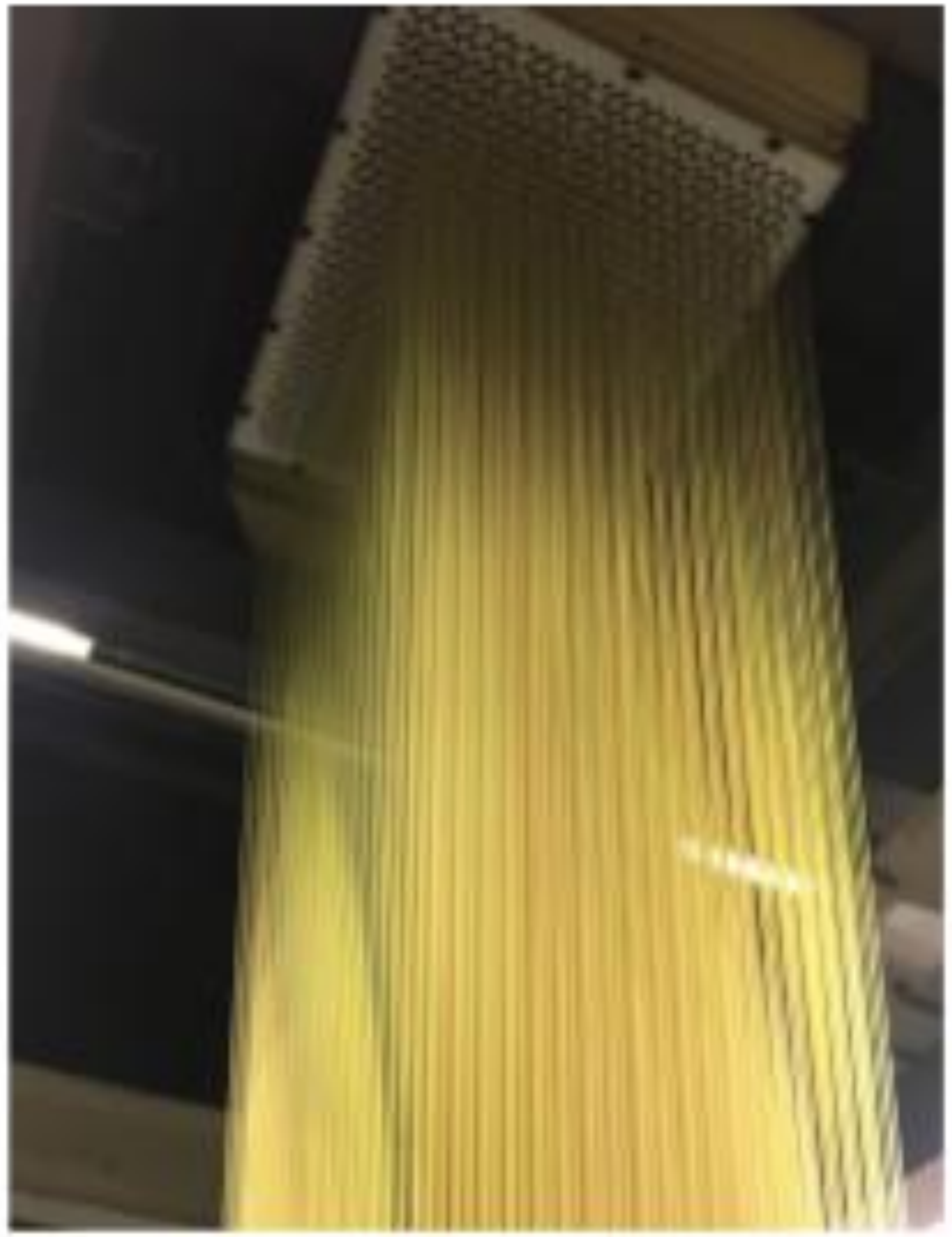


Generic Orthogonal Architecture



1” Thick

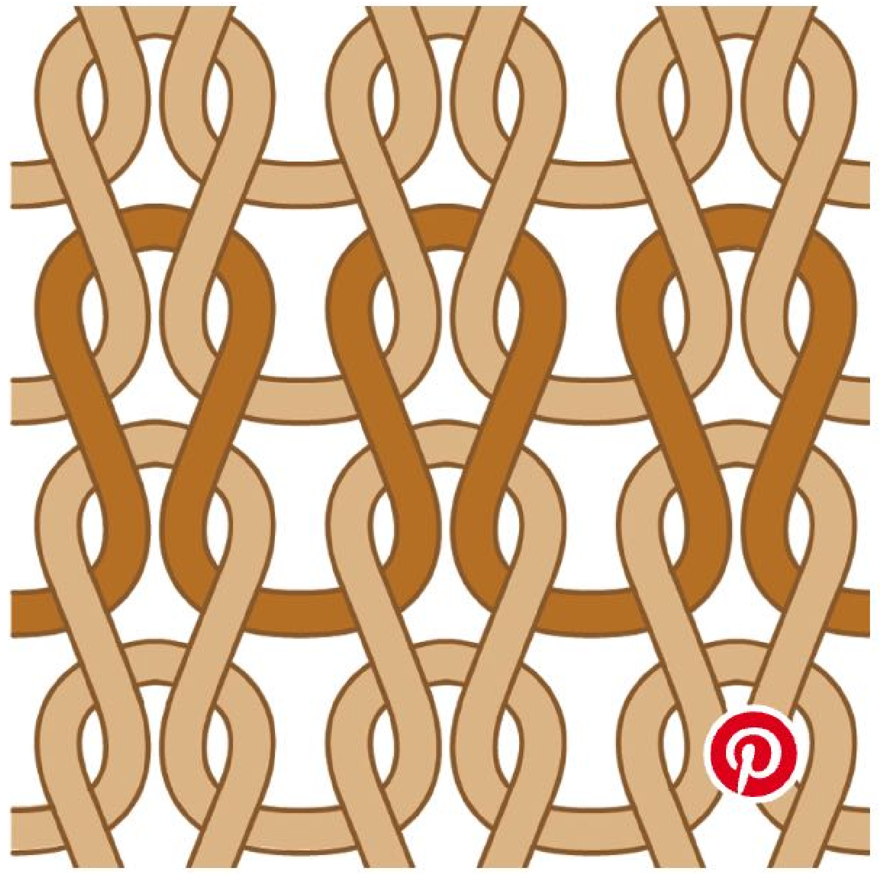

17

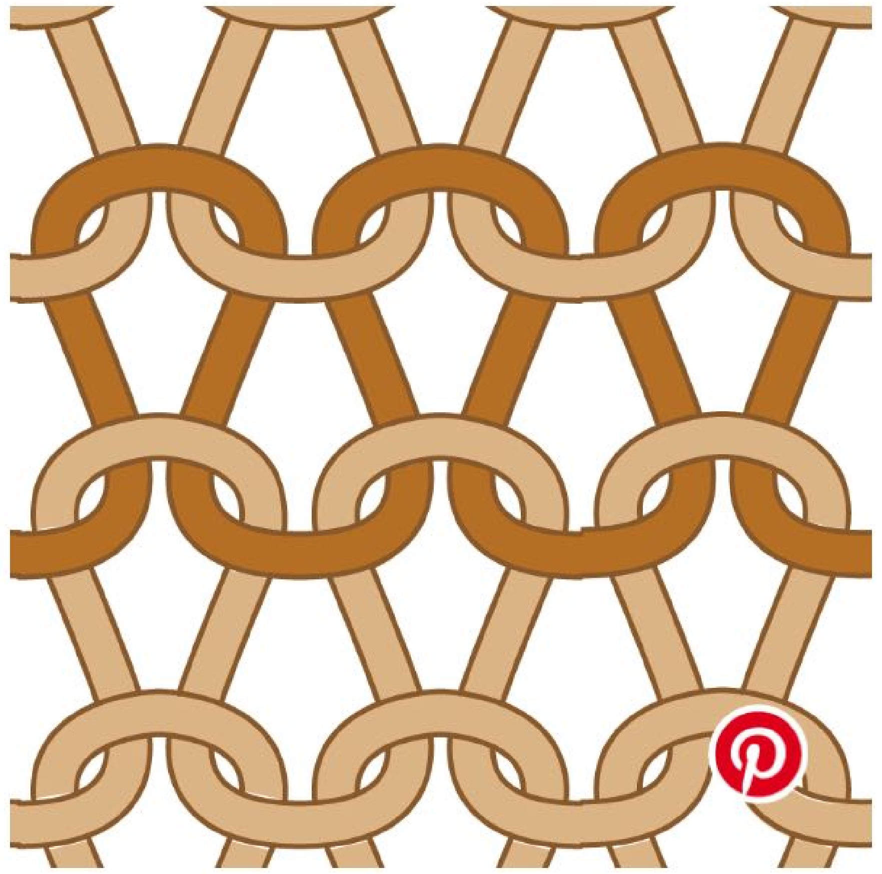

Weaving Objects:
Spatial Design and Functionality of 3D Woven Textiles
A1
A2
A3
A4
A5
A6

Knitting

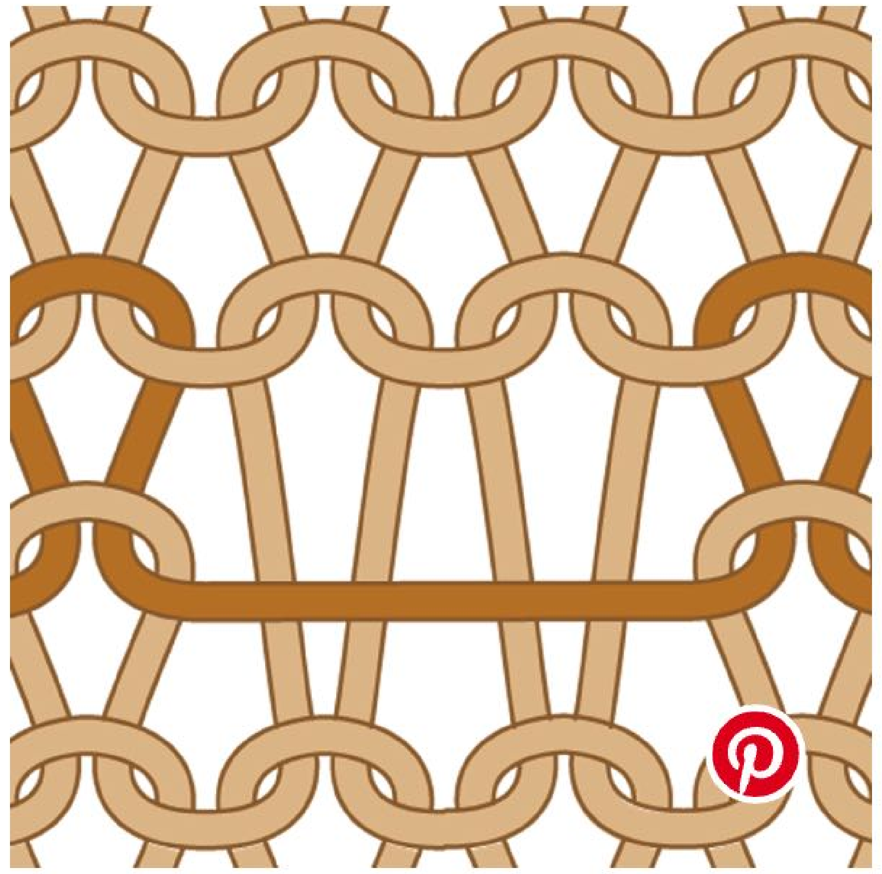
Four basic stitches



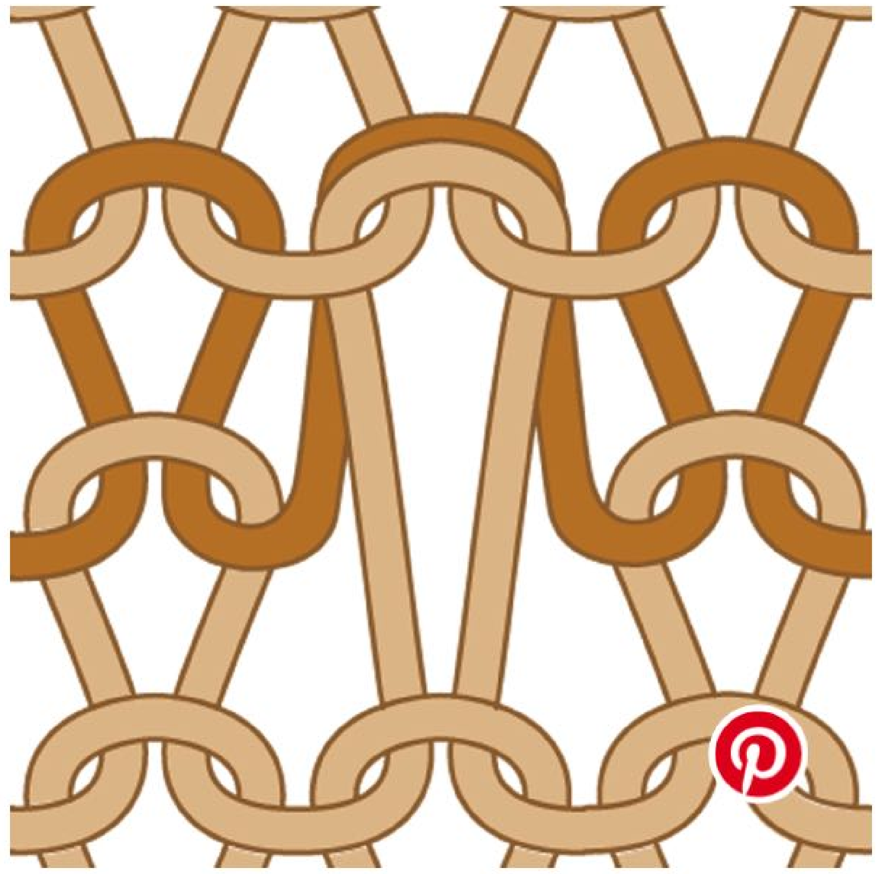
Knit stitch



Purl stitch



Missed-stitch



Tuck stitch

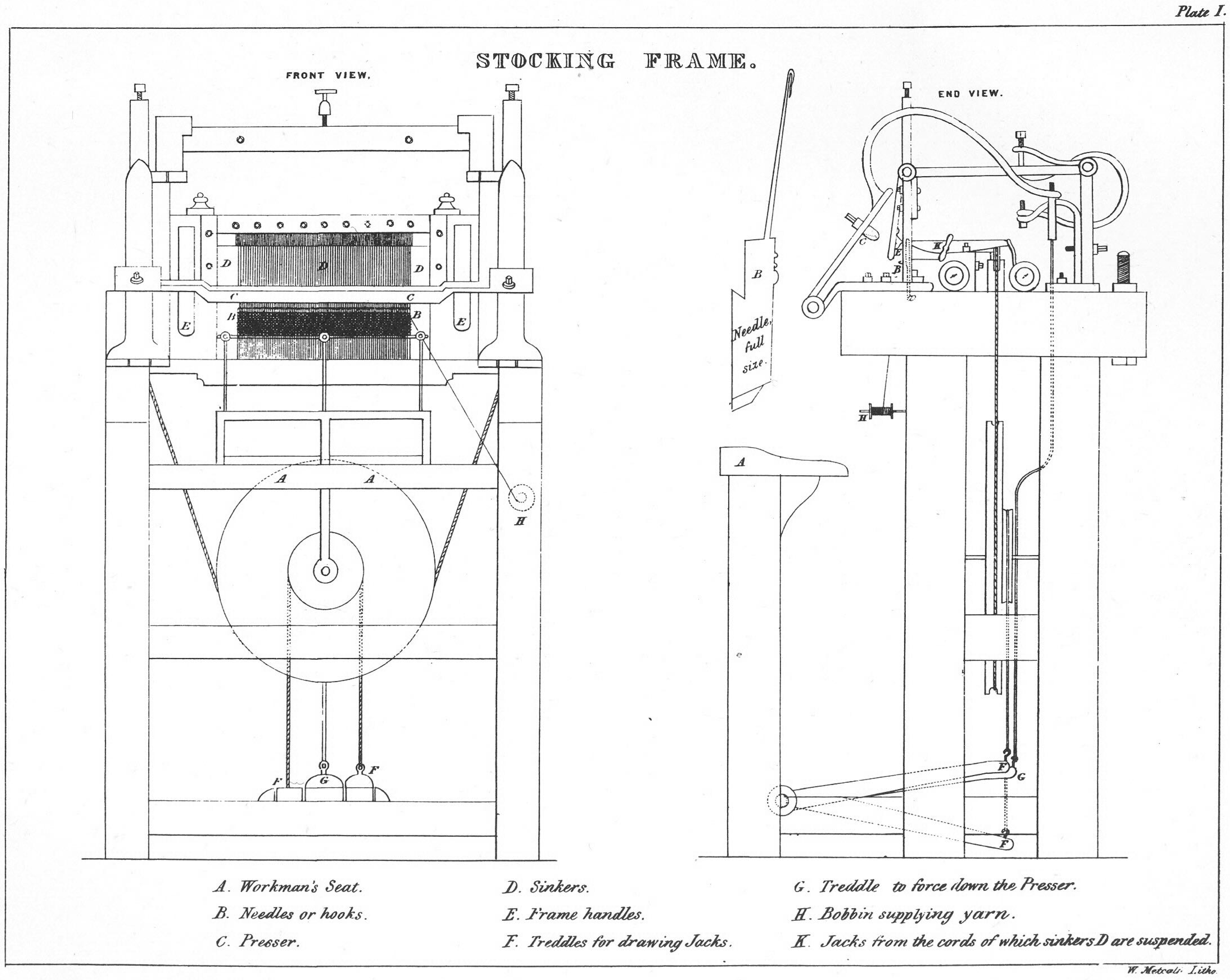
https://www.threadsmagazine.com/2008/11/19/know-your-knits

