AU Science Club – June 18, 2019
Textiles 101

By John L. Steen

Agenda

1. Family background in textiles
2. Background of textiles, fibers,and yarns
3. Early history
4. Natural fibers including asbestos.
5. Early history of synthetic yarns-Nylon polyester and acrylic.
6. Briefly types of fabrics.

PHOTOS

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"Way Down South in the Land of Cotton"

Courtesy: Cotton-Textile Institute

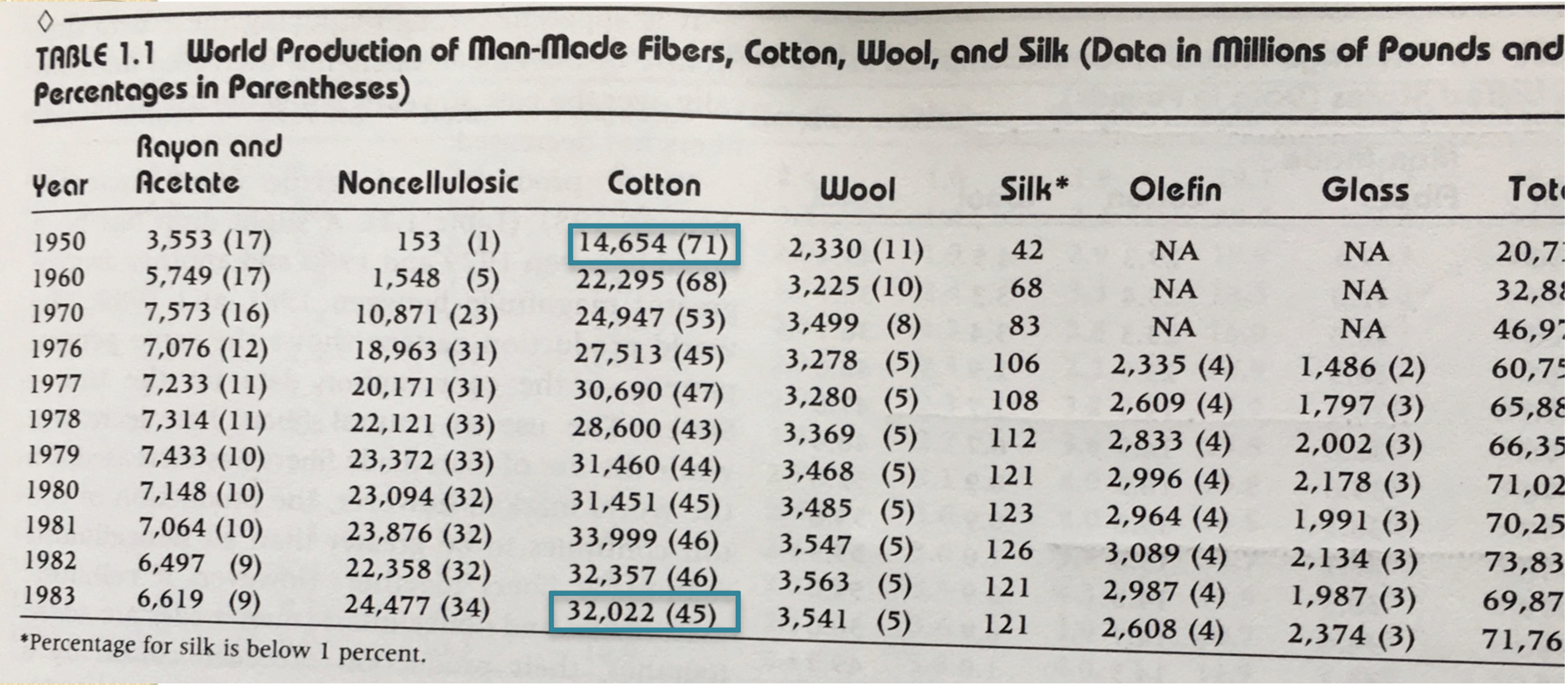
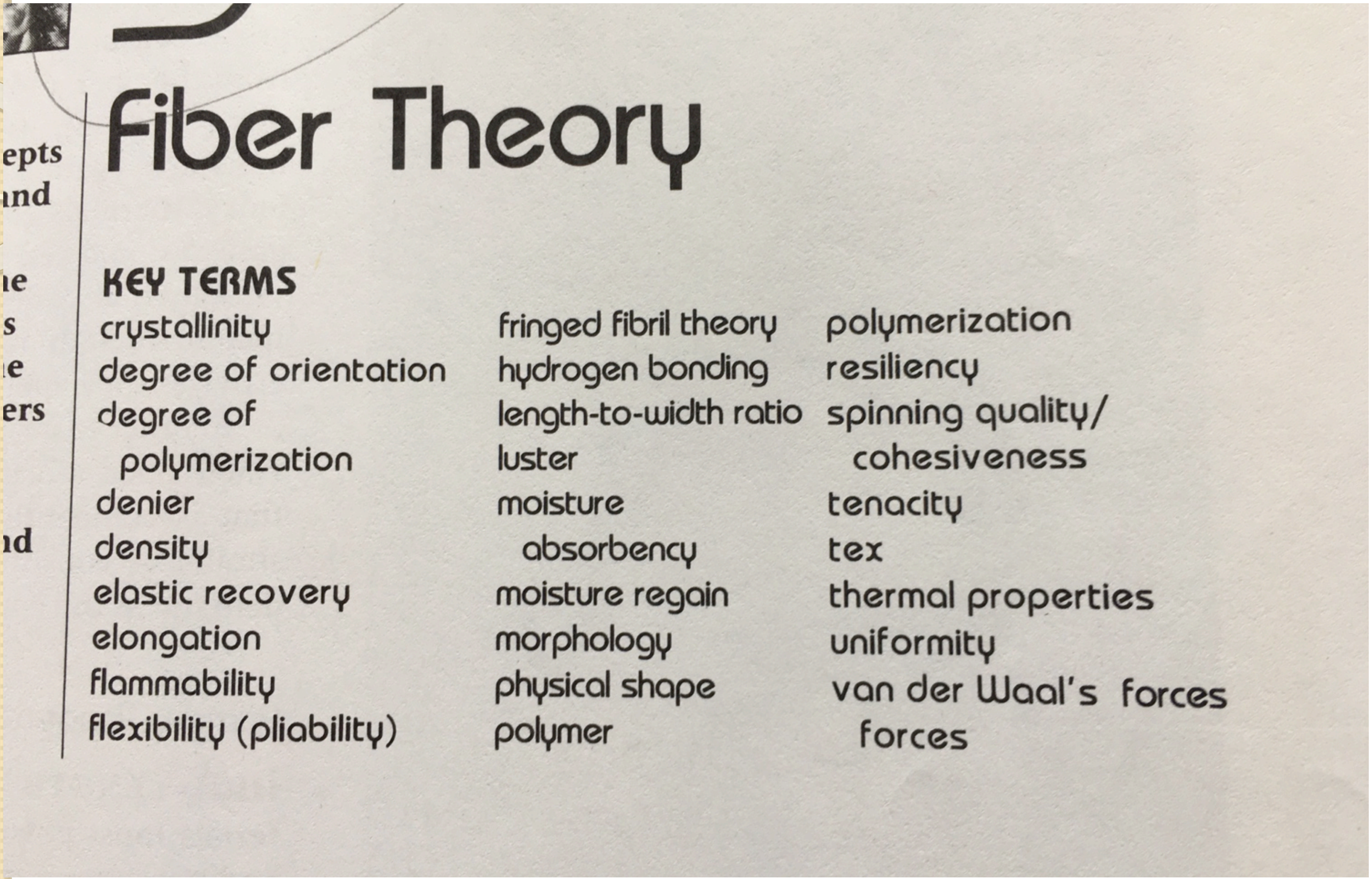


TABLE 1.1 World Production of Man-Made Fibers, Cotton, Wool, and Silk (Data in Millions of Pounds and Percentages in Parentheses)

Year	Rayon and Acetate	Noncellulosic	Cotton	Wool	Silk*	Olefin	Glass	Tot
1950	3,553 (17)	153 (1)	14,654 (71)	2,330 (11)	42	NA	NA	20,7
1960	5,749 (17)	1,548 (5)	22,295 (68)	3,225 (10)	68	NA	NA	32,8
1970	7,573 (16)	10,871 (23)	24,947 (53)	3,499 (8)	83	NA	NA	46,9
1976	7,076 (12)	18,963 (31)	27,513 (45)	3,278 (5)	106	2,335 (4)	1,486 (2)	60,7
1977	7,233 (11)	20,171 (31)	30,690 (47)	3,280 (5)	108	2,609 (4)	1,797 (3)	65,8
1978	7,314 (11)	22,121 (33)	28,600 (43)	3,369 (5)	112	2,833 (4)	2,002 (3)	66,35
1979	7,433 (10)	23,372 (33)	31,460 (44)	3,468 (5)	121	2,996 (4)	2,178 (3)	71,02
1980	7,148 (10)	23,094 (32)	31,451 (45)	3,485 (5)	123	2,964 (4)	1,991 (3)	70,25
1981	7,064 (10)	23,876 (32)	33,999 (46)	3,547 (5)	126	3,089 (4)	2,134 (3)	73,83
1982	6,497 (9)	22,358 (32)	32,357 (46)	3,563 (5)	121	2,987 (4)	1,987 (3)	69,87
1983	6,619 (9)	24,477 (34)	32,022 (45)	3,541 (5)	121	2,608 (4)	2,374 (3)	71,76

*Percentage for silk is below 1 percent.