Stocking Frame

https://en.wikipedia.org/wiki/Stocking_frame

- Mechanical "straight knitting" machine that imitated hand knitting
- Invented in 1589 by William Lee of Calverton near Nottingham
- "**framework knitting**, was the first major stage in the mechanisation of the textile industry, and played an important part in the early history of the Industrial Revolution"
- 1789, Samuel Wise, a clockmaker patents rotary motion version for powered strocking frame
    - First powered loom design in 1784 by Edmund Cartwright (built in 1785)
- By 1812, there were estimated to be over 25,000 frames in use, most of them in the three counties, and the frame had come back to Calverton.
- For reference:
    - By 1850 there were 260,000 power looms in England

Stocking frame at Ruddington Framework Knitters' Museum

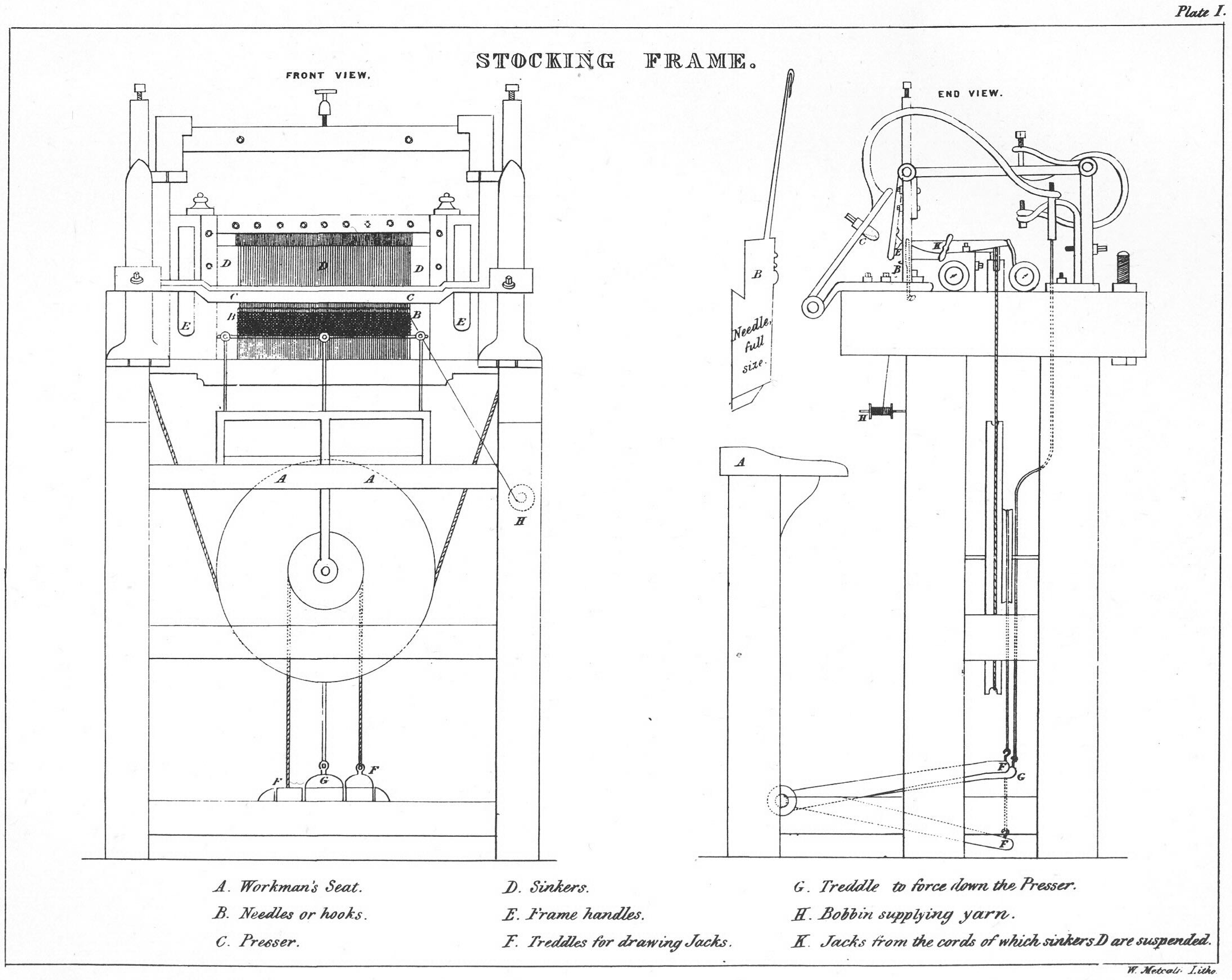


Interesting History

The machine imitated the movements of hand knitters. Lee demonstrated the operation of the device to Queen Elizabeth I, hoping to obtain a patent, but she refused, fearing the effects on hand-knitting industries. The original frame had eight needles to the inch, which produced only coarse fabric. Lee later improved the mechanism with 20 needles to the inch. By 1598 he was able to knit stockings from silk, as well as wool, but was again refused a patent by James I. Lee moved to France, under the patronage of Henri IV, with his workers and his machines, but was unable to sustain his business. He died in Paris around 1614. Most of his workers returned to England with their frames, which were sold in London.[3]

The commercial failure of Lee's design might have led to a dead-end for the knitting machine, but John Ashton, one of Lee's assistants, made a crucial improvement by adding the mechanism known as a "divider".[3] This is used after the jack sinkers have pulled down a large loop over all the needles, and the sinker bar has separated out the loop, the dividers are rested on the loop to give the bearded needles guidance as they are pulled forward.

https://en.wikipedia.org/wiki/Stocking_frame

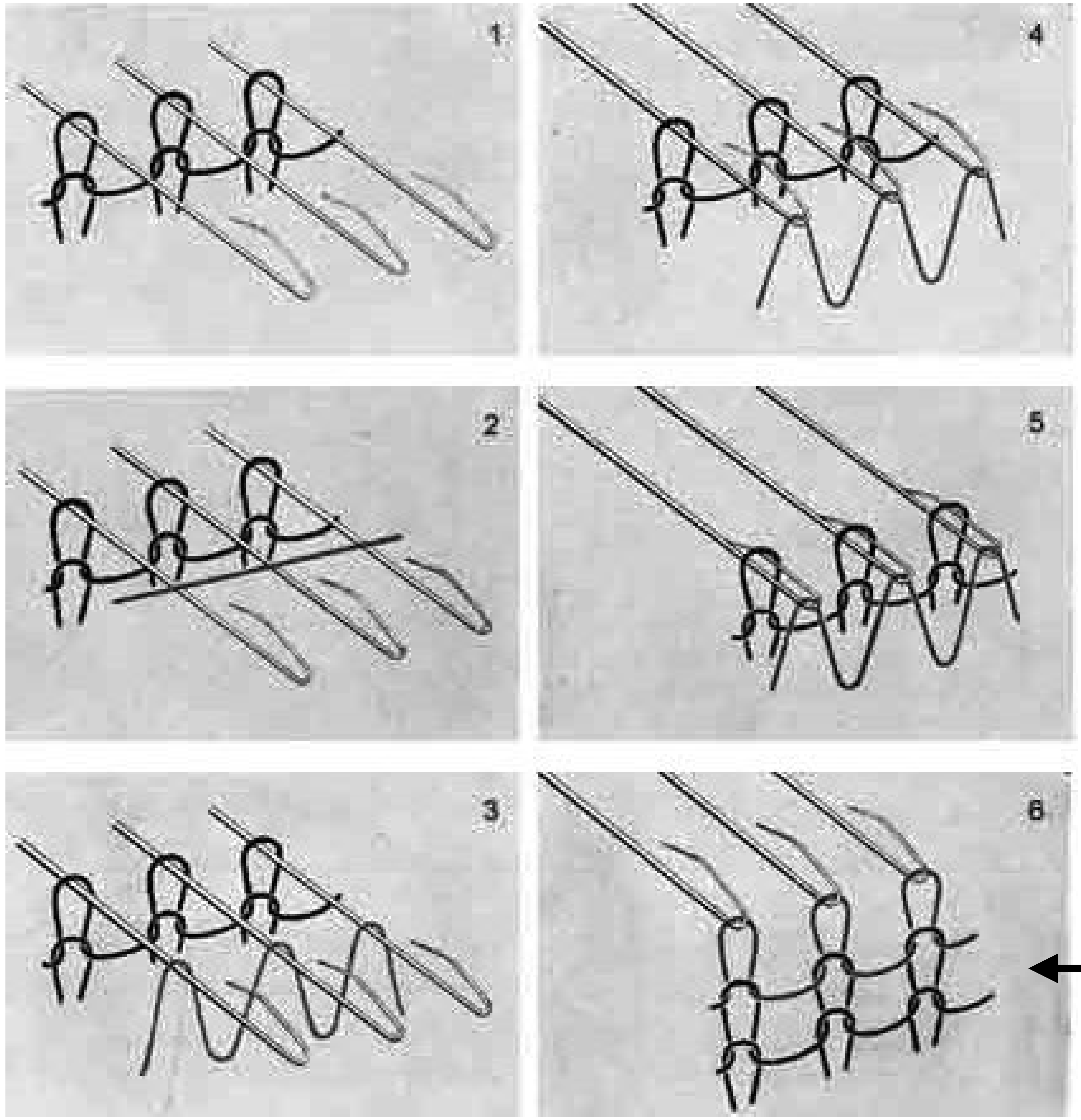


Interesting History (moar!)

- Luddism
- Protection of Stocking Frames, etc. Act 1788
- Destruction of Stocking Frames, etc. Act 1812
- Worshipful Company of Framework Knitters

https://en.wikipedia.org/wiki/Stocking_frame

Knitting machine process: Single-bed, 6-stage cycle



https://en.wikipedia.org/wiki/Stocking_frame

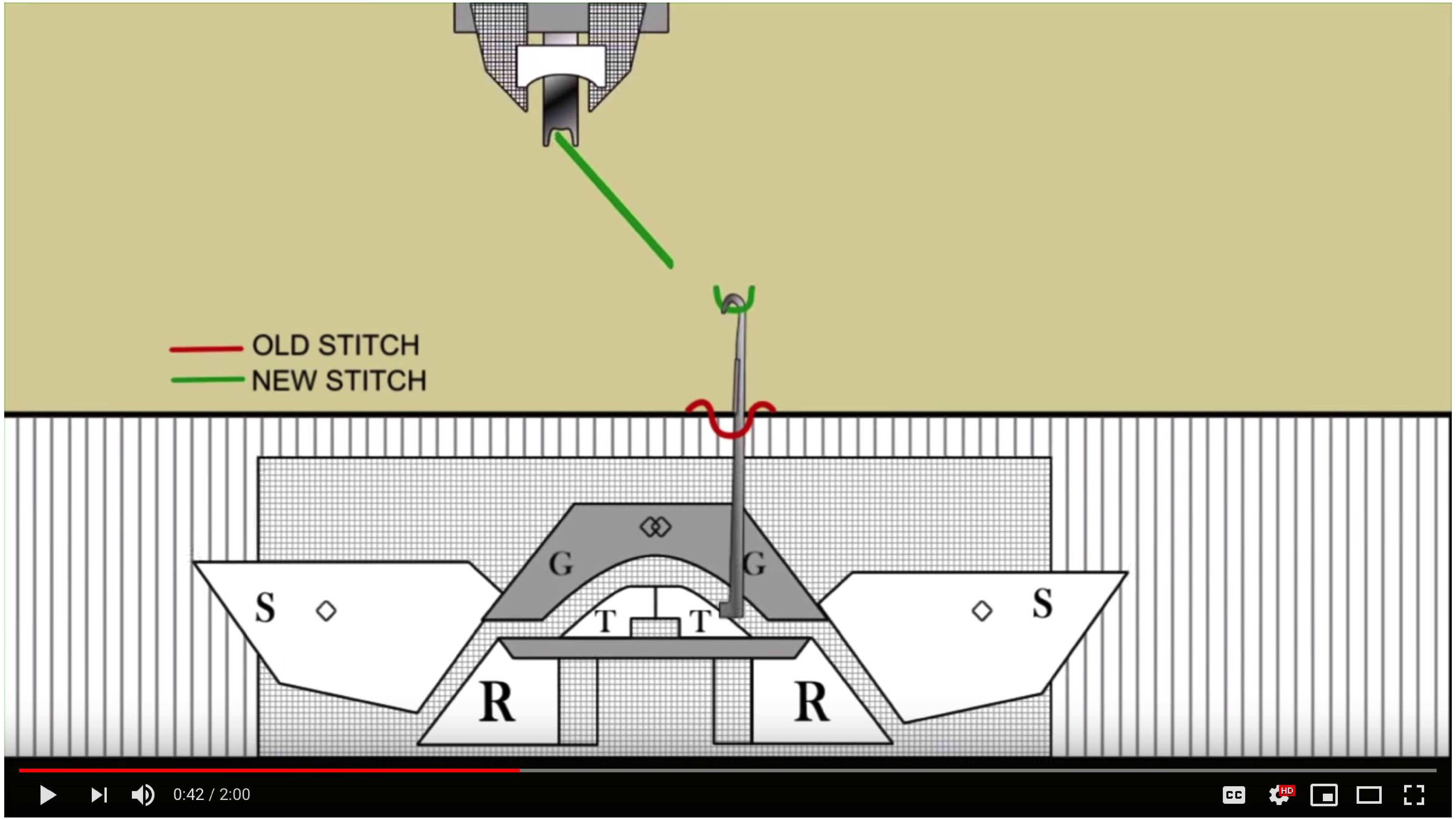
The mechanical movements:[2]

1. The needle bar goes forward; the open needles clear the web.
2. The weft thread is laid on the needles; the jack sinkers descend and form loops.
3. The weft thread is pushed down by the divider bar.
4. The jack sinkers come forward pulling the thread into the beard of the open needles.
5. The presser bar drops, the needle loops close and the old row of stitches is drawn off the needle.
6. The jack sinkers come down in front of the knitting and pull it up so the process can begin again.

Stockinette pattern (only "knit" operations)

Knitting machine process:

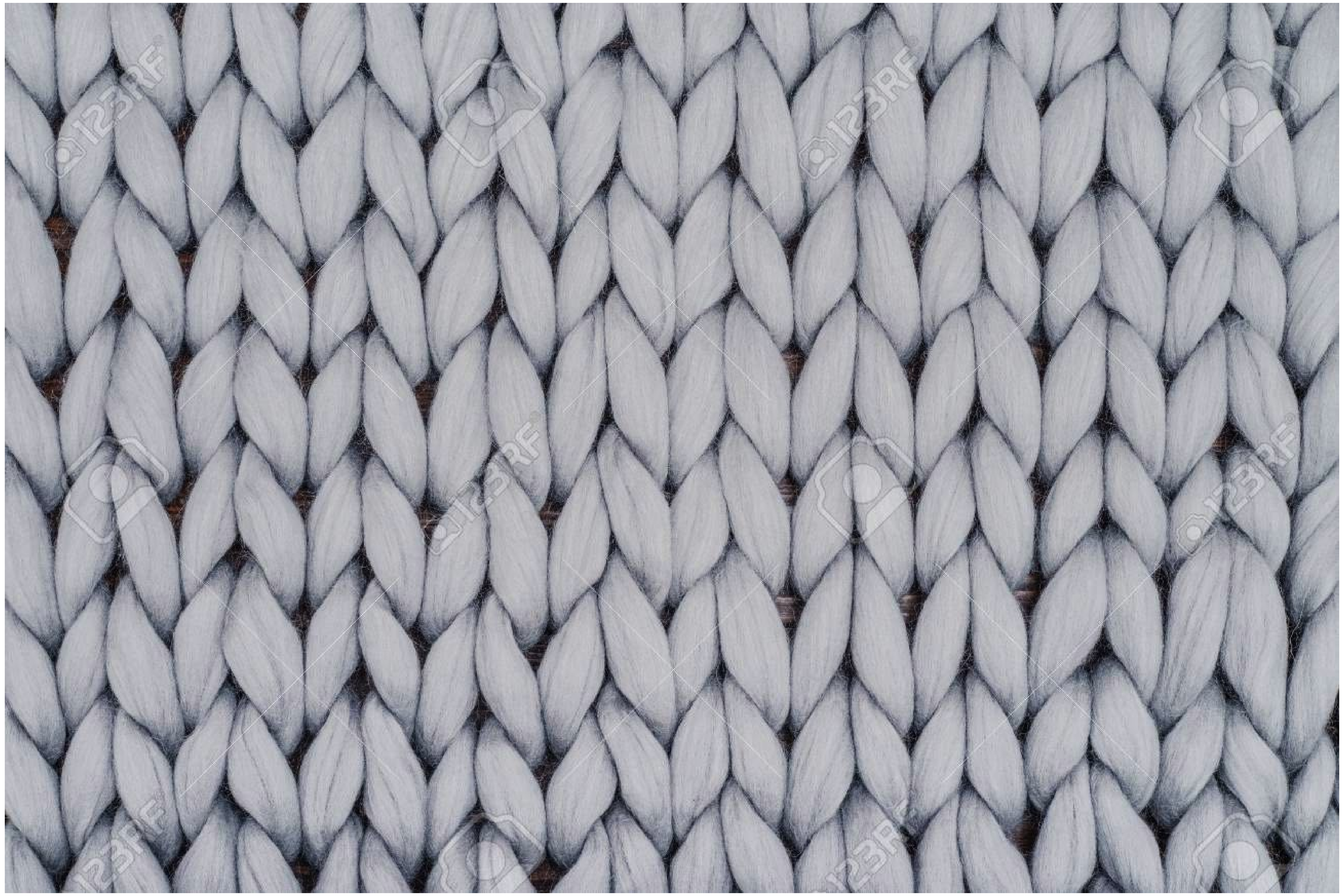
Carriage cams set to "all needles knitting"



Knitting Machines: All Needles Knitting

https://www.youtube.com/watch?v=NGLsnhnR7UU

Student-Parallel Simulation of a Knitting Machine



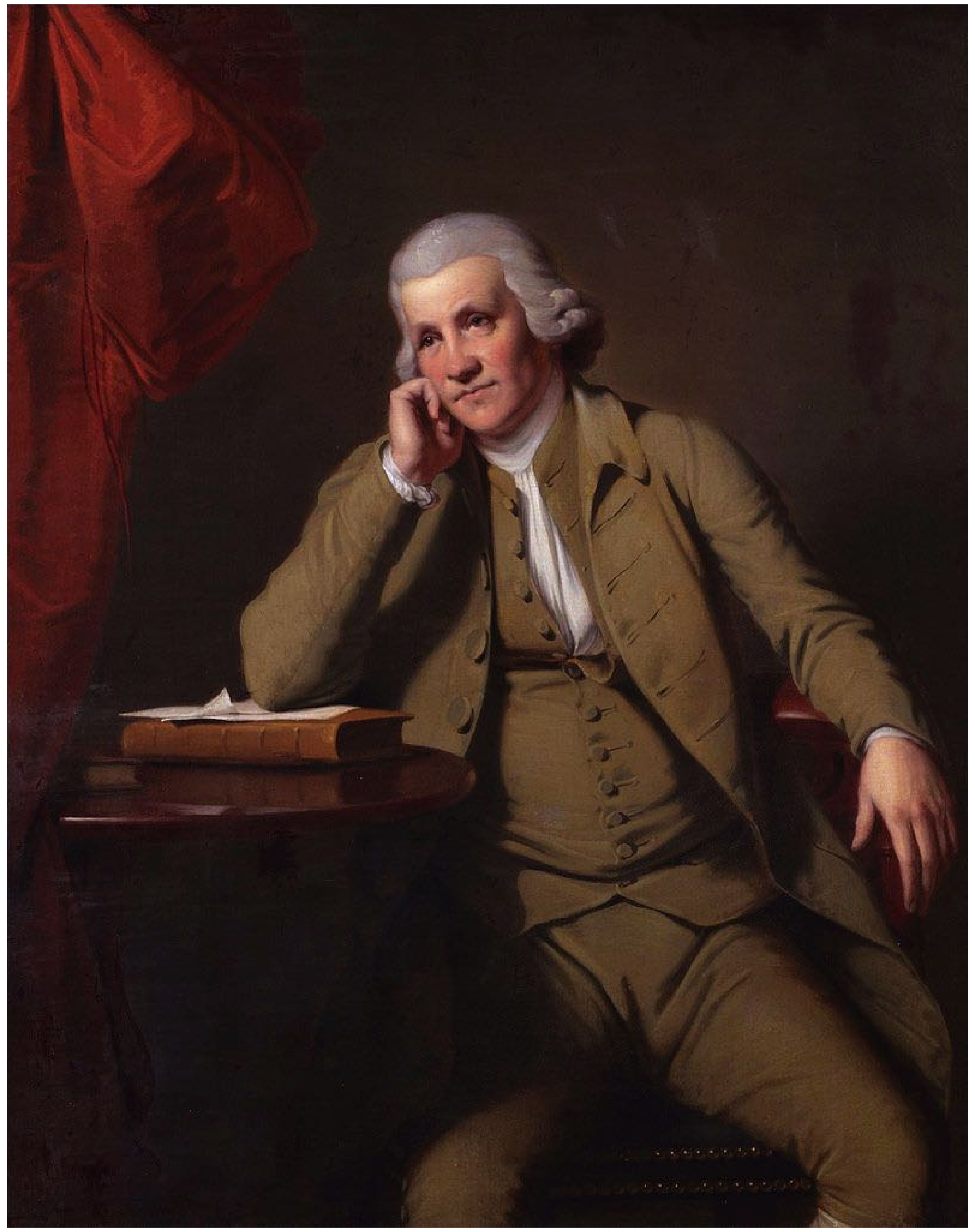
Basic knitted cloth patterns

[Kaldor et al., SIGGRAPH 2008]

The Derby Rib

https://en.wikipedia.org/wiki/Jedediah_Strutt#The_Derby_Rib

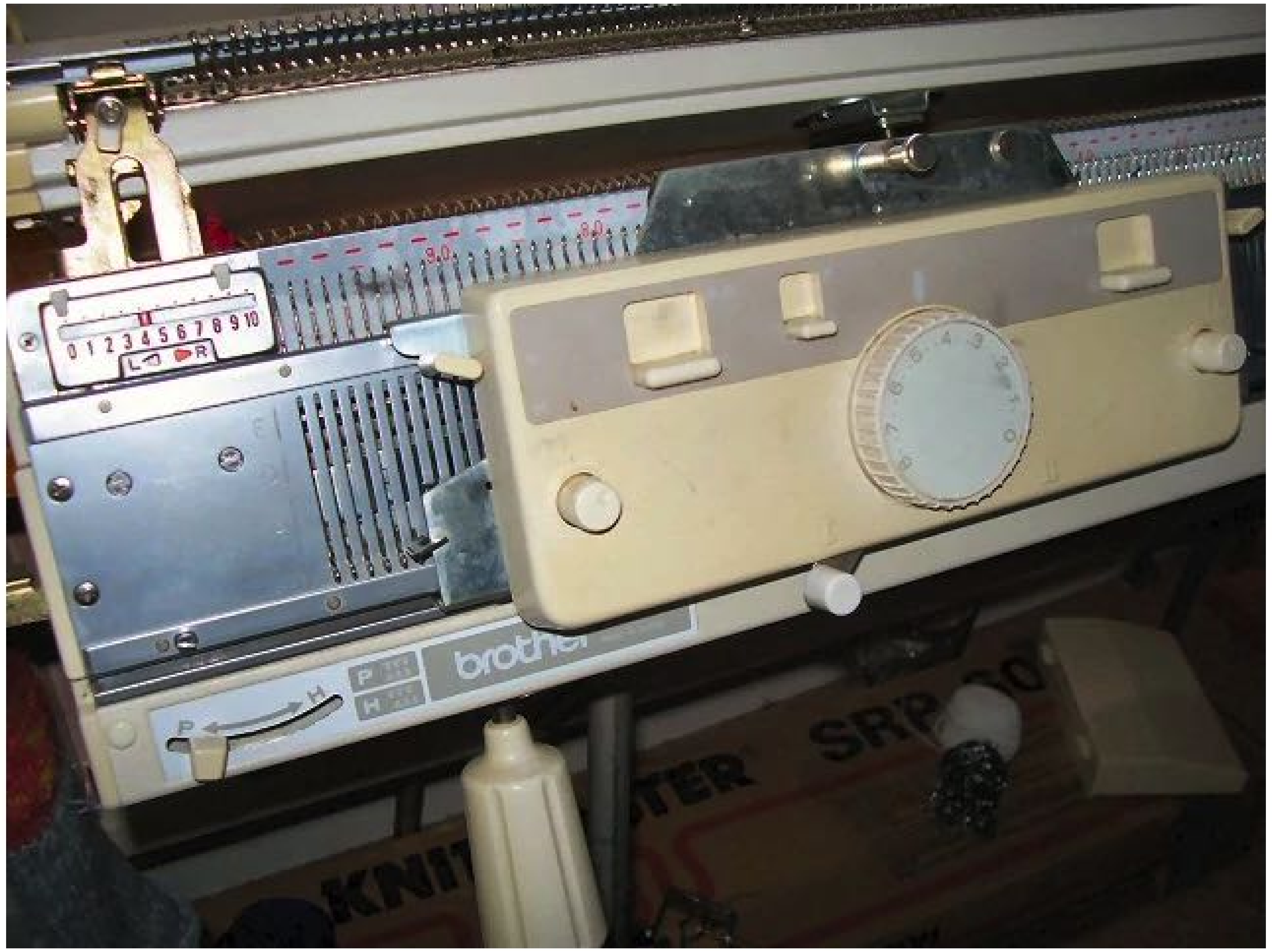
- "Strutt and his brother-in-law William Woollat developed an attachment to the stocking frame that allowed the production of ribbed stockings. Their machine became known as the Derby Rib machine, and the stockings it produced quickly became popular."
- "Strutt's brother-in-law, William Woolatt, employed one Mr. Roper of Locko who had produced an idea for an attachment to the stocking frame to knit ribbed stockings. He had made one or two specimens which he showed to his friends, though he lacked the interest (and the capital) to develop his idea. Woolatt conferred with Strutt, who sold a horse and paid Roper £5 for his invention. Strutt and Woolatt turned the device into a viable machine and took out a patent in 1759."
- "Their machine became known as the Derby Rib machine, and the stockings it produced quickly became popular. Cotton was cheaper than silk and more comfortable than wool but demand was far exceeding supply."



Jedediah Strutt

Ribber

Brother KR850



This is the standard gauge ribber. It goes with most 800 and 900 series knitting machines. It can do slip and tuck, and using the lili buttons (small round white knobs, one either side) it can do a bird's eye backing on double bed jacquard.

The swing lever at the bottom can be used to tighten the tension.

https://machineknitting.fandom.com/wiki/Brother_KR850

1x1 Ribbing

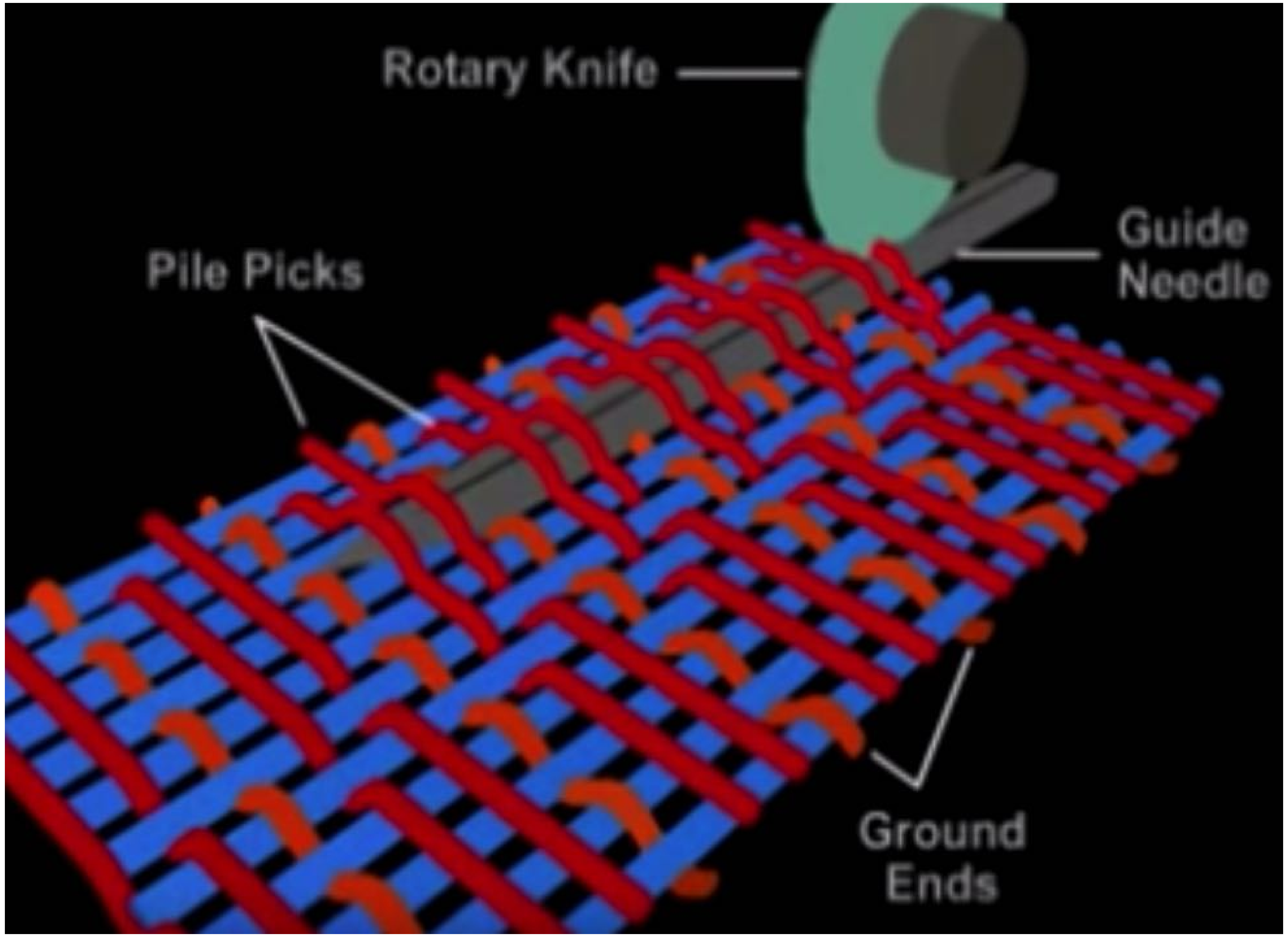
https://en.wikipedia.org/wiki/Ribbing_(knitting)