Fiber Theory

KEY TERMS

- crystallinity
- degree of orientation
- degree of polymerization
- denier
- density
- elastic recovery
- elongation
- flammability
- flexibility (pliability)
- fringed fibril theory
- hydrogen bonding
- length-to-width ratio
- luster
- moisture absorbency
- moisture regain
- morphology
- physical shape
- polymer
- polymerization
- resiliency
- spinning quality/ cohesiveness
- tenacity
- tex
- thermal properties
- uniformity
- van der Waal's forces forces

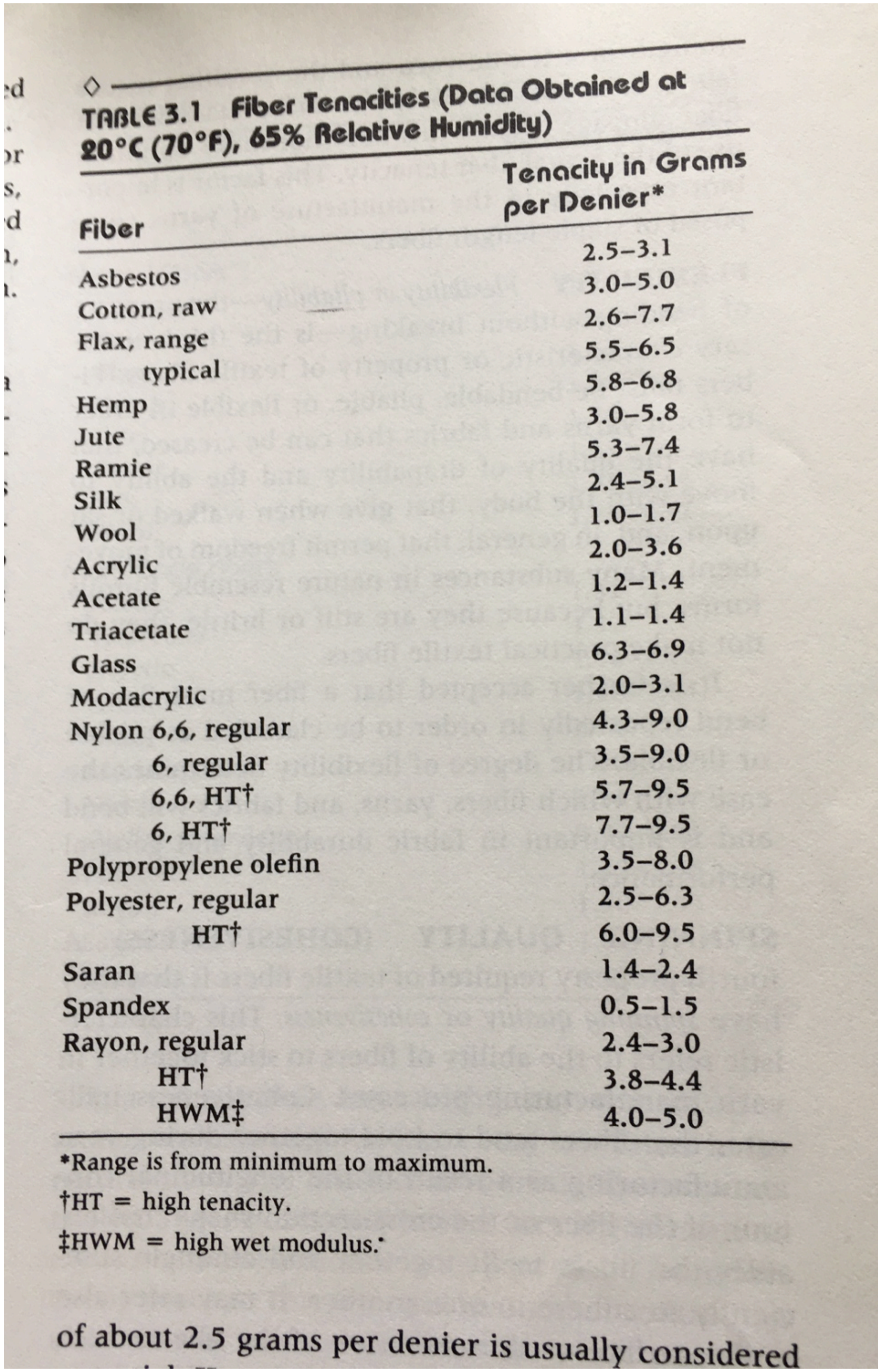


TABLE 3.1 Fiber Tenacities (Data Obtained at 20°C (70°F), 65% Relative Humidity)

Fiber	Tenacity in Grams per Denier*
Asbestos	2.5–3.1
Cotton, raw	3.0–5.0
Flax, range	2.6–7.7
typical	5.5–6.5
Hemp	5.8–6.8
Jute	3.0–5.8
Ramie	5.3–7.4
Silk	2.4–5.1
Wool	1.0–1.7
Acrylic	2.0–3.6
Acetate	1.2–1.4
Triacetate	1.1–1.4
Glass	6.3–6.9
Modacrylic	2.0–3.1
Nylon 6,6, regular	4.3–9.0
6, regular	3.5–9.0
6,6, HT†	5.7–9.5
6, HT†	7.7–9.5
Polypropylene olefin	3.5–8.0
Polyester, regular	2.5–6.3
HT†	6.0–9.5
Saran	1.4–2.4
Spandex	0.5–1.5
Rayon, regular	2.4–3.0
HT†	3.8–4.4
HWM‡	4.0–5.0

*Range is from minimum to maximum.

†HT = high tenacity.

‡HWM = high wet modulus.

of about 2.5 grams per denier is usually considered

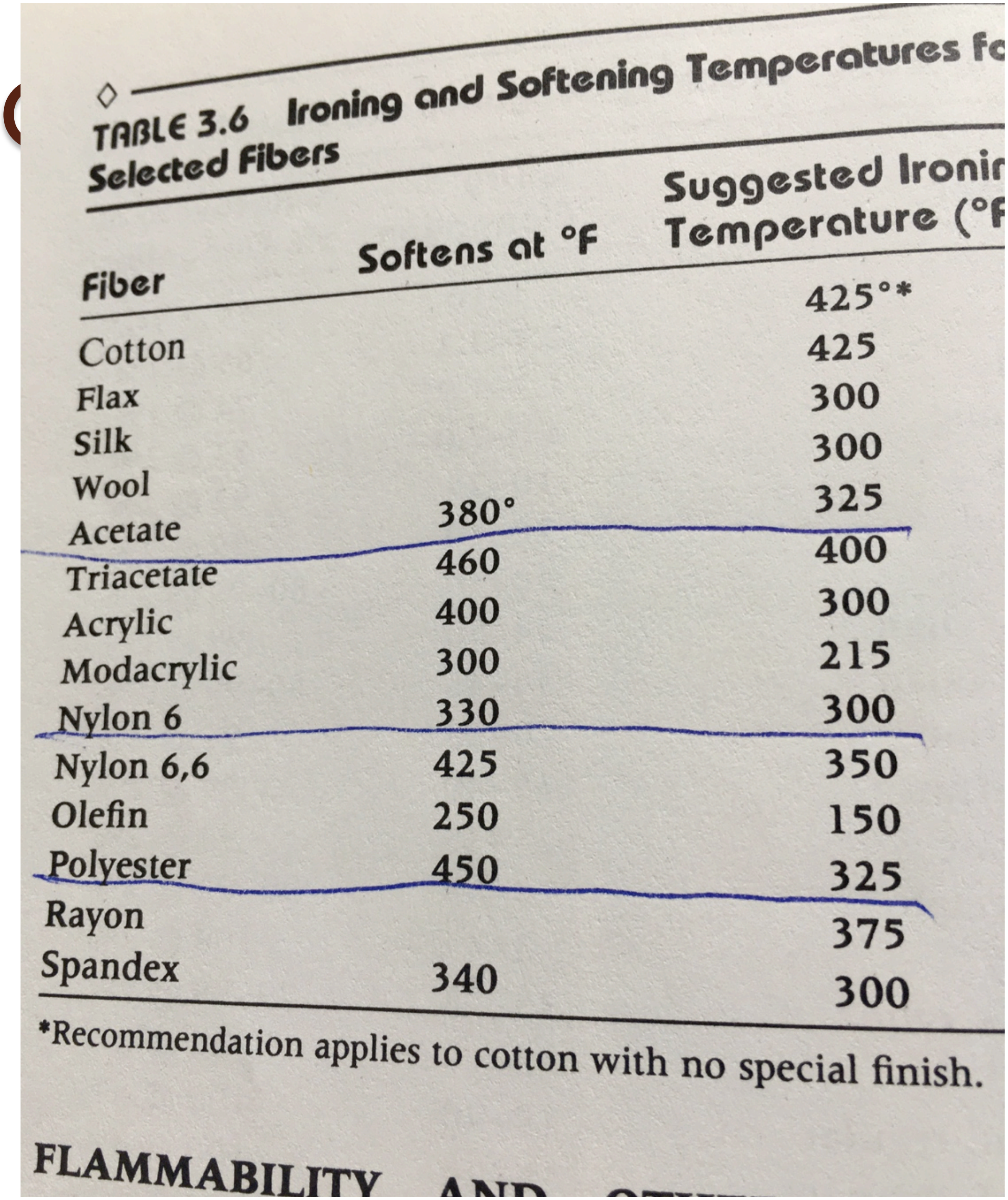


TABLE 3.6 Ironing and Softening Temperatures fo Selected Fibers

Fiber	Softens at °F	Suggested Ironi Temperature (°F
Cotton		425°*
Flax		425
Silk		300
Wool		300
Acetate	380°	325
Triacetate	460	400
Acrylic	400	300
Modacrylic	300	215
Nylon 6	330	300
Nylon 6,6	425	350
Olefin	250	150
Polyester	450	325
Rayon		375
Spandex	340	300

*Recommendation applies to cotton with no special finish.