Ribber, V-bed

https://www.youtube.com/watch?v=wdzHSw0BDyk

https://www.youtube.com/watch?v=HWFU6tHPsCo

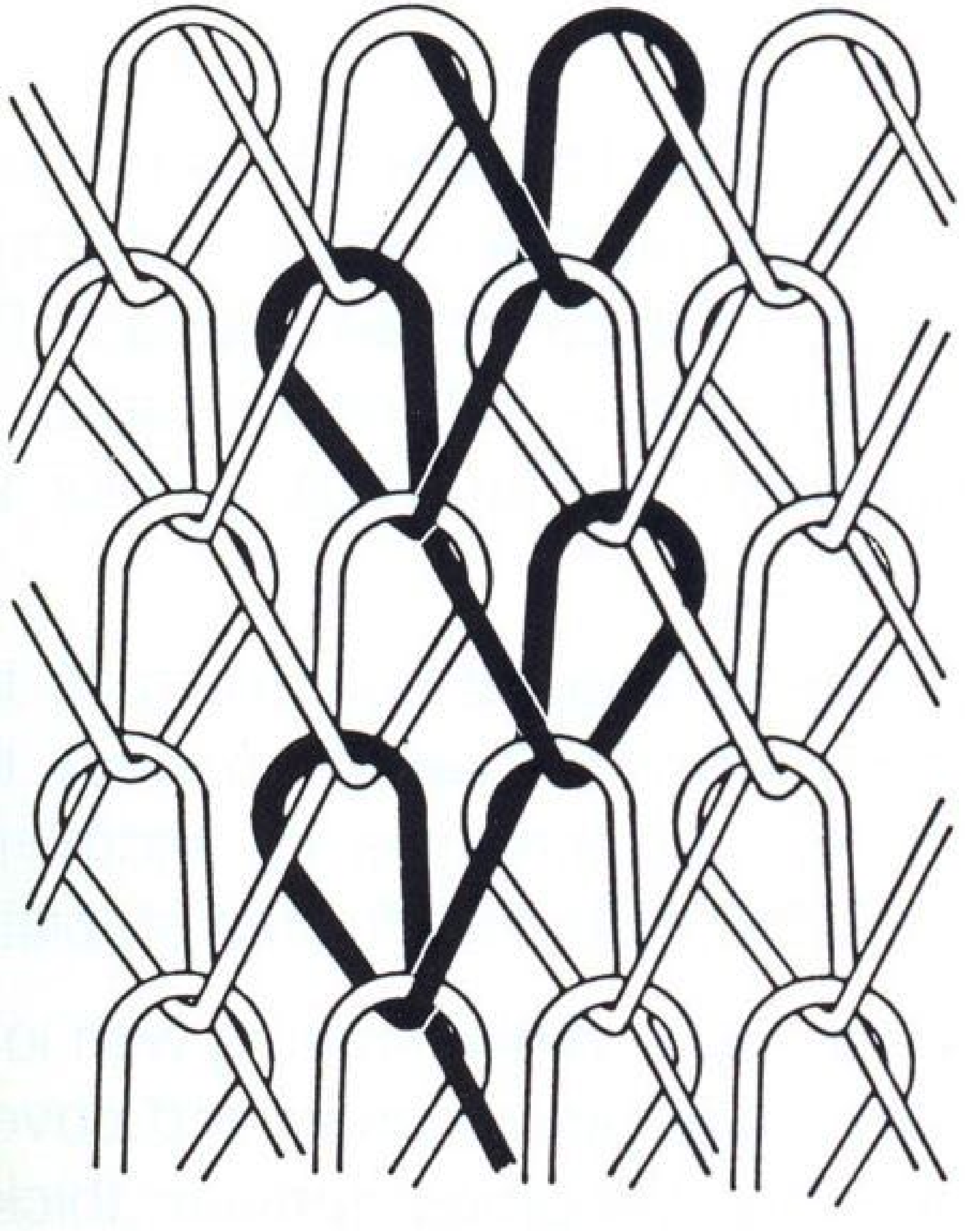
Crepe, Corduroy & Velvet



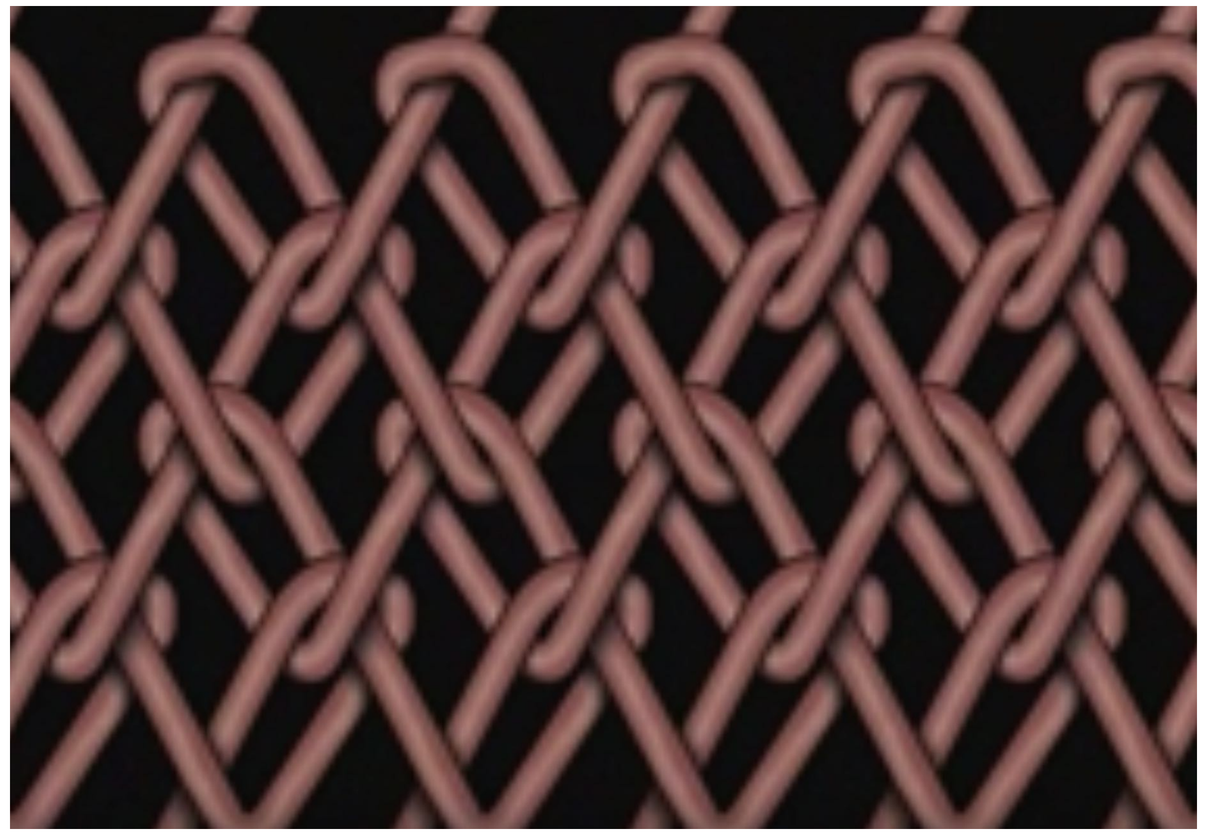
Warp knitting

https://en.wikipedia.org/wiki/Warp_knitting

- Warp knitting is a family of knitting methods in which the yarn zigzags along the length of the fabric; i.e., following adjacent columns, or wales, of knitting, rather than a single row, or course. For comparison, knitting across the width of the fabric is called weft knitting.
- Since warp knitting requires that the number of separate strands of yarn, or ends, equals the number of stitches in a row, **warp knitting is almost always done by machine rather than by hand**.
- Highly parallel knitting machine process
- Widely used for stretchy sportswear



Tricot



https://youtu.be/KSlkY5Z6hhM?t=60

Warp knitting examples

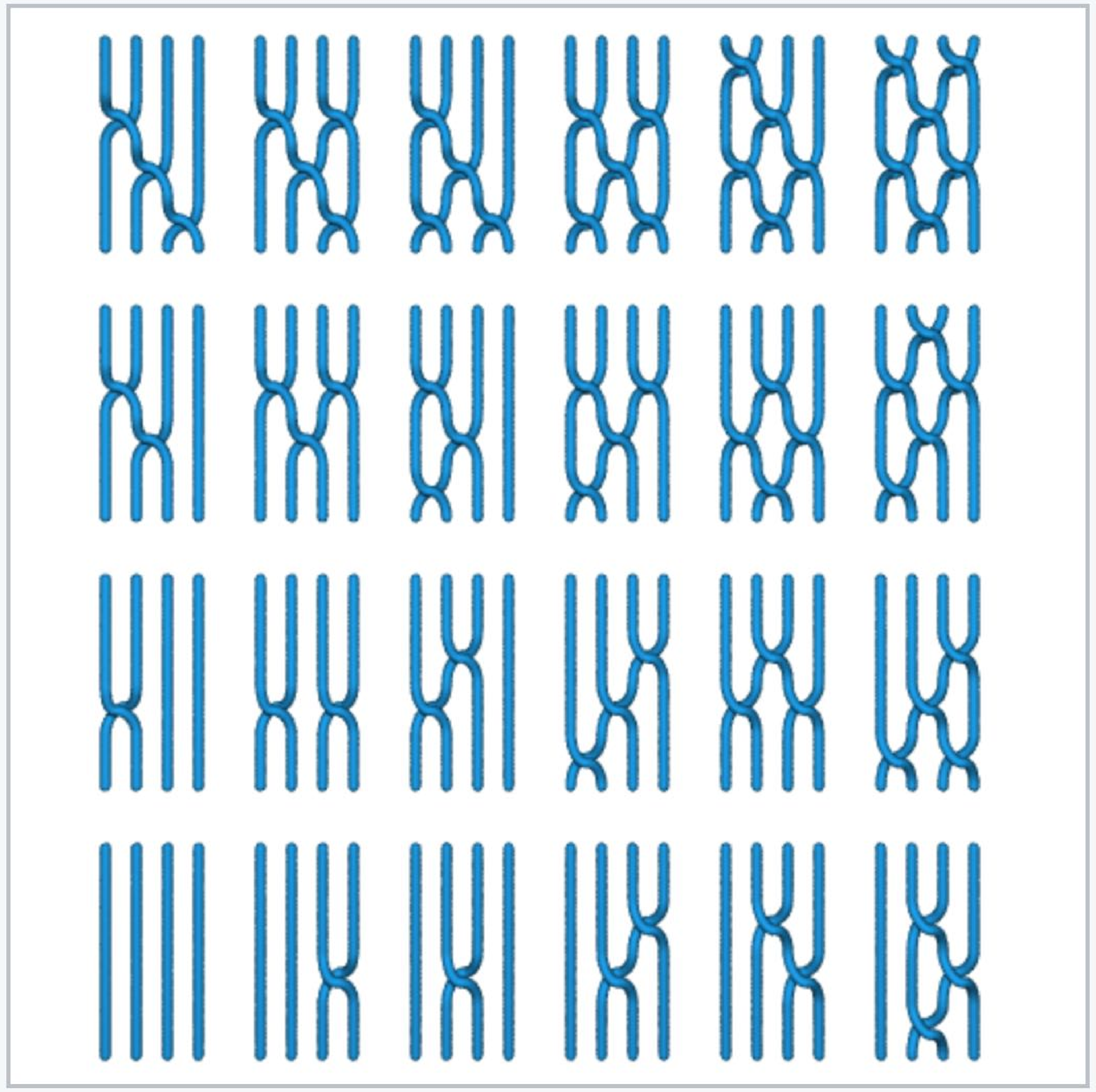
https://en.wikipedia.org/wiki/Warp_knitting

WKS, Warp Knit Seamless by Cifra
https://www.youtube.com/watch?v=ChVnB3M6tS0

Braiding Machines

Braids

https://en.wikipedia.org/wiki/Braid



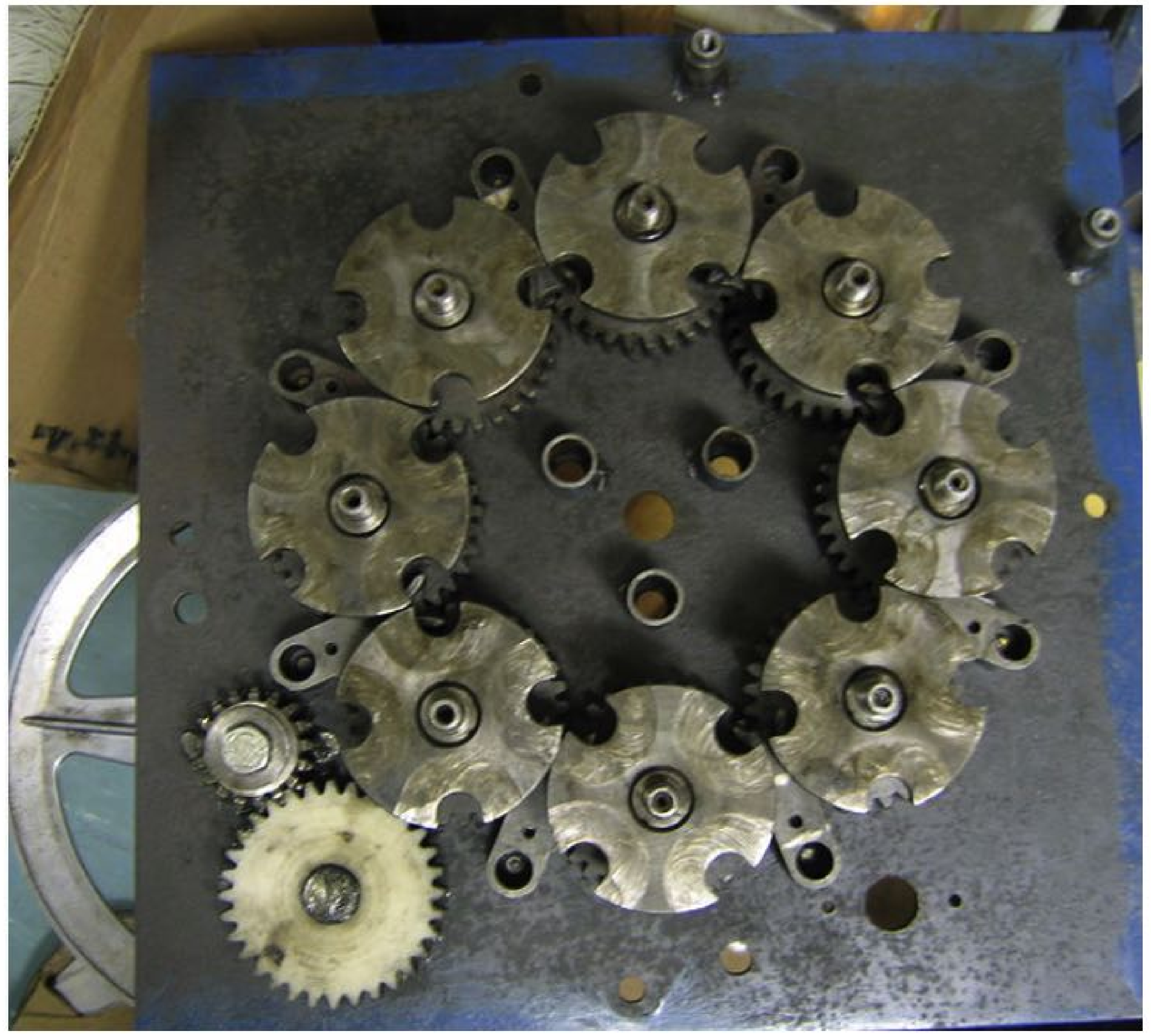
The 24 elements of a permutation group on 4 elements as braids. All crossings shown are of the left-over-right type, but other choices are possible. Changing the order of the operations can change the result, meaning that the operations are non-commutative.

https://en.wikipedia.org/wiki/Braid_group

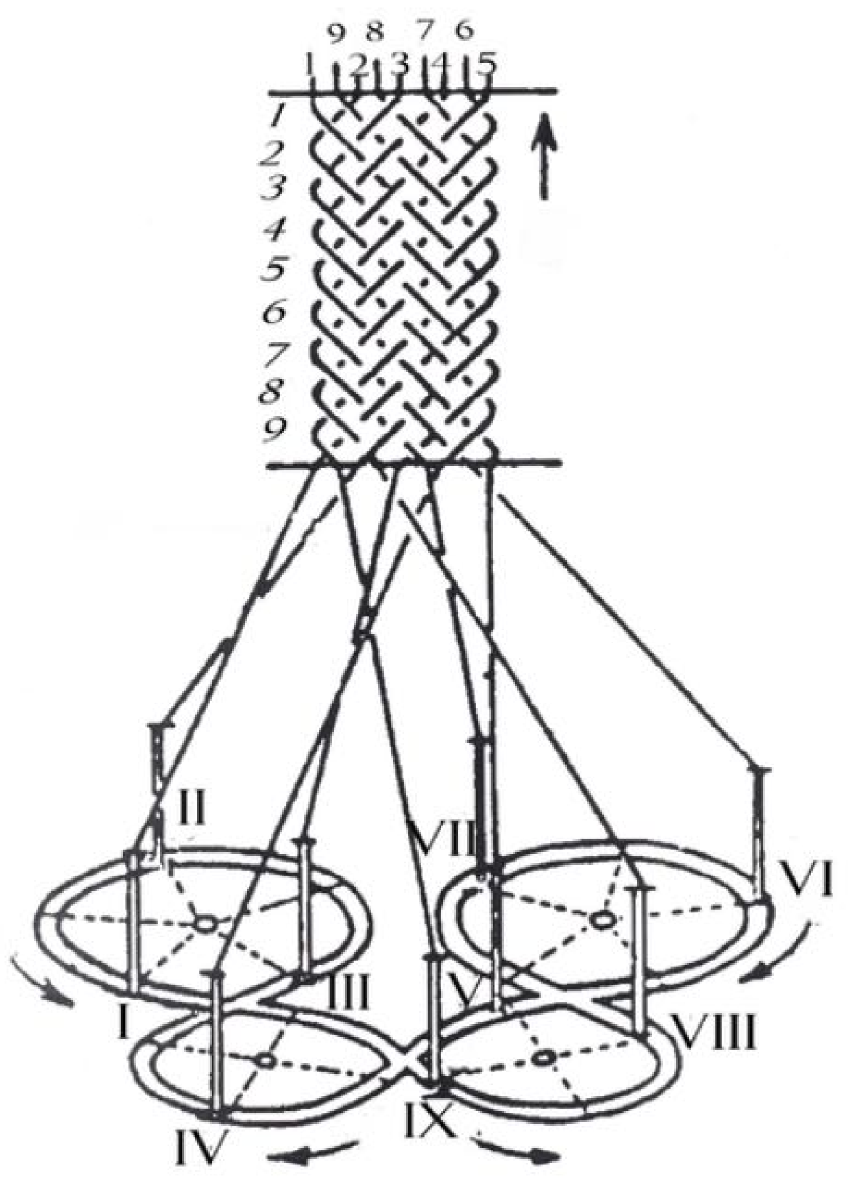
Braiding Machines

https://en.wikipedia.org/wiki/Braiding_machine

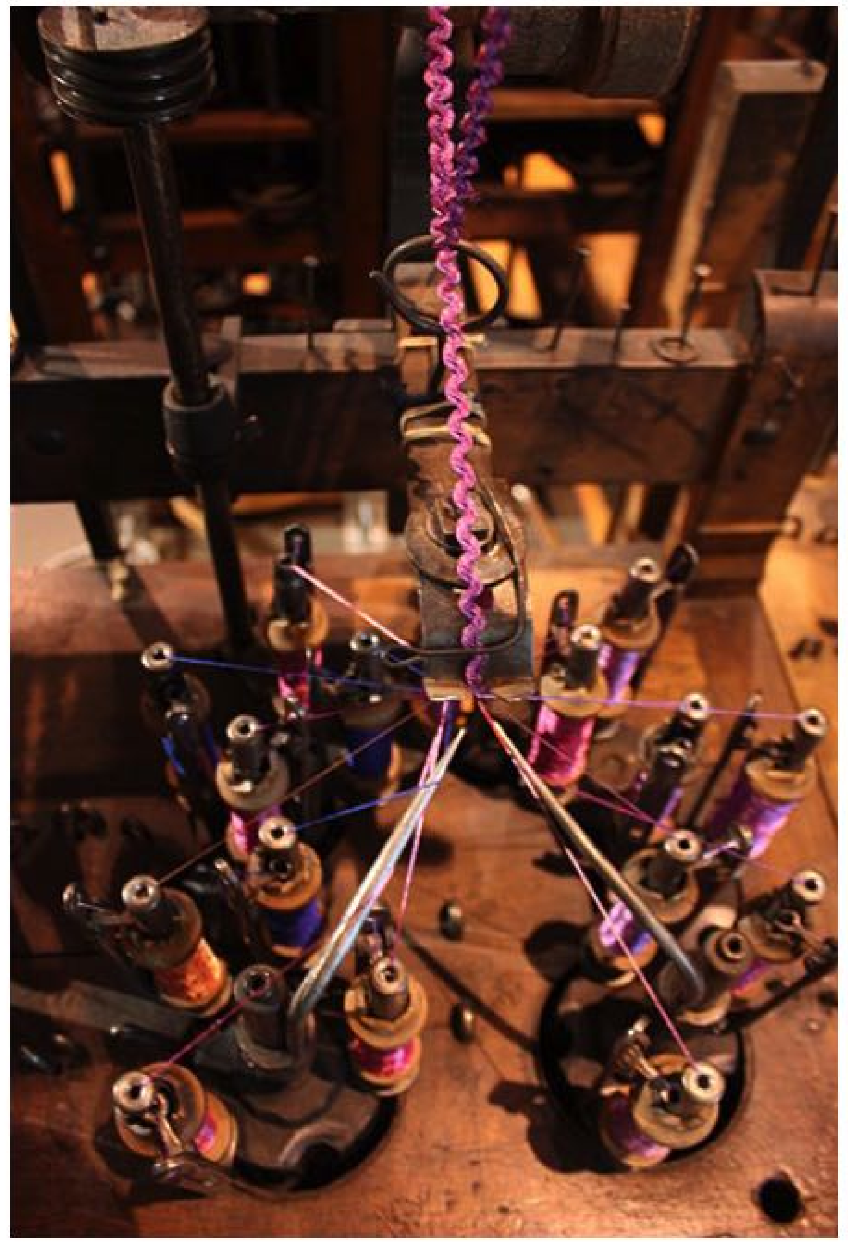
A horn gear braiding machine at the Arbetets Museum (Museum of Work) in Norrköping, Sweden



Horn gears mounted on a track plate



A horn gear machine used to produce a flat braid

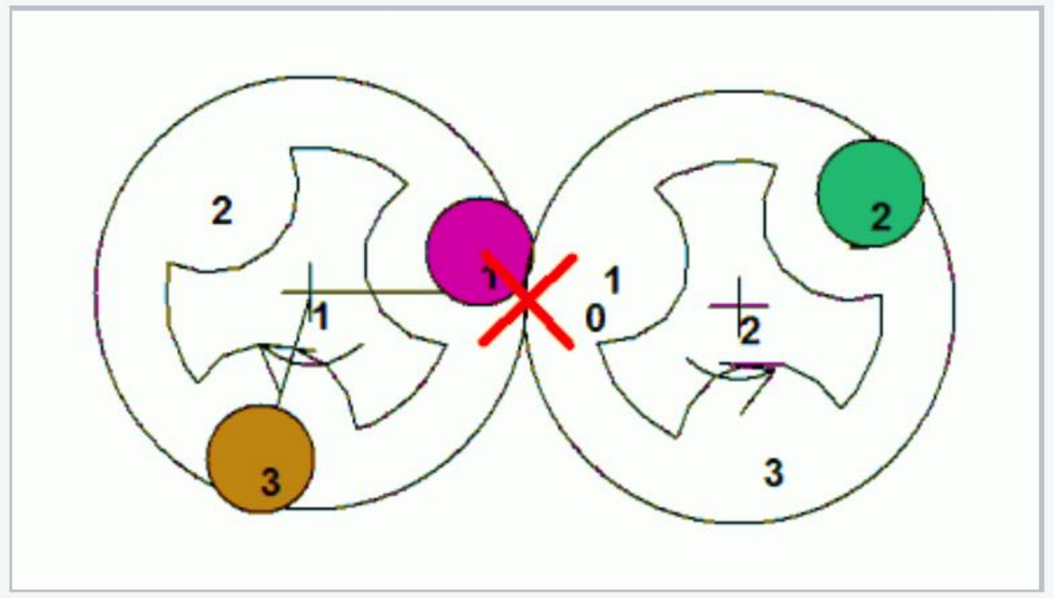


A 19th century braider used to produce rickrack. The wavy edges are produced by varying thread tension.[3]

Braiding Machines

https://en.wikipedia.org/wiki/Braiding_machine

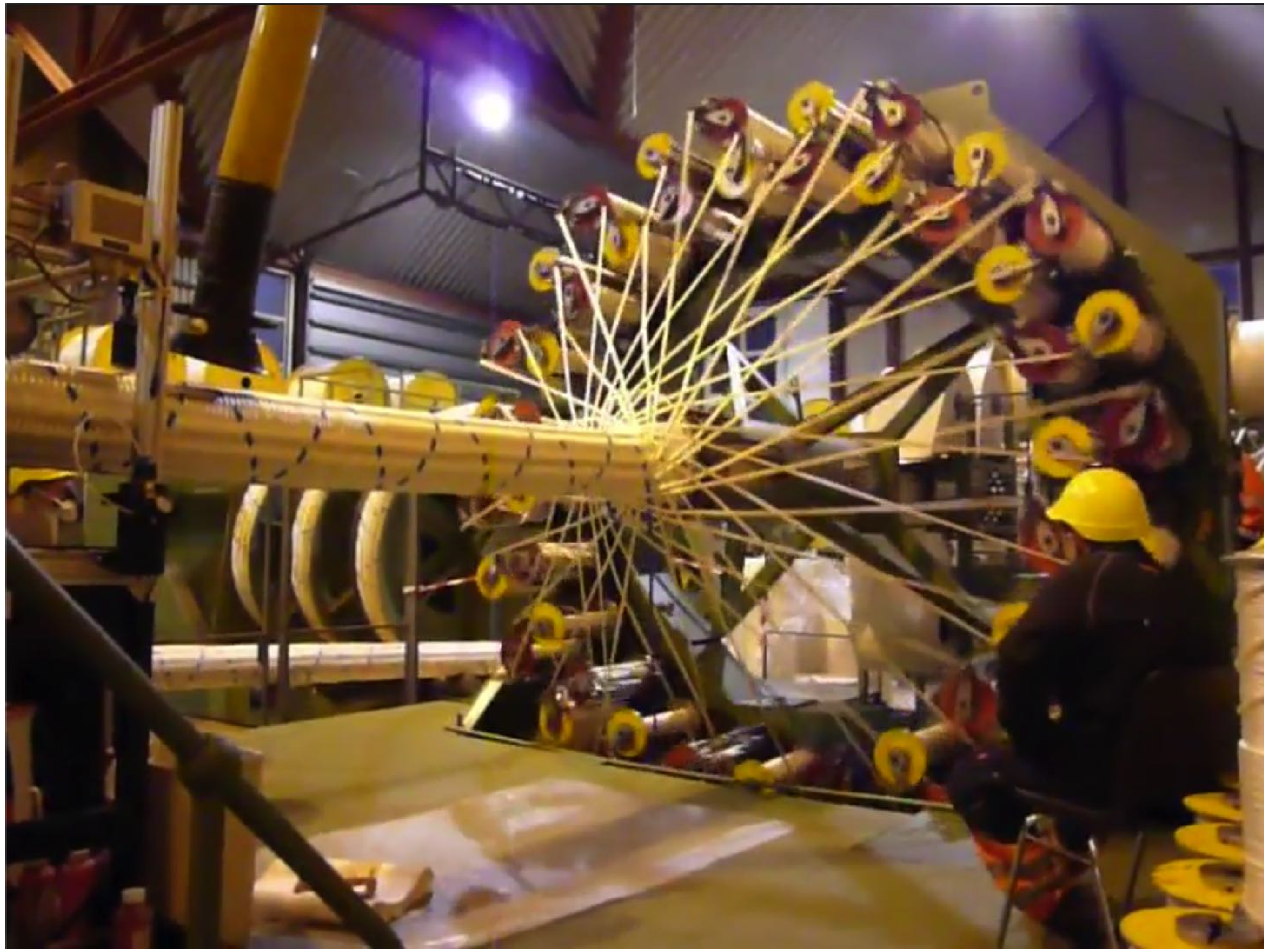
1925 braiding machine in action



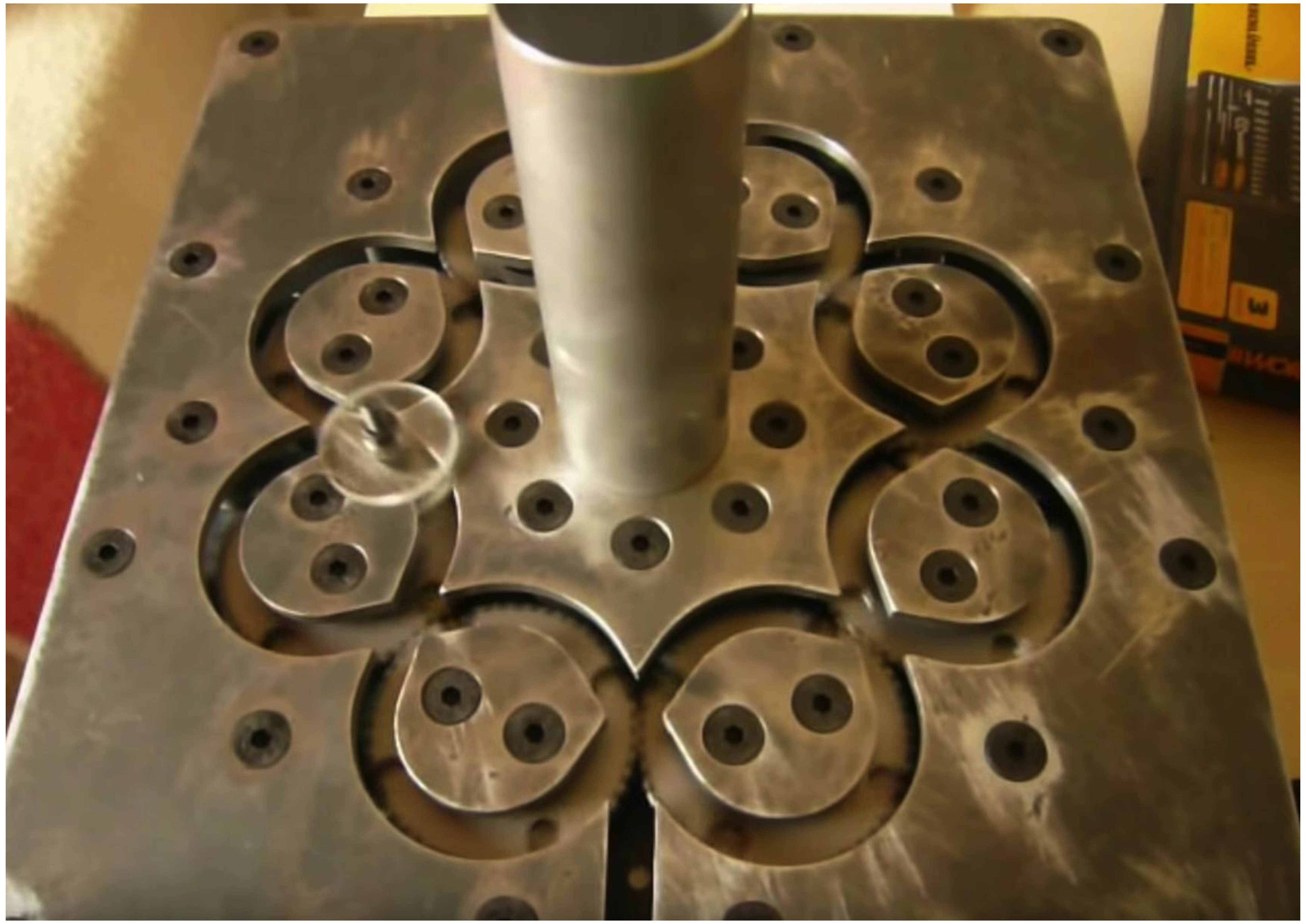
The smallest braiding machine consists of two horn gears and three bobbins. This produces a flat, 3-strand braid.