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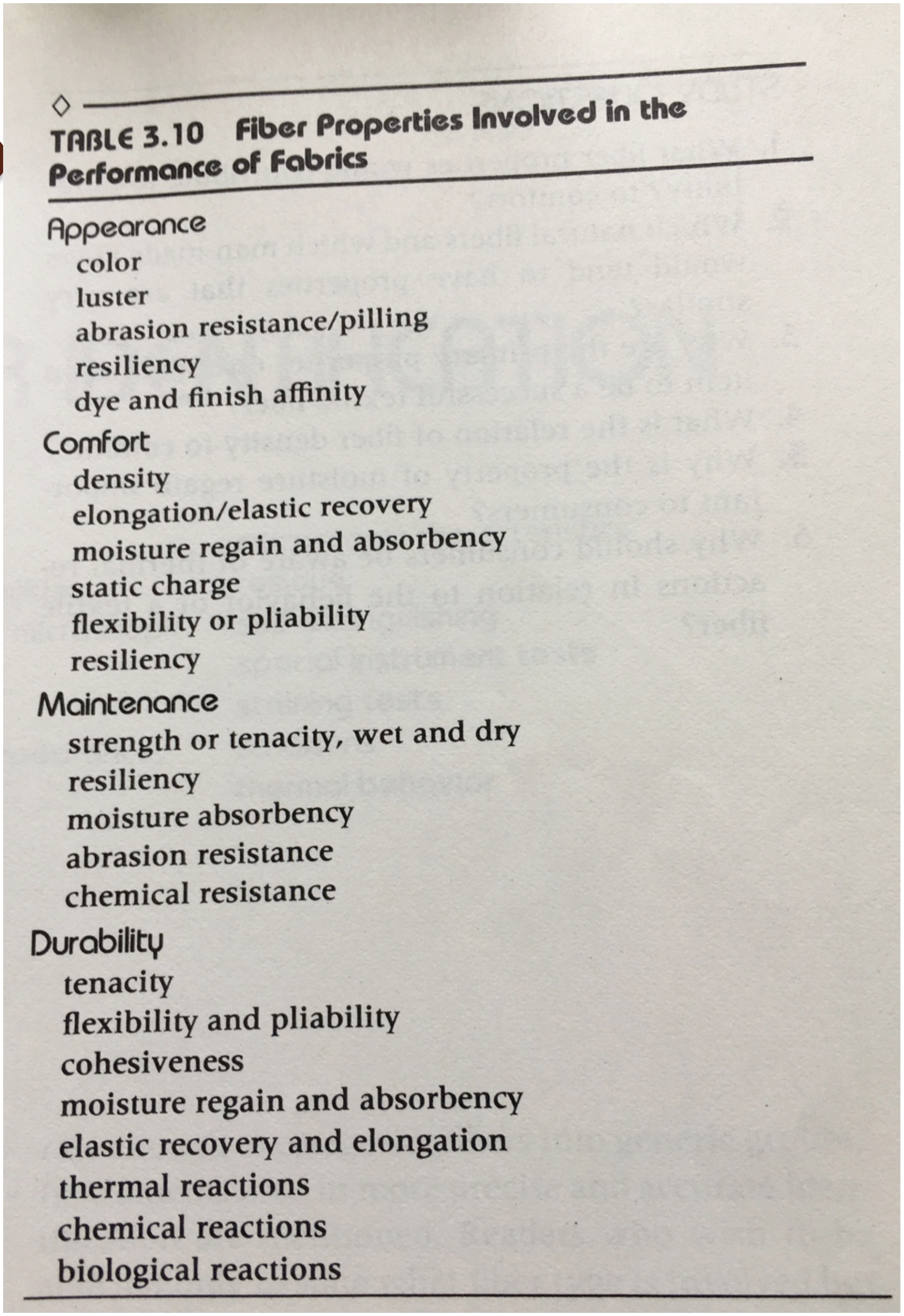


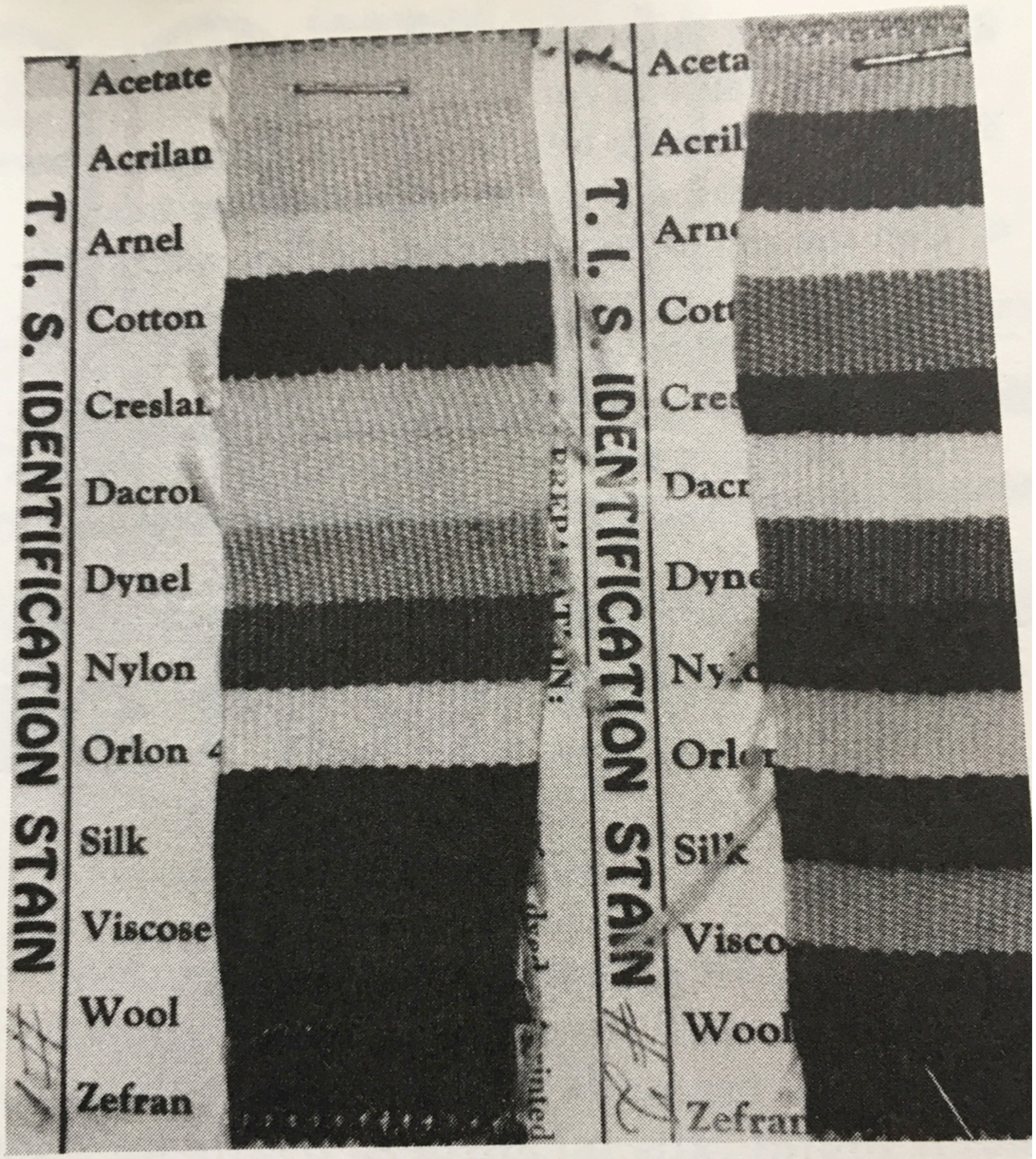
TABLE 3.10 Fiber Properties Involved in the Performance of Fabrics

Appearance
- color
- luster
- abrasion resistance/pilling
- resiliency
- dye and finish affinity

Comfort
- density
- elongation/elastic recovery
- moisture regain and absorbency
- static charge
- flexibility or pliability
- resiliency

Maintenance
- strength or tenacity, wet and dry
- resiliency
- moisture absorbency
- abrasion resistance
- chemical resistance

Durability
- tenacity
- flexibility and pliability
- cohesiveness
- moisture regain and absorbency
- elastic recovery and elongation
- thermal reactions
- chemical reactions
- biological reactions



4.1 Multifiber testfabric stained with two different fiber identification dyes. Note differences among various fibers.

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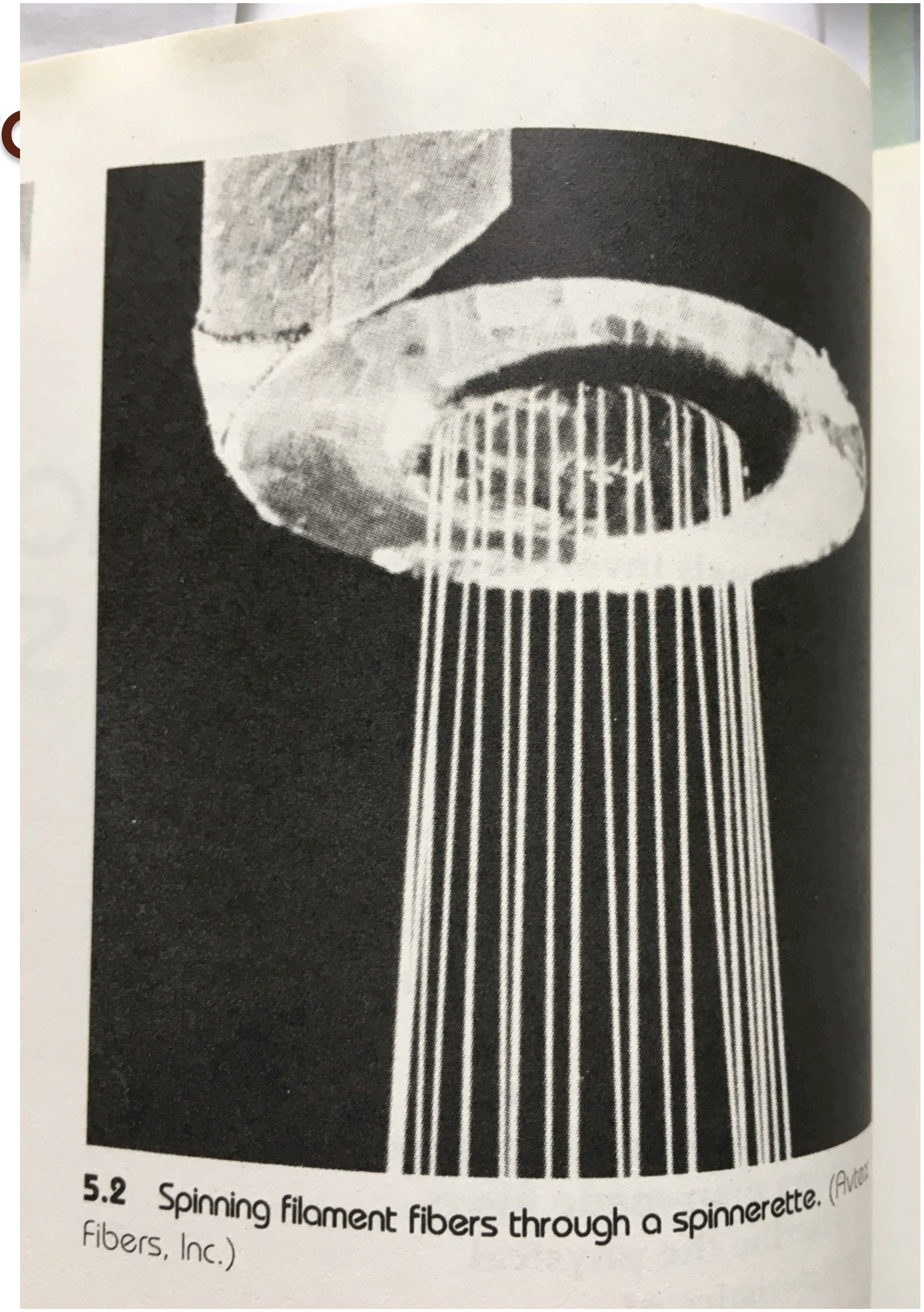
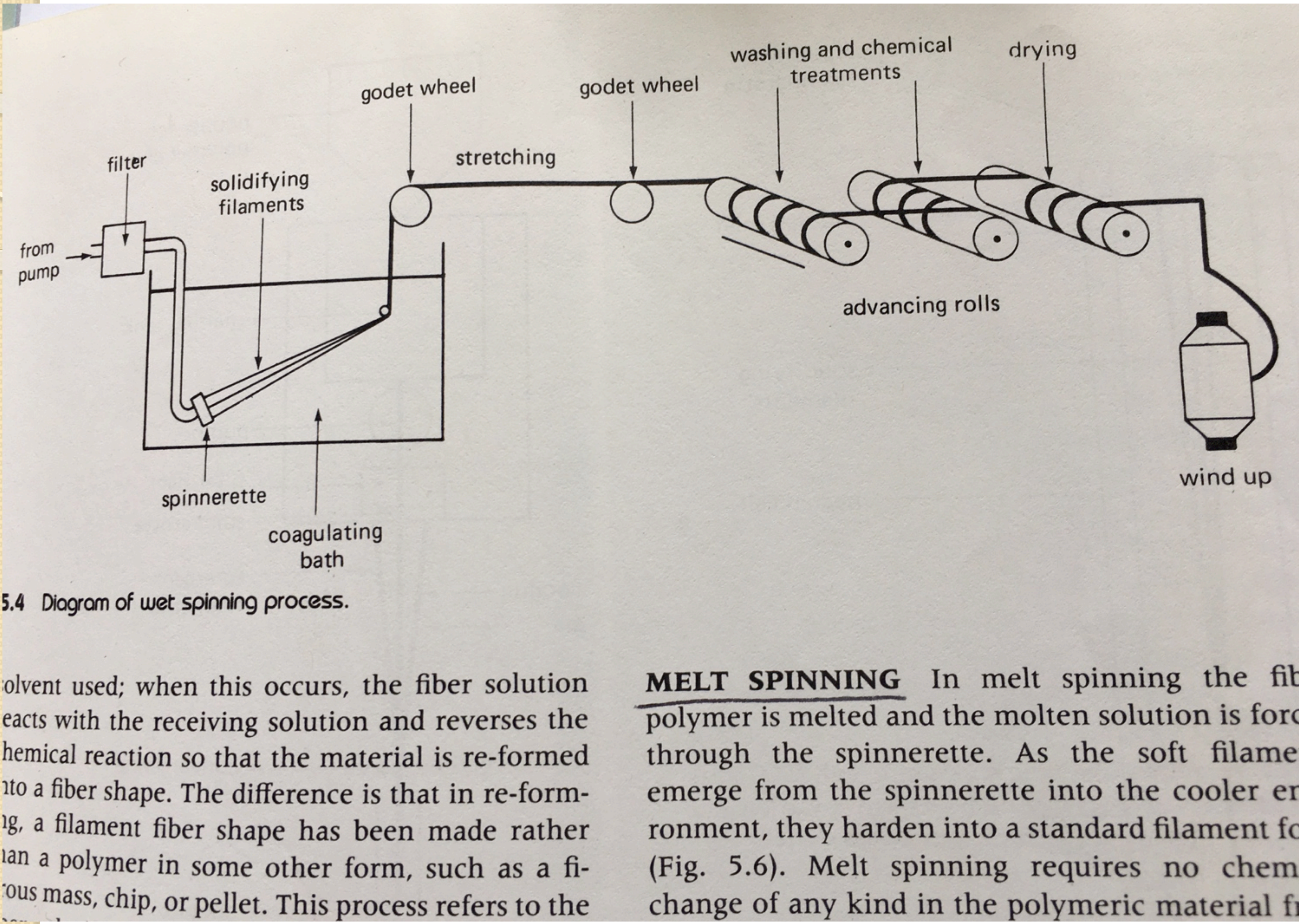


5.2 Spinning filament fibers through a spinnerette. (Avtex Fibers, Inc.)



5.4 Diagram of wet spinning process.

olvent used; when this occurs, the fiber solution
eacts with the receiving solution and reverses the
hemical reaction so that the material is re-formed
nto a fiber shape. The difference is that in re-form-
ıg, a filament fiber shape has been made rather
ıan a polymer in some other form, such as a fi-
ous mass, chip, or pellet. This process refers to the

MELT SPINNING In melt spinning the fib
polymer is melted and the molten solution is forc
through the spinnerette. As the soft filame
emerge from the spinnerette into the cooler er
ronment, they harden into a standard filament fc
(Fig. 5.6). Melt spinning requires no chem
change of any kind in the polymeric material fr