Braiding Machines

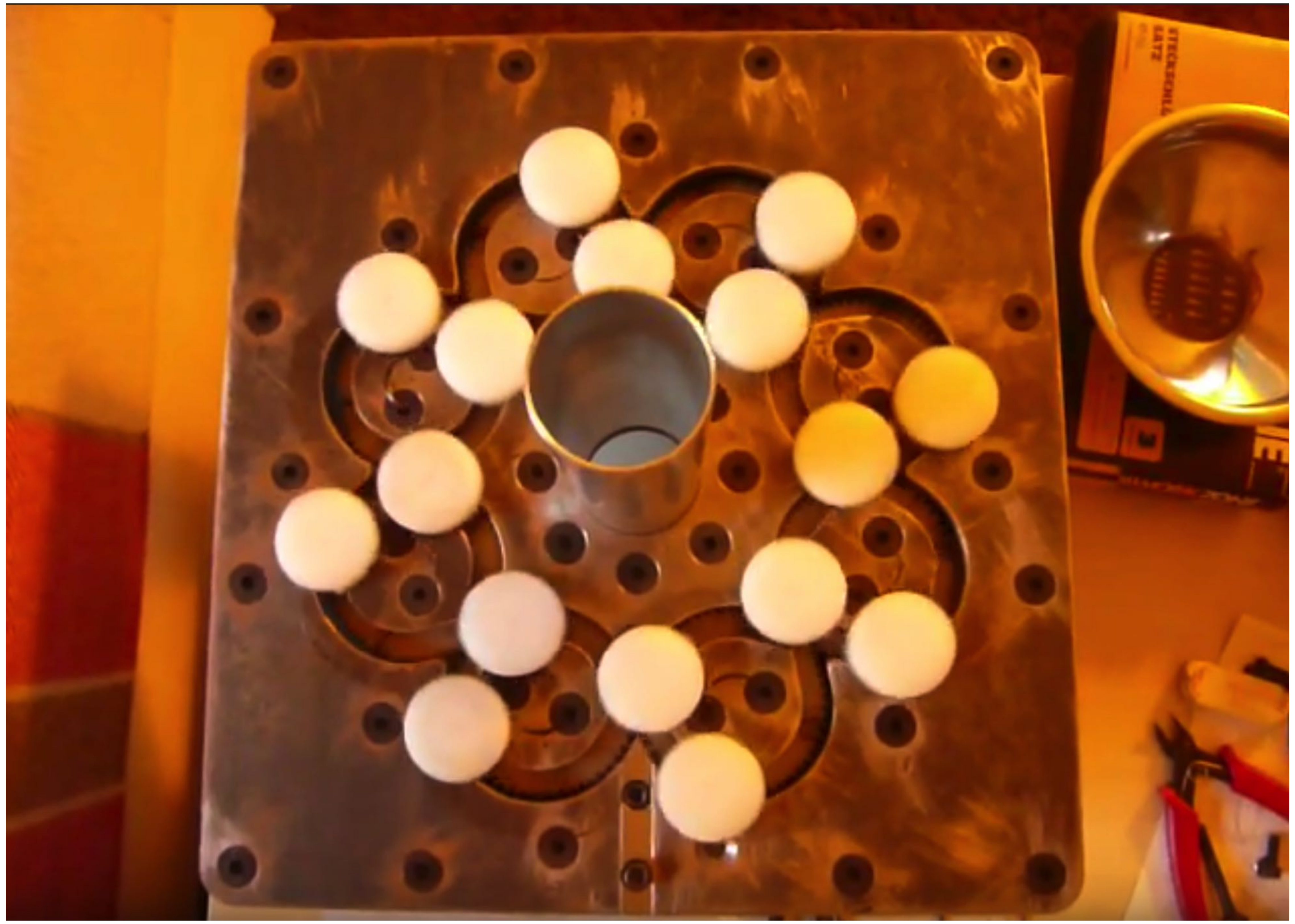
https://en.wikipedia.org/wiki/Braiding_machine



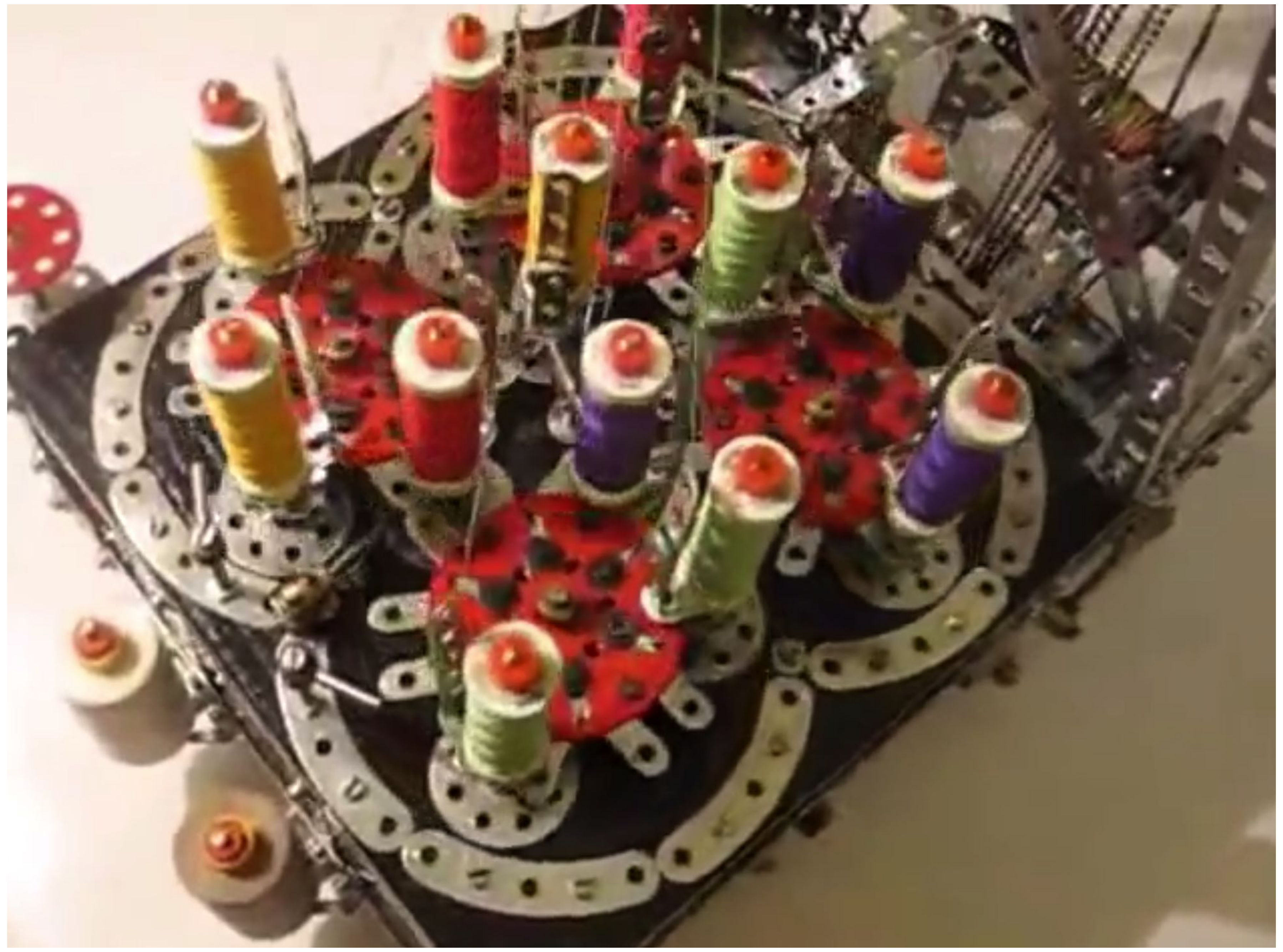
https://i.imgur.com/CDe2GQT.gifv



DIY Maypole Braider - How does it work?
https://www.youtube.com/watch?v=WlrzuZpJ2N8
(https://www.youtube.com/watch?v=vrvDPKAg1Vc)



DIY Maypole Braider Bobbin Test
https://www.youtube.com/watch?v=D1QKoLUxjeQ



Meccano Braiding Machine

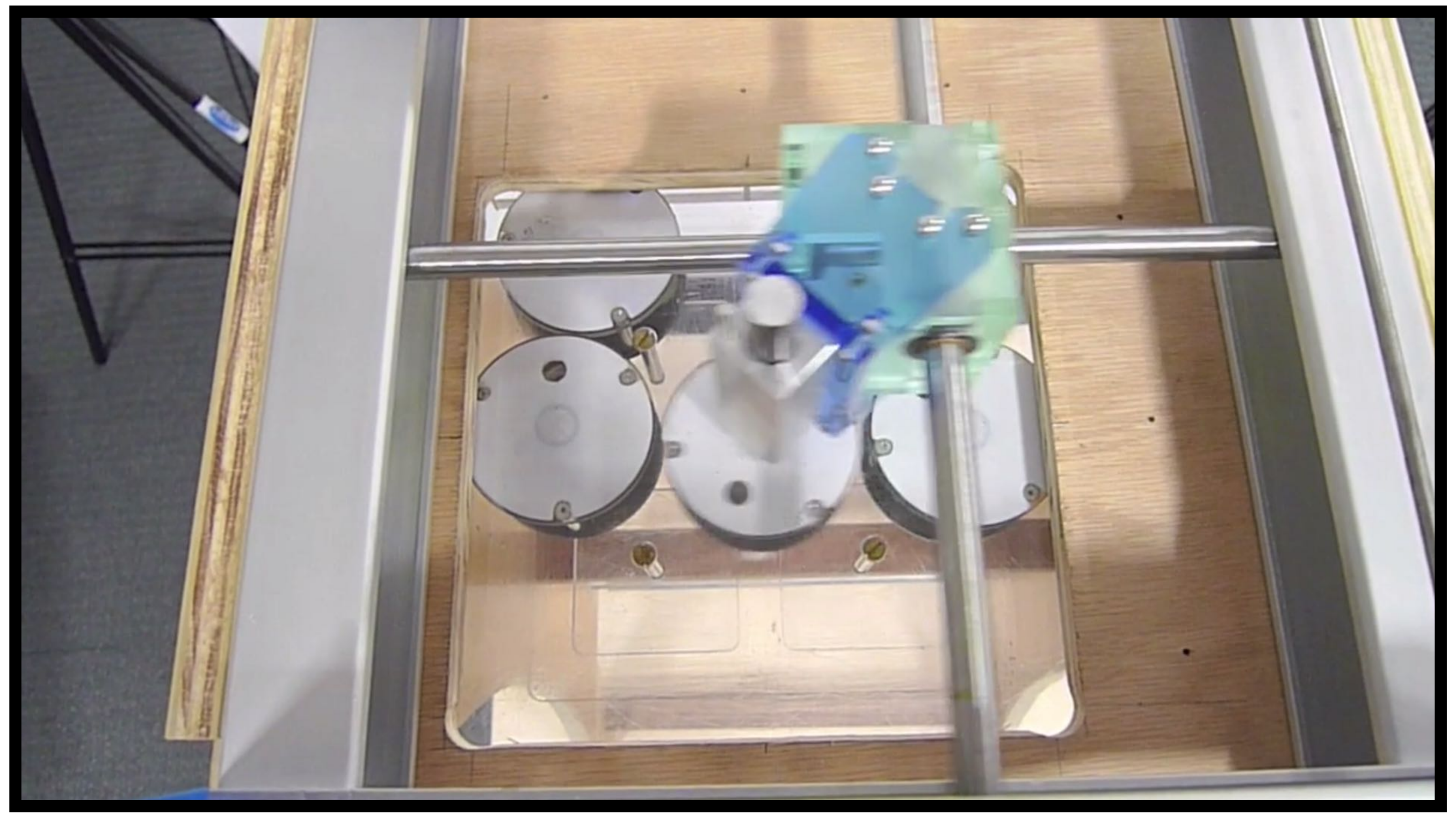
https://www.youtube.com/watch?v=8s376KrNvbY

https://youtu.be/MCVlJFS9Wwo?t=108

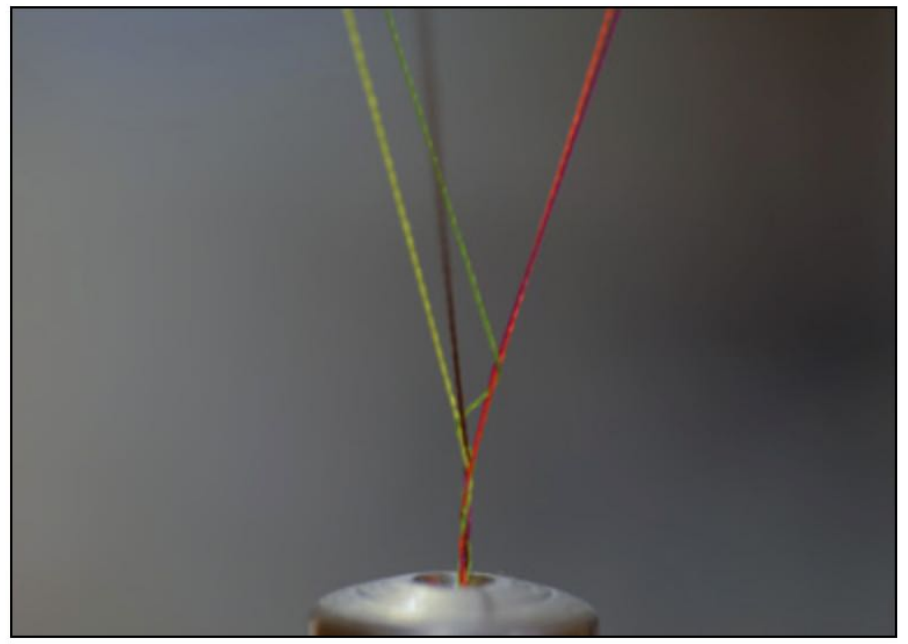
Braiding Machine - How they Braid a Rope

Interweave: CNC Braiding Machine (Ilan Moyer)

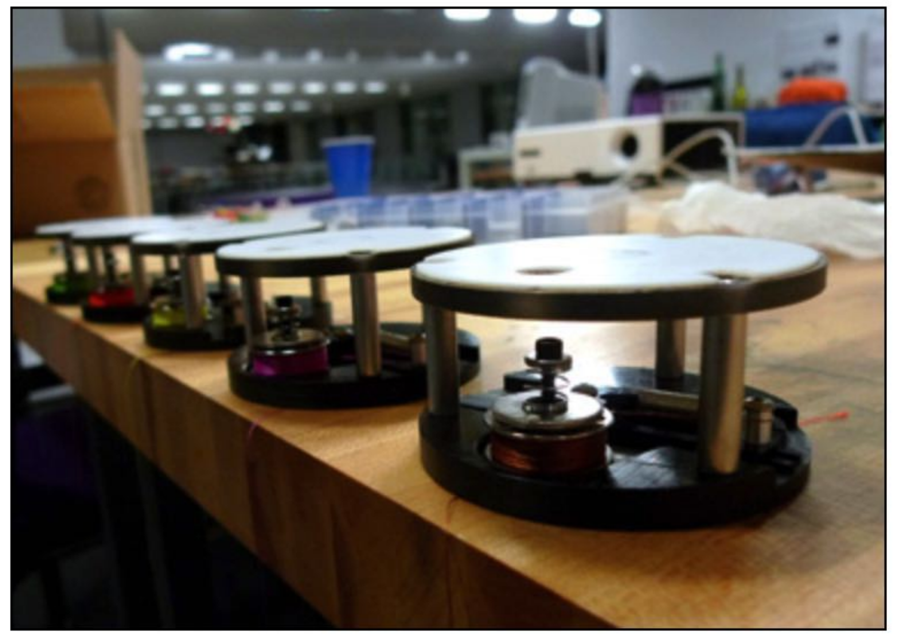
http://web.mit.edu/imoyer/www/portfolio/interweave/index.html