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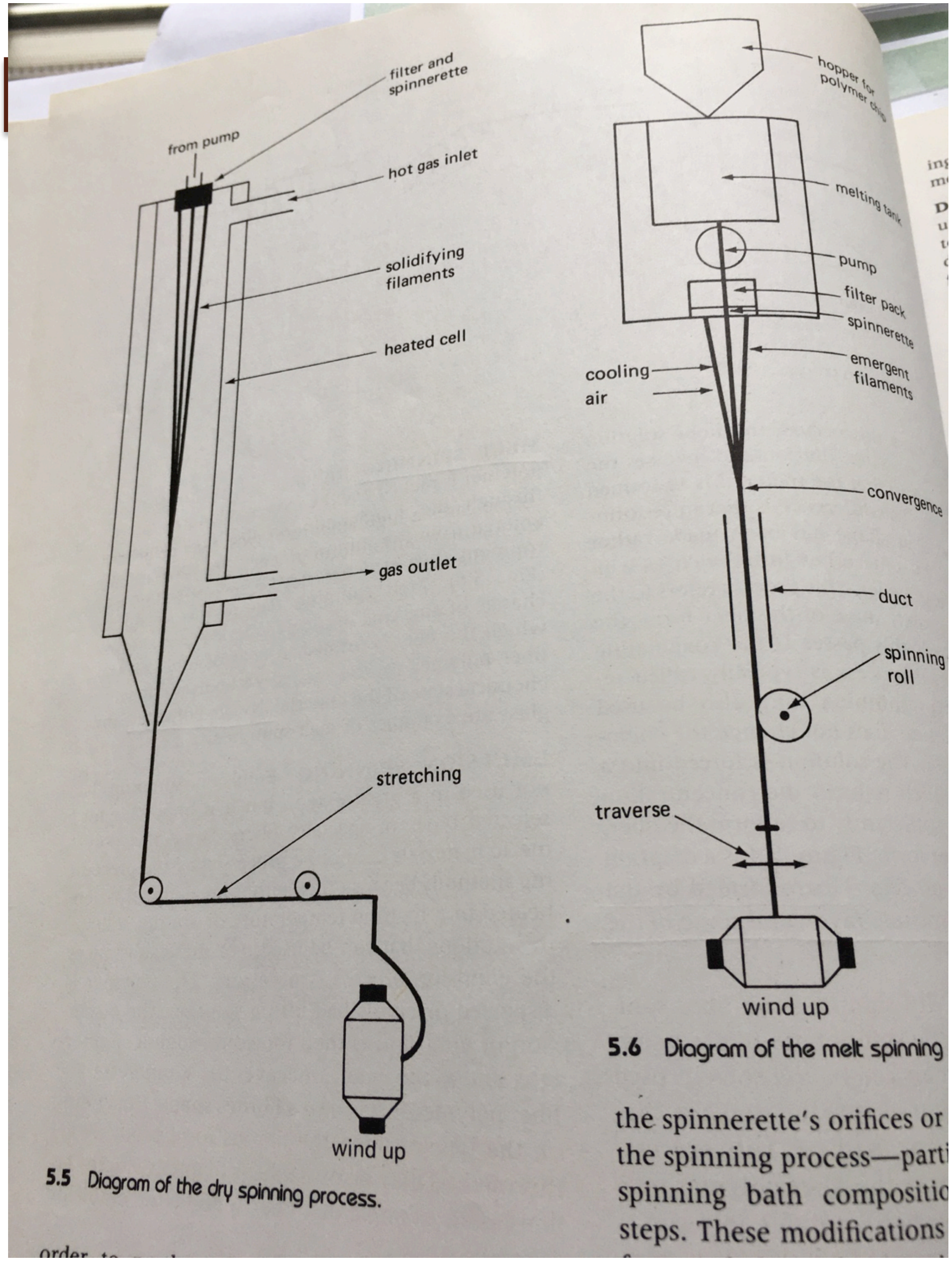
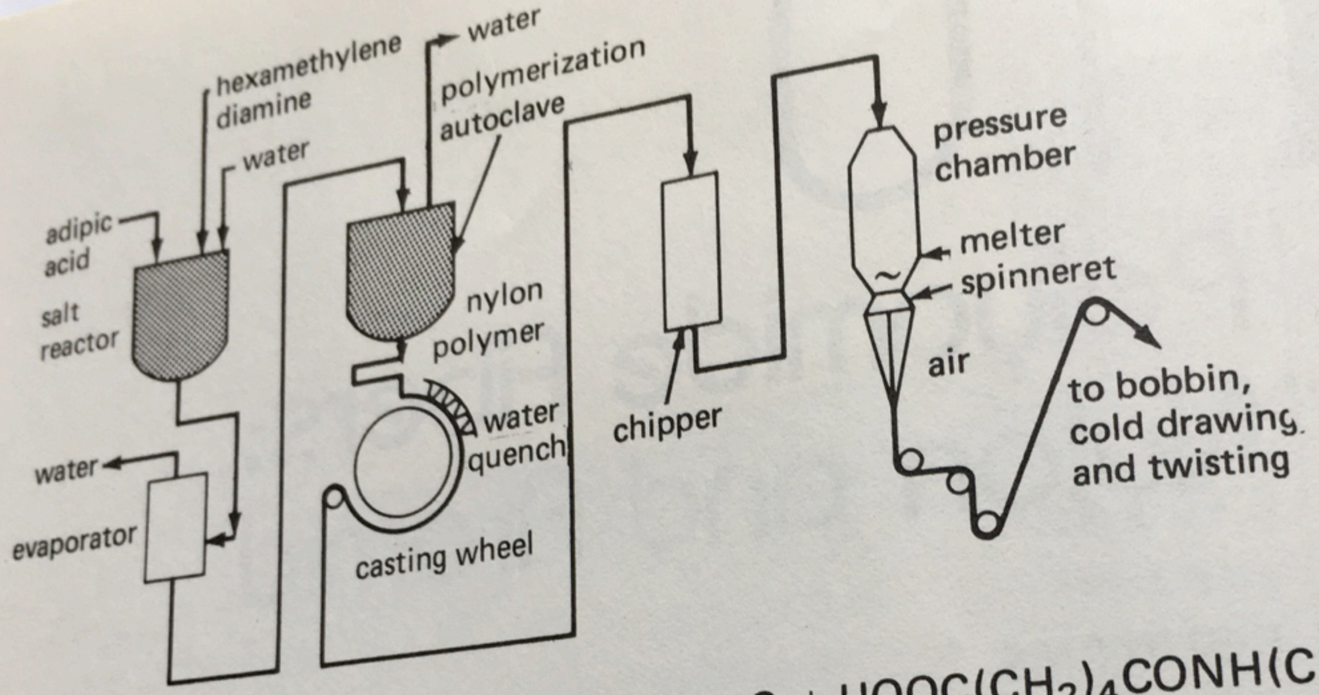


5.5 Diagram of the dry spinning process.

5.6 Diagram of the melt spinning

the spinnerette's orifices or
the spinning process—parti
spinning bath compositio
steps. These modifications

order

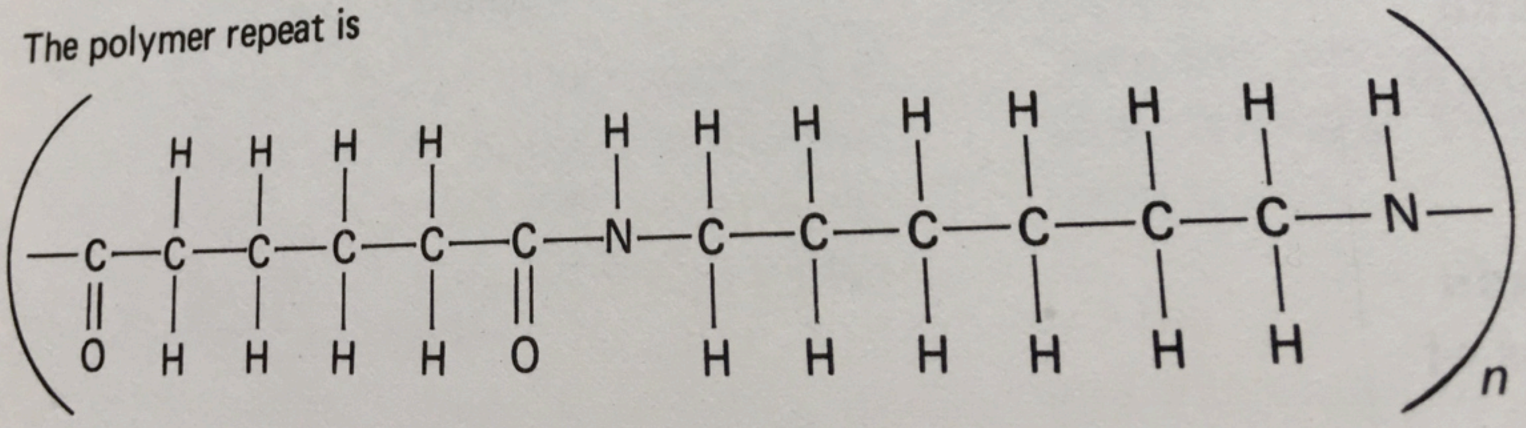


10.1 Flow diagram showing manufacture of nylon 6,6.

$$\mathrm{HOOC(CH_2)_4COOH + NH_2(CH_2)_6\,NH_2 \rightarrow H_2O + HOOC(CH_2)_4CONH(CH_2)_6NH_2}$$

adipic acid + hexamethylene diamine → water + hexamethylenediamine adipamide

The polymer repeat is



$$\left(-\underset{\underset{O}{\|}}{C}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{O}{\|}}{C}-\overset{\overset{H}{|}}{N}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\overset{\overset{H}{|}}{N}- \right)_n$$

n = times repeated in final molecule = 50–80+

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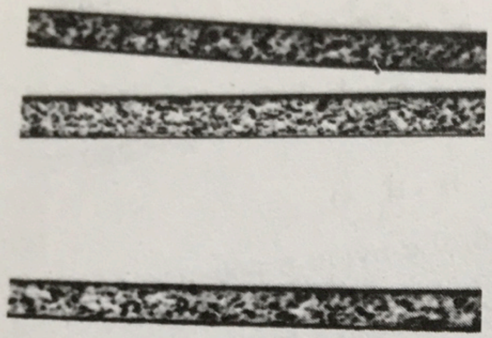
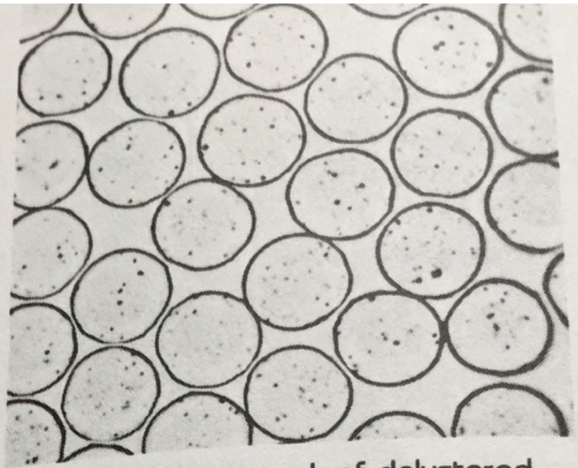
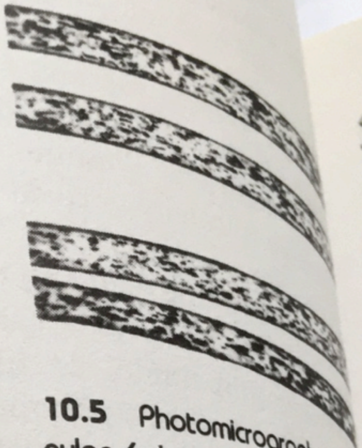


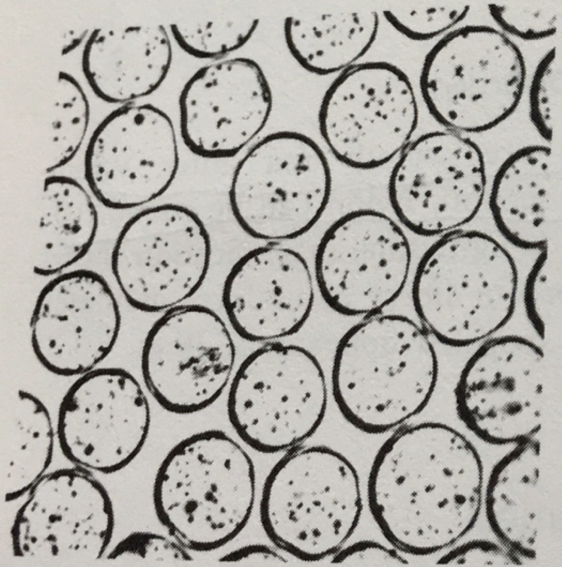
10.3 Photomicrograph of delustered nylon 6,6, longitudinal view. (DuPont Company)



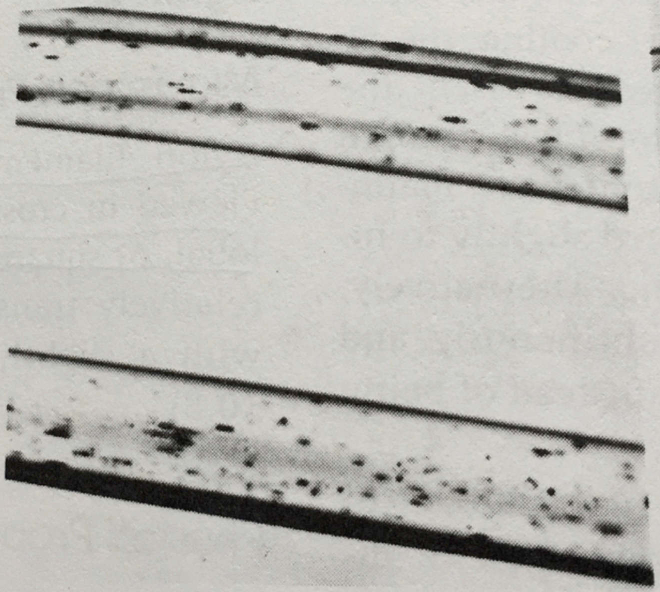
10.4 Photomicrograph of delustered nylon 6,6, cross section. (DuPont Company)



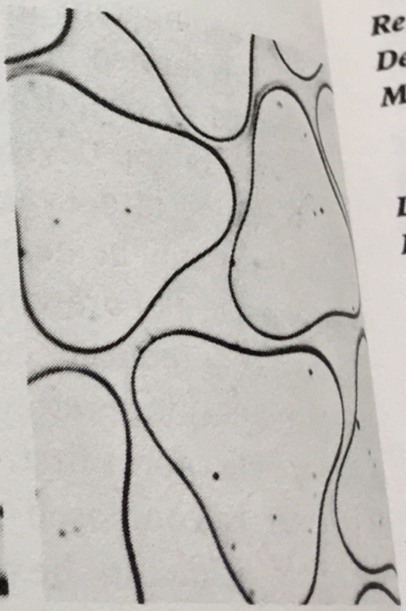
10.5 Photomicrograph of del nylon 6, longitudinal view. (Du Company)



10.6 Photomicrograph of delustered nylon 6, cross section. (DuPont Company)



10.7 Photomicrograph of trilobal nylon 6,6, longitudinal view. (DuPont Company)



10.8 Photomicrograph of trilob 6,6, cross section. (DuPont Co

◇ TABLE 10.

Property

Shape

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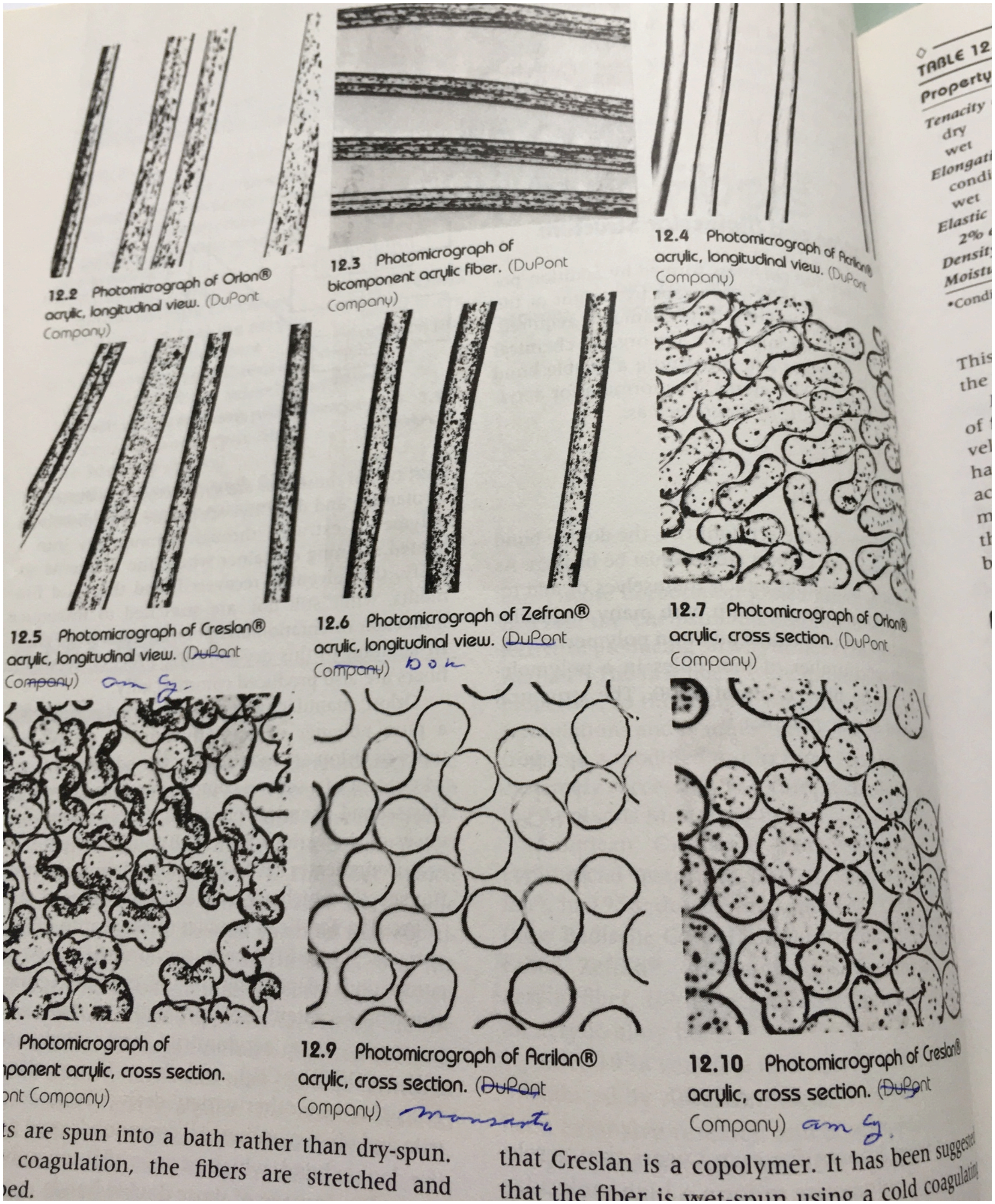

12.2 Photomicrograph of Orlon® acrylic, longitudinal view. (DuPont Company)

12.3 Photomicrograph of bicomponent acrylic fiber. (DuPont Company)

12.4 Photomicrograph of Acrilan® acrylic, longitudinal view. (DuPont Company)

12.5 Photomicrograph of Creslan® acrylic, longitudinal view. (~~DuPont~~ ~~Company~~) am cy.

12.6 Photomicrograph of Zefran® acrylic, longitudinal view. (~~DuPont~~ ~~Company~~) Dow

12.7 Photomicrograph of Orlon® acrylic, cross section. (DuPont Company)

Photomicrograph of
ponent acrylic, cross section.
ont Company)