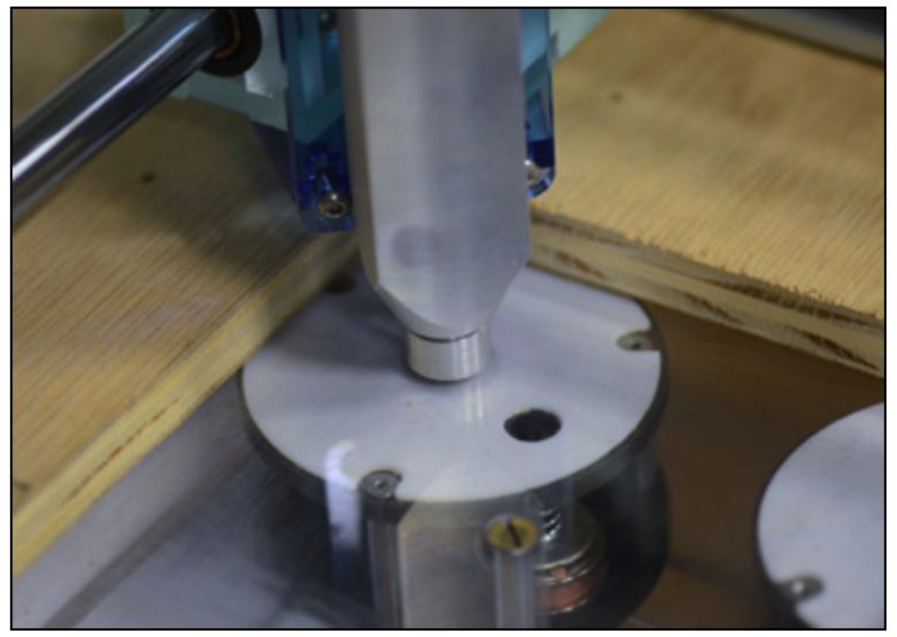
https://vimeo.com/20952577



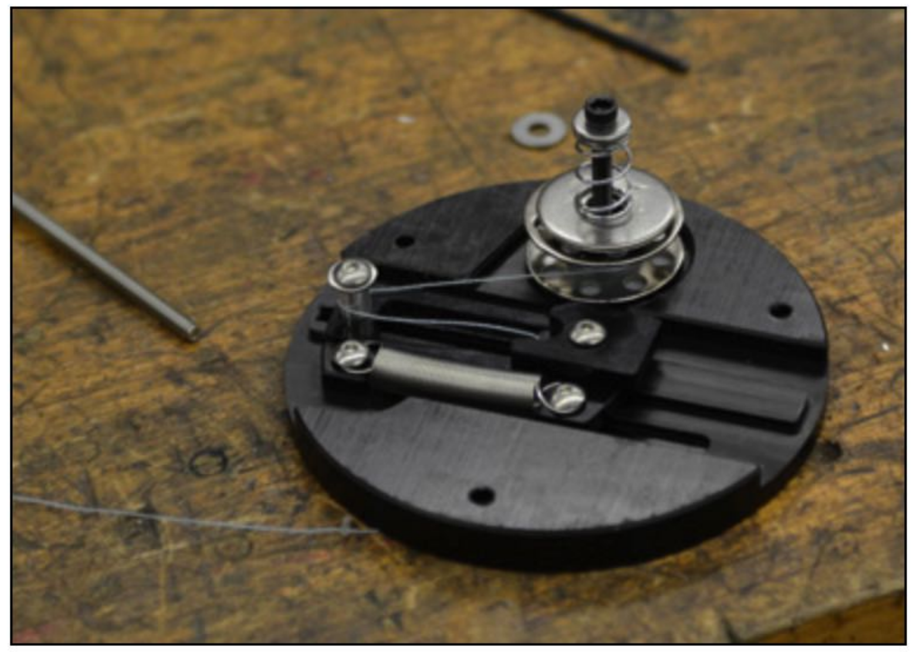
The braid forming at the aperture.



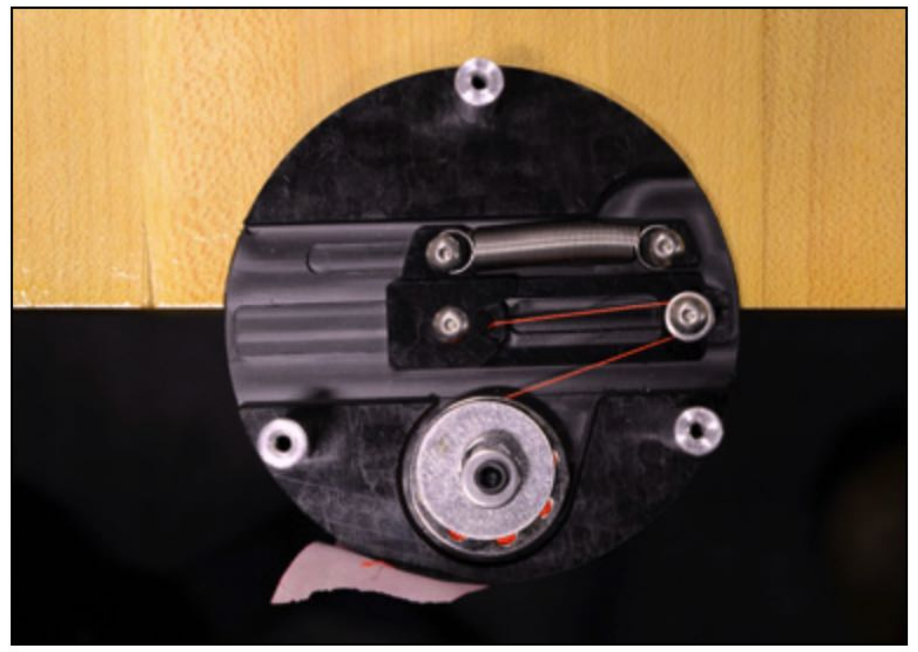
Different types and/or colors of thread are held in pucks.



Each puck contains an embedded magnet that can couple to the head of a moving XY stage.

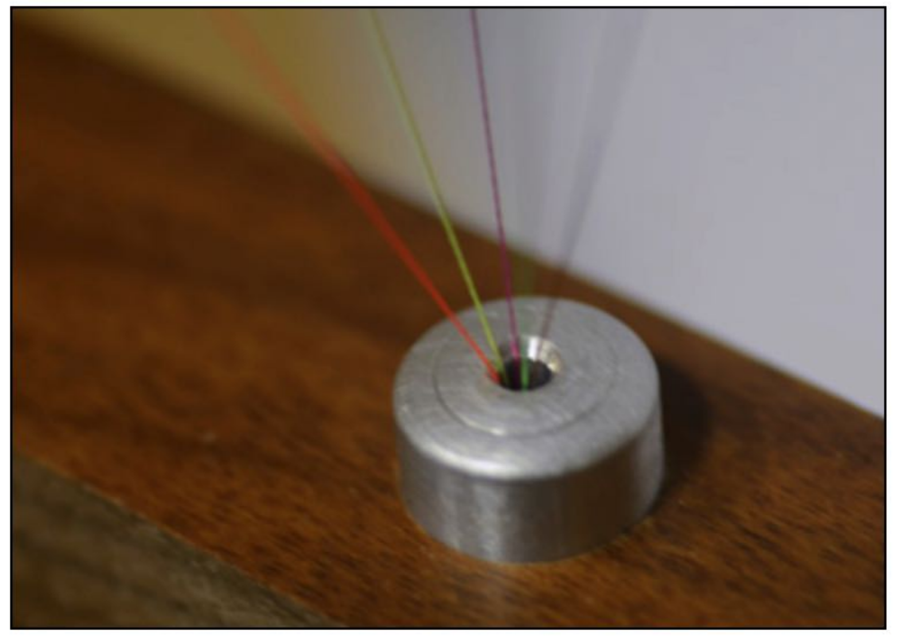


The core of the puck.



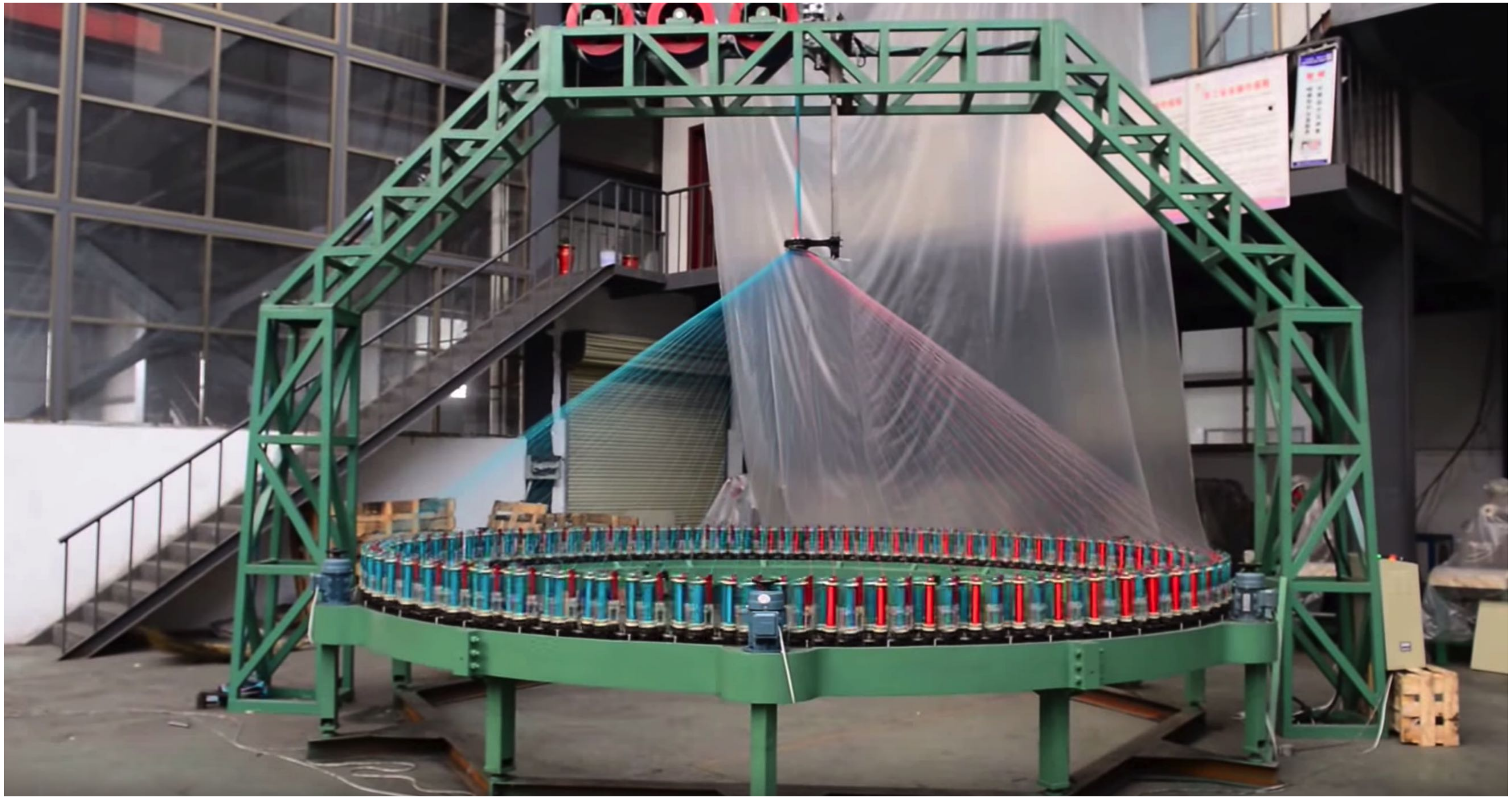
A spring-loaded tensioner keeps the thread taut through the puck's range of motion.

The pucks are supported on an acrylic grid with slots for the threads to pass.



All of the threads reconvene as they pass thru an aperture in the bottom of the device before being spooled onto a rotating take-up shaft.