12.9 Photomicrograph of Acrilan® acrylic, cross section. (~~DuPont~~ Company) Monsanto

12.10 Photomicrograph of Creslan® acrylic, cross section. (~~DuPont~~ Company) am cy.

ts are spun into a bath rather than dry-spun. coagulation, the fibers are stretched and ed.

that Creslan is a copolymer. It has been suggested that the fiber is wet-spun using a cold coagulating

◇ TABLE 12
Property
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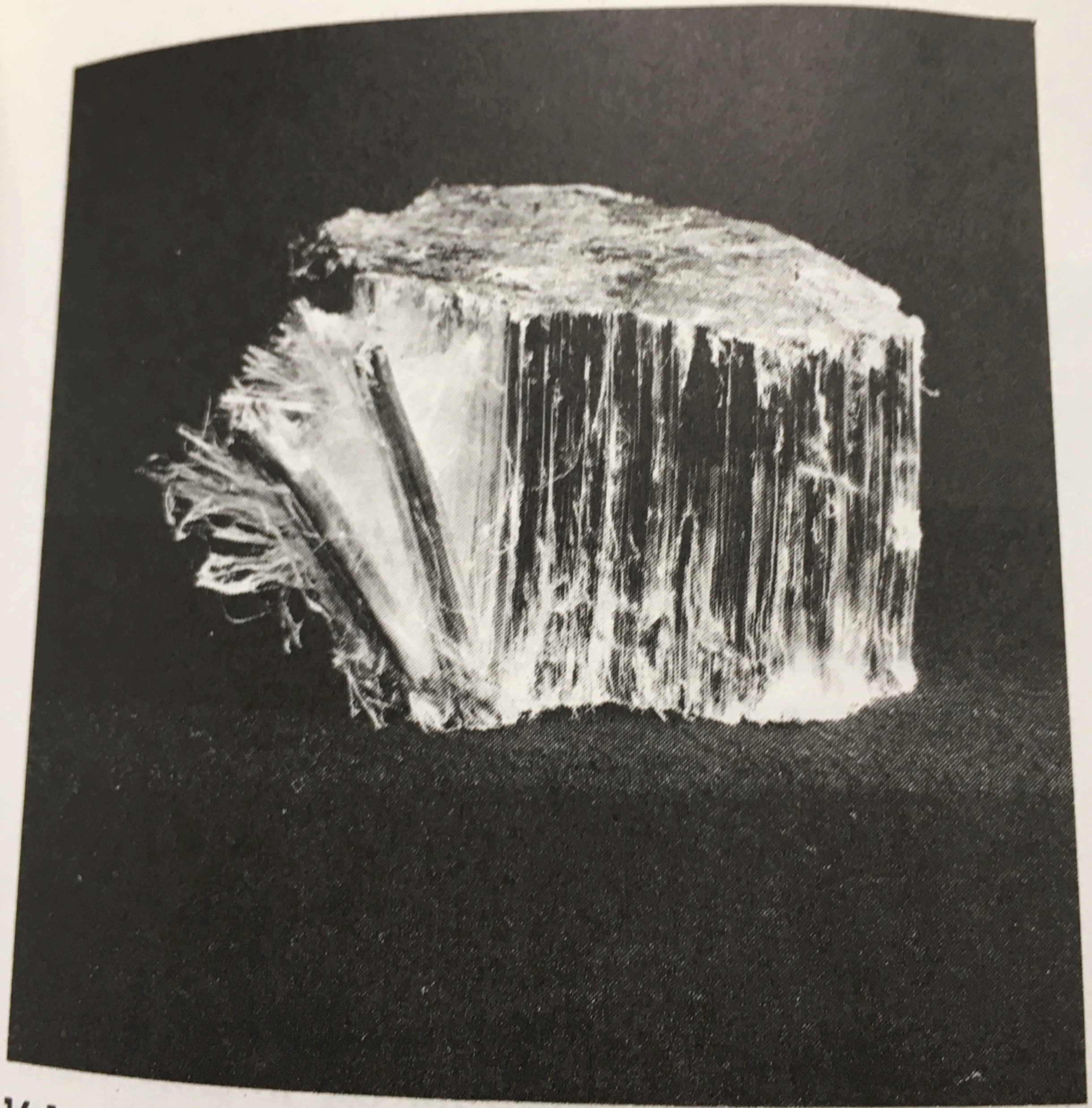
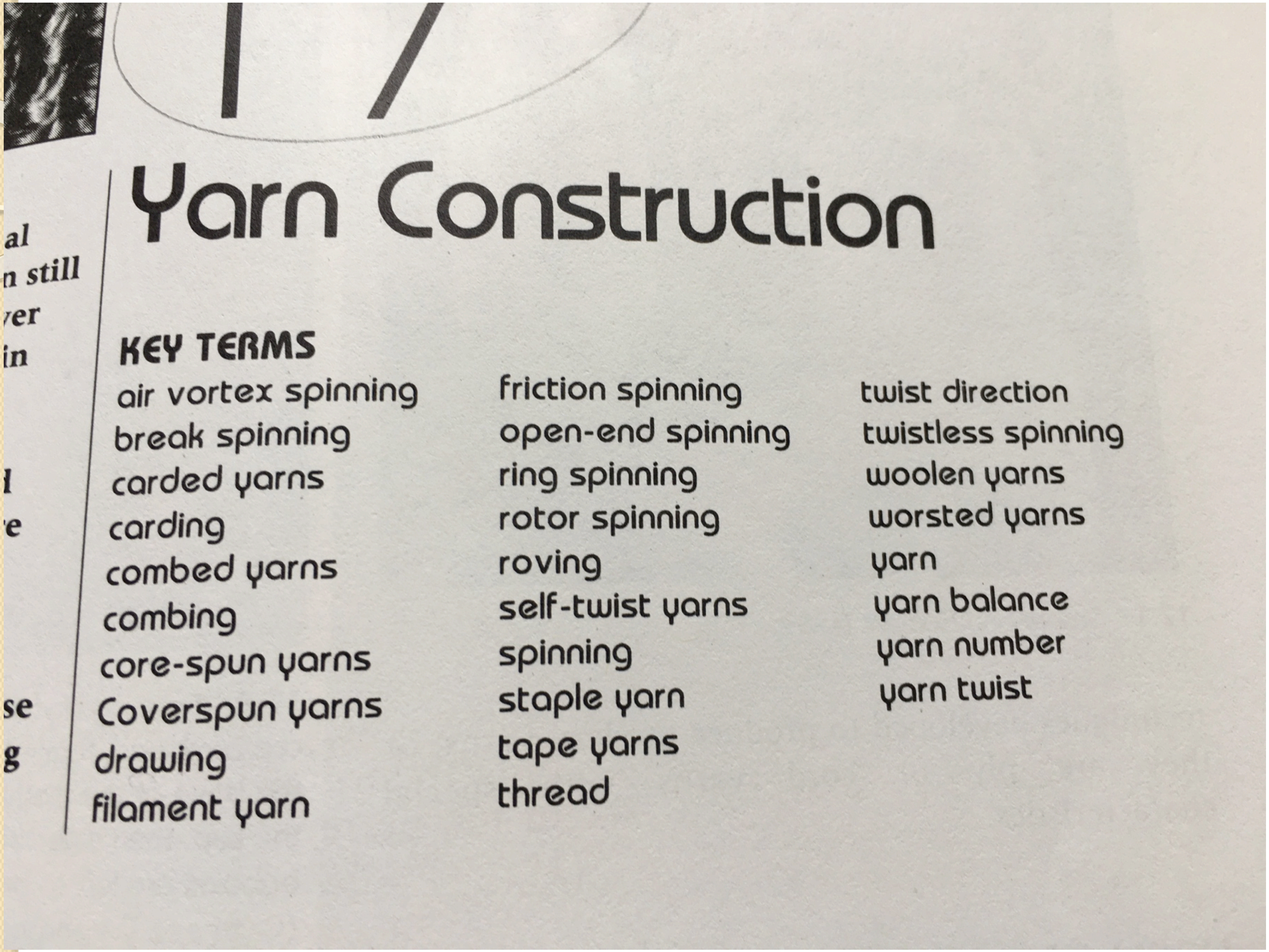