300 Carriers Braiding Machine



https://www.youtube.com/watch?v=prUQzHBIYK4

Some Computing Trends

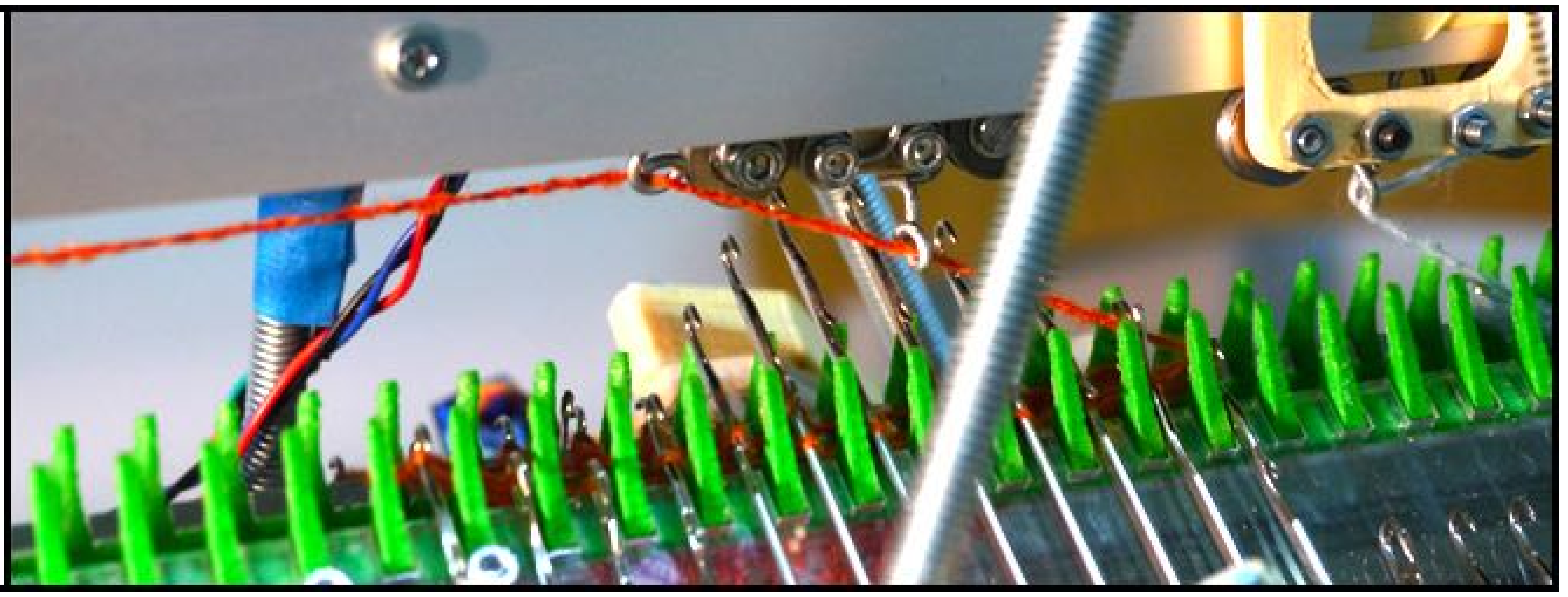
Hacking Knitting Machines

Becky Stern

https://makezine.com/2010/11/05/hack_your_knitting_machine/

https://learn.adafruit.com/electroknit

OpenKnit

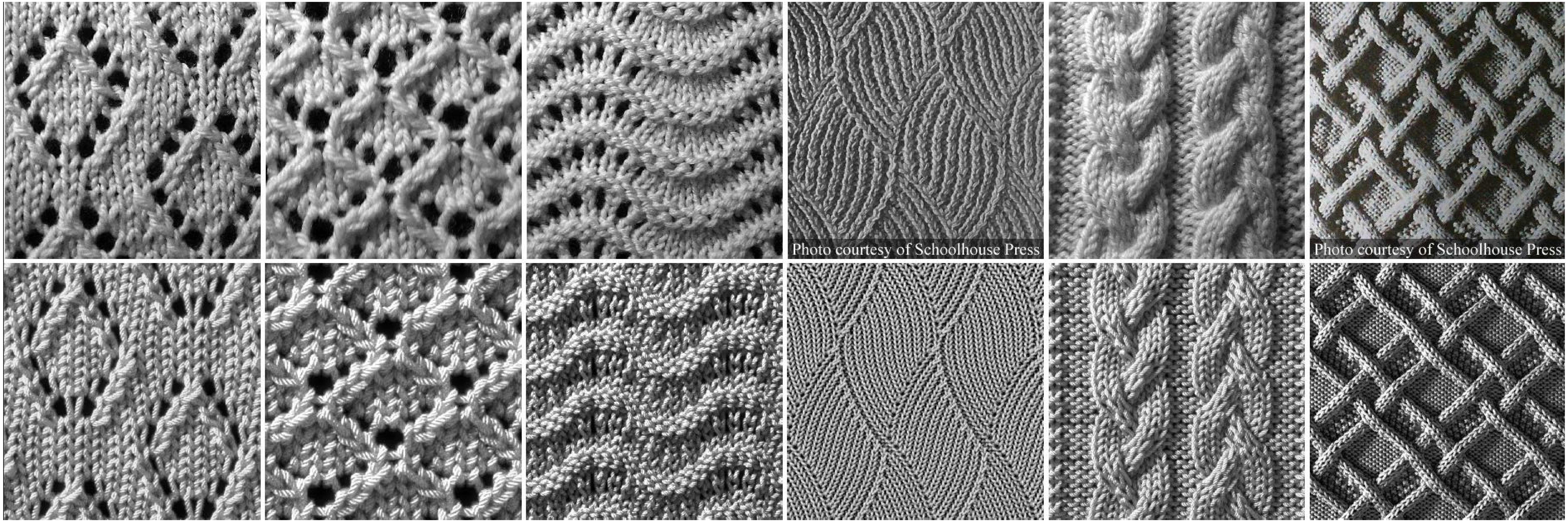


https://openknit.org

Kniterate

https://www.kniterate.com/

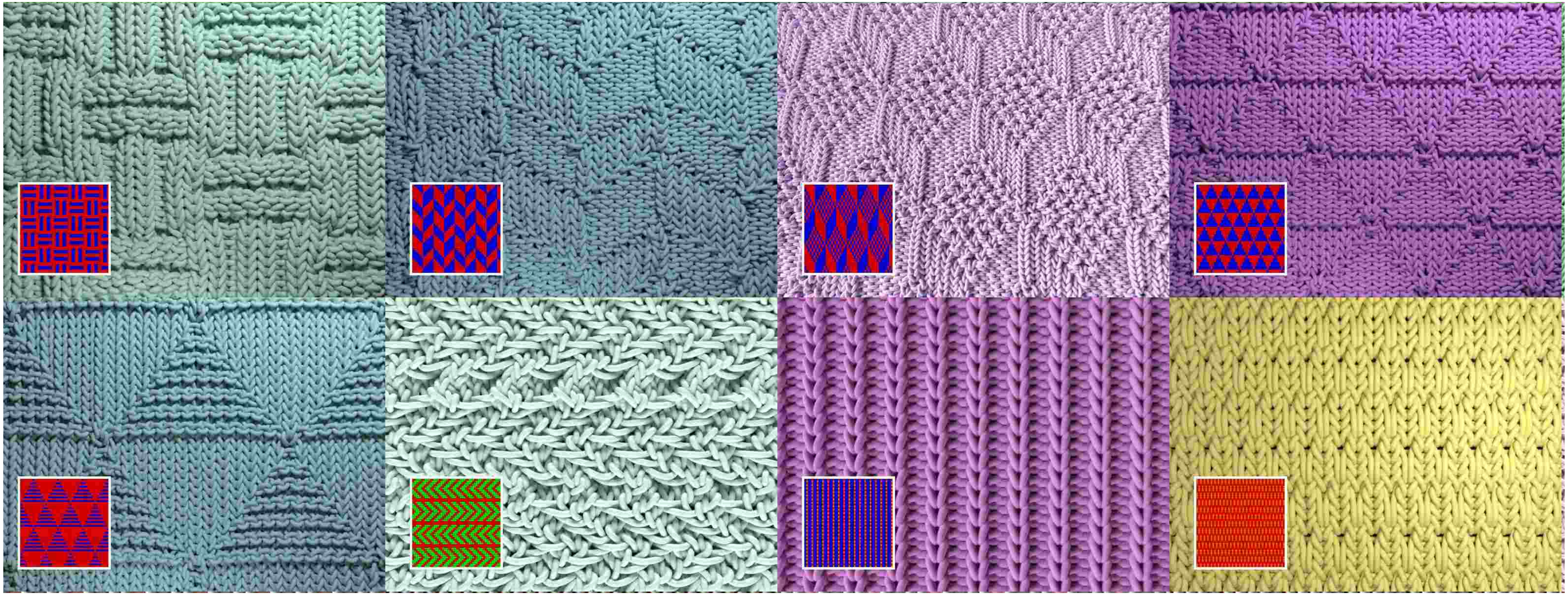
3D Digital Representation & Simulation



[Yuksel et al. 2012]

Interactive Pattern Design & Visualization

Patterns designed with our tool:



Jonathan Leaf et al.

Knitout

https://textiles-lab.github.io/knitout

The "Knitout" (.k) File Format v0.5.3

Knitout (.k) is a file format that can represent low-level knitting machine instructions in a machine-independent way. The format is easy to read and write from code, and reasonably human-readable. It is hoped that knitout can serve as an output file format for design tools, and an input file format for knitting machines and simulators.

Knitout has no relation to the custom sock vendor of the same name.

The remainder of this document describes the format itself, the design principles behind the format, and ends with some comments about particular decisions.

History

1. Version 0.5.3 -- clarify that carrier names are strings. (Jim McCann)
2. Version 0.5.2 -- clarify that ;;Carriers header is required. (Jim McCann)
3. Version 0.5.1 -- add ;!source: comments, fix typo in example. (Jim McCann)
4. Version 0.5 -- racking sign swapped. (Jim McCann)
5. Version 0.4 -- total re-write, placed in the public domain. (Jim McCann)

Contributing

Please do not hesitate to get in touch with ideas, comments, or improvements for the specification. Without your input, knitout cannot grow into a useful specification.

To provide feedback, use the Issues page. You may also contact the authors directly using the knitout-feedback@cs.cmu.edu e-mail alias.

File Format

Knitout is a straightforward list of knitting instructions to execute to create a knit object, along with a header describing specific information about the machine it is designed to run on.

Extensions, Encoding, Line Endings

Knitout files are named with the `.k` extension.

Knitout files contain UTF8-encoded text.

Knitout is line-oriented, and knitout files use the LF character to terminate lines (`'\n'`, hex: `0xA`).

Programs that write knitout format files should name then with a `.k` extension, encode them as UTF8, use only the "space" (U+0020) and "tab" (U+0009) characters for whitespace, and use the LF character (U+000A) as a line ending. Programs that read knitout files should support files produced in this way, and may support other extensions, encodings, whitespace characters, and line endings (though they should warn that the file is not standard).

Example File

This example file uses an alternating-tuck cast-on, followed by two rows of plain knitting, and drops instead of binding off.

```
;!knitout-2
;;Machine: SWG091N2
;;Gauge: 15
;;Yarn-5: 50-50 Rust
;;Carriers: 1 2 3 4 5 6 7 8 9 10
;;Position: Right

inhook 5

tuck - f10 5
tuck - f8 5
tuck - f6 5
tuck - f4 5
tuck - f2 5
tuck + f1 5
tuck + f3 5
tuck + f5 5
tuck + f7 5
tuck + f9 5

releasehook 5

knit - f10 5
knit - f9 5
knit - f8 5
knit - f7 5
knit - f6 5
knit - f5 5
knit - f4 5
knit - f3 5
knit - f2 5
knit - f1 5

knit + f1 5
knit + f2 5
knit + f3 5
knit + f4 5
knit + f5 5
knit + f6 5
knit + f7 5
knit + f8 5
knit + f9 5
knit + f10 5

outhook 5
```

Compilation

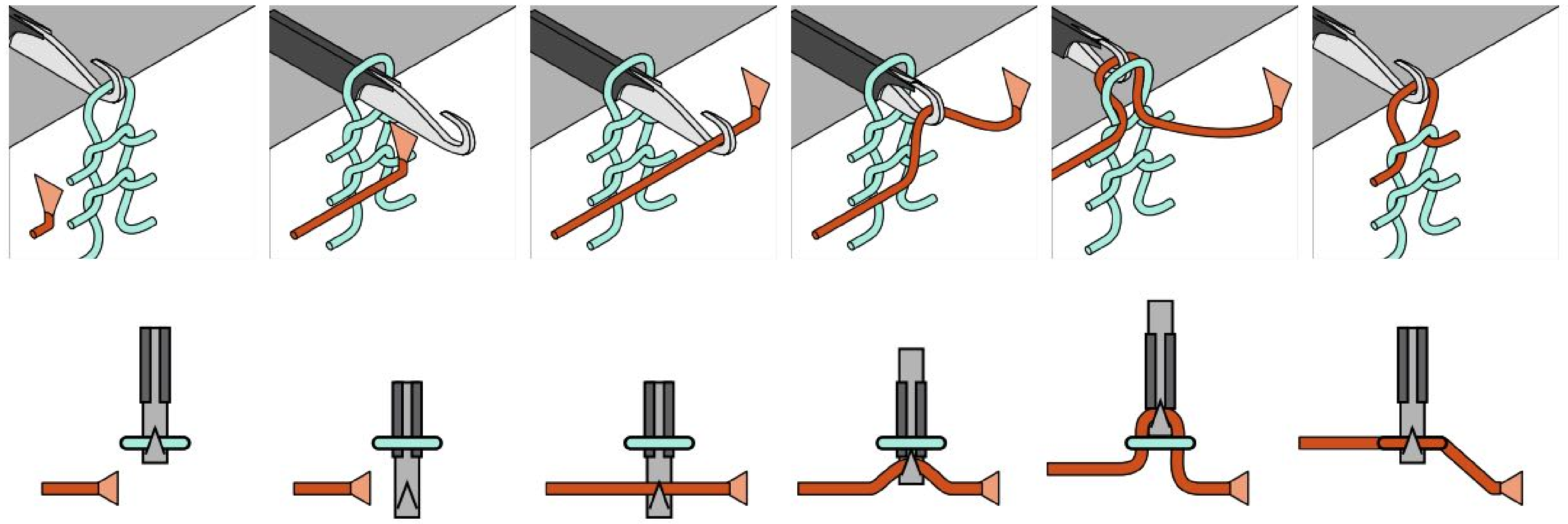
A Compiler for 3D Machine Knitting

James McCann[1] Lea Albaugh[1] Vidya Narayanan[1] April Grow[1,2]
Wojciech Matusik[3] Jen Mankoff[1,4] Jessica Hodgins[1]

[1]Disney Research [2]UC Santa Cruz [3]Massacusetts Institute of Technology [4]Carnegie Mellon University

Figure 1: *Our compiler processes high-level primitives into low-level instructions for production on industrial knitting machines.*

Knit. Knitting a needle pulls a new loop of yarn through the *all of the loops* currently held by that needle. Mechanically, the needle reaches forward, the yarn carrier moves over it, and the needle retracts, using a secondary mechanical action to lift the loops that it was holding up and over the new loop and off of its tip.



Knit, like tuck, has a direction. The above example is a "knit right" because the yarn carrier moves to the right when supplying the yarn for the new loop.

knit y, d, n

Given: $y \in \mathcal{Y}, d \in \{+, -\}, n \in \{f_i\} \cup \{b_i\}, n \neq []$

$l \leftarrow \text{loop}(y, d, n)$

$\text{pull}(l, \text{reverse}(n))$

$n \leftarrow [l]$

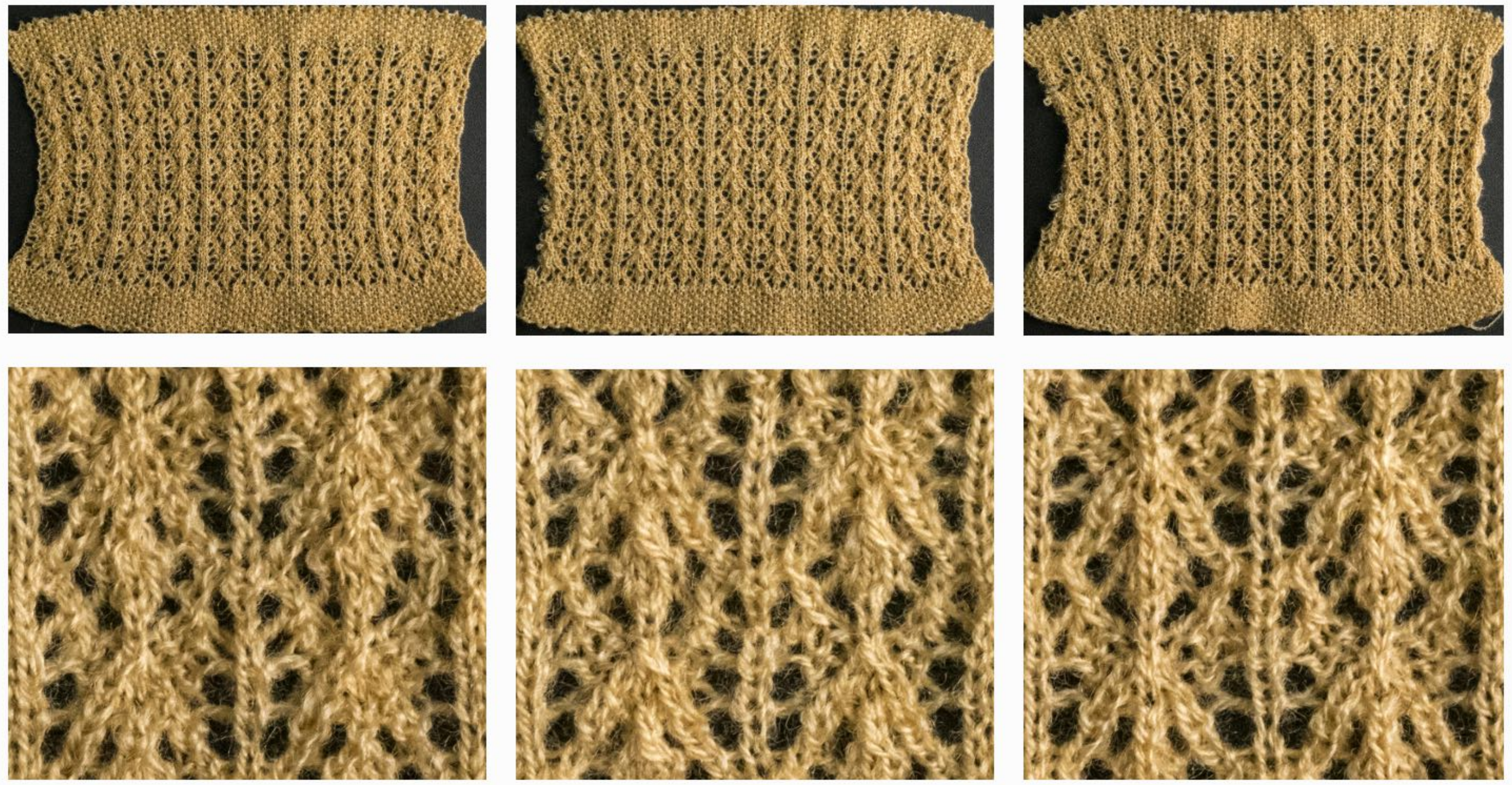
Where "pull" means to pull a loop through a list of other loops; and "reverse" reverses the order of a list.

https://s3-us-west-1.amazonaws.com/disneyresearch/wp-content/uploads/20160705213118/A-Compiler-for-3D-Machine-Knitting-Paper.pdf

Motion Planning

Efficient Transfer Planning for Flat Knitting

Jenny Lin Vidya Narayanan Jim McCann



Collapse-stretch-expand 25m 37s | **Schoolbus** 6m 28s | **Schoolbus+sliders** 6m 49s

Abstract

Industrial knitting machines form fabric by manipulating loops of yarn held on hundreds of hook-shaped needles. Transfer planning algorithms generate a sequence of machine instructions that move loops between their current needles and given target needles. In this paper we describe how to compute the run-time cost of a transfer plan in terms of machine passes, and compare the plans generated by several existing and new transfer planning algorithms under this metric over a a large benchmarking set of transfer operations taken from example flat lace patterns, along with synthetically generated patterns.

See https://textiles-lab.github.io/projects/on-demand-knitting/

Final Thoughts