16.1 Asbestos rock showing both rock and fiber form.
(Manville Products Corporation)

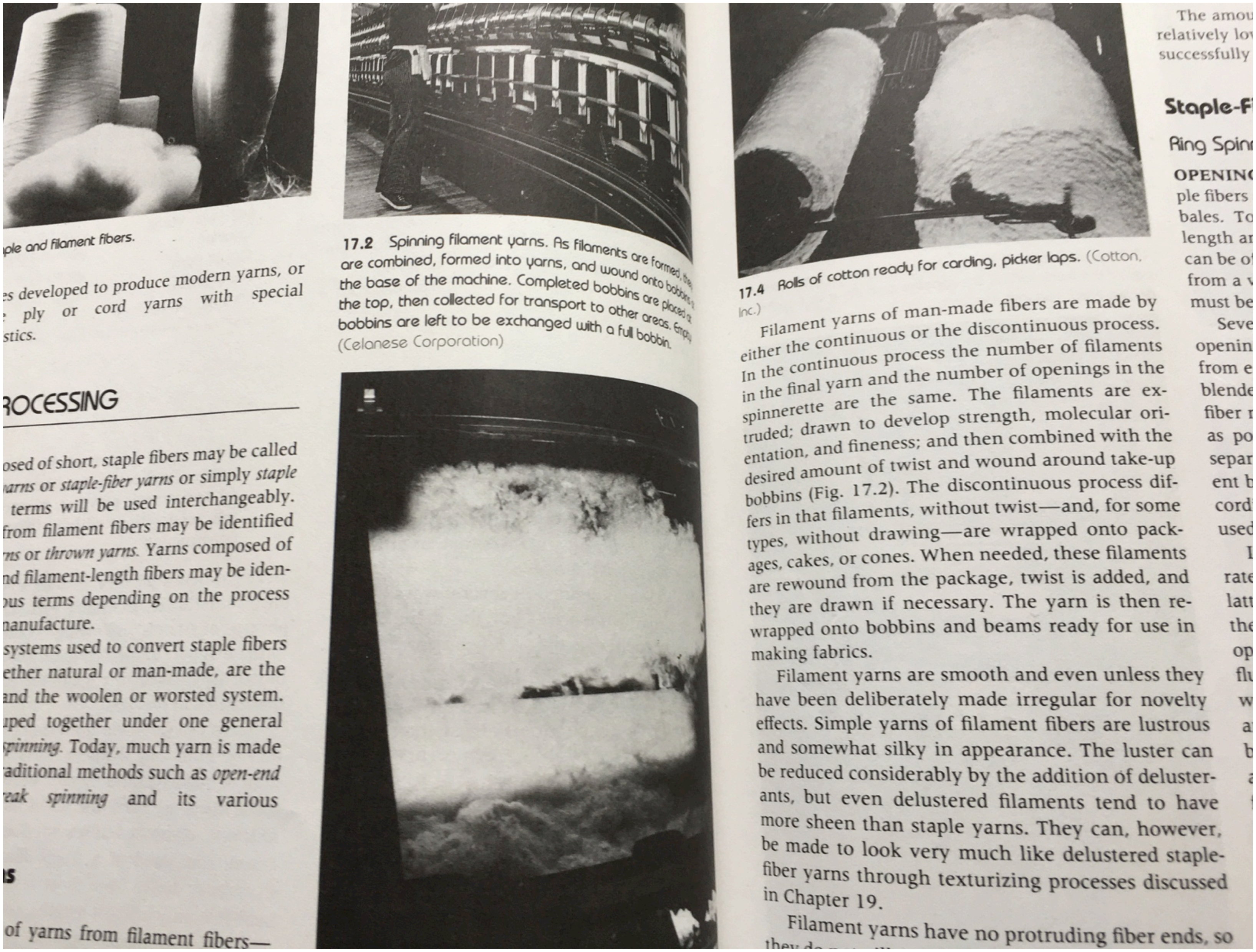


17

Yarn Construction

KEY TERMS

- air vortex spinning
- break spinning
- carded yarns
- carding
- combed yarns
- combing
- core-spun yarns
- Coverspun yarns
- drawing
- filament yarn
- friction spinning
- open-end spinning
- ring spinning
- rotor spinning
- roving
- self-twist yarns
- spinning
- staple yarn
- tape yarns
- thread
- twist direction
- twistless spinning
- woolen yarns
- worsted yarns
- yarn
- yarn balance
- yarn number
- yarn twist



ple and filament fibers.

es developed to produce modern yarns, or
ply or cord yarns with special
stics.

ROCESSING

osed of short, staple fibers may be called
arns or *staple-fiber yarns* or simply *staple*
terms will be used interchangeably.
from filament fibers may be identified
ns or *thrown yarns.* Yarns composed of
nd filament-length fibers may be iden-
ous terms depending on the process
nanufacture.
systems used to convert staple fibers
ether natural or man-made, are the
and the woolen or worsted system.
uped together under one general
pinning. Today, much yarn is made
aditional methods such as *open-end*
eak spinning and its various

S

of yarns from filament fibers—

17.2 Spinning filament yarns. As filaments are formed, they are combined, formed into yarns, and wound onto bobbins at the base of the machine. Completed bobbins are placed at the top, then collected for transport to other areas. Empty bobbins are left to be exchanged with a full bobbin. (Celanese Corporation)

17.4 Rolls of cotton ready for carding, picker laps. (Cotton, Inc.)

Filament yarns of man-made fibers are made by either the continuous or the discontinuous process. In the continuous process the number of filaments in the final yarn and the number of openings in the spinnerette are the same. The filaments are extruded; drawn to develop strength, molecular orientation, and fineness; and then combined with the desired amount of twist and wound around take-up bobbins (Fig. 17.2). The discontinuous process differs in that filaments, without twist—and, for some types, without drawing—are wrapped onto packages, cakes, or cones. When needed, these filaments are rewound from the package, twist is added, and they are drawn if necessary. The yarn is then rewrapped onto bobbins and beams ready for use in making fabrics.

Filament yarns are smooth and even unless they have been deliberately made irregular for novelty effects. Simple yarns of filament fibers are lustrous and somewhat silky in appearance. The luster can be reduced considerably by the addition of delusterants, but even delustered filaments tend to have more sheen than staple yarns. They can, however, be made to look very much like delustered staple-fiber yarns through texturizing processes discussed in Chapter 19.

Filament yarns have no protruding fiber ends, so

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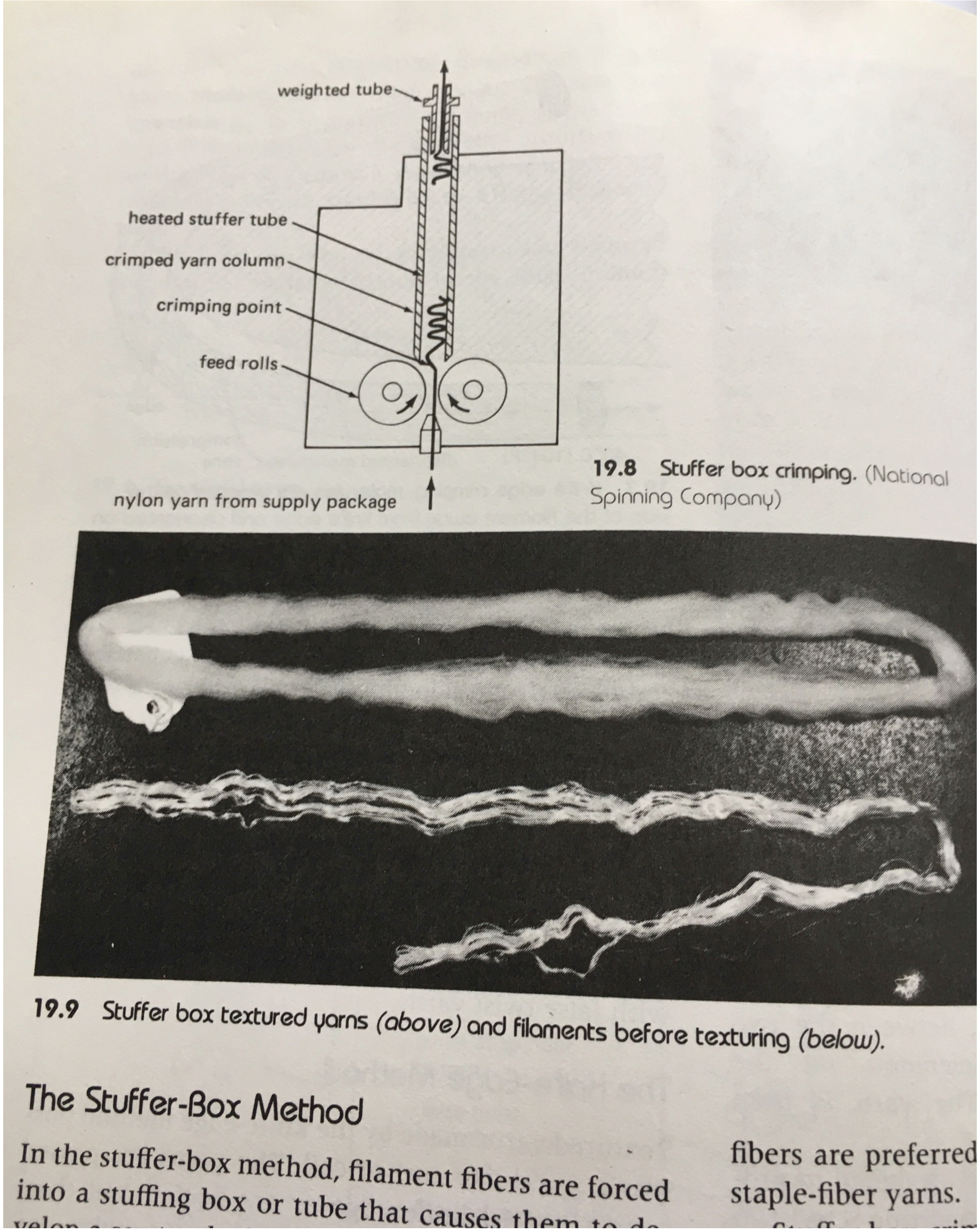


19.8 Stuffer box crimping. (National Spinning Company)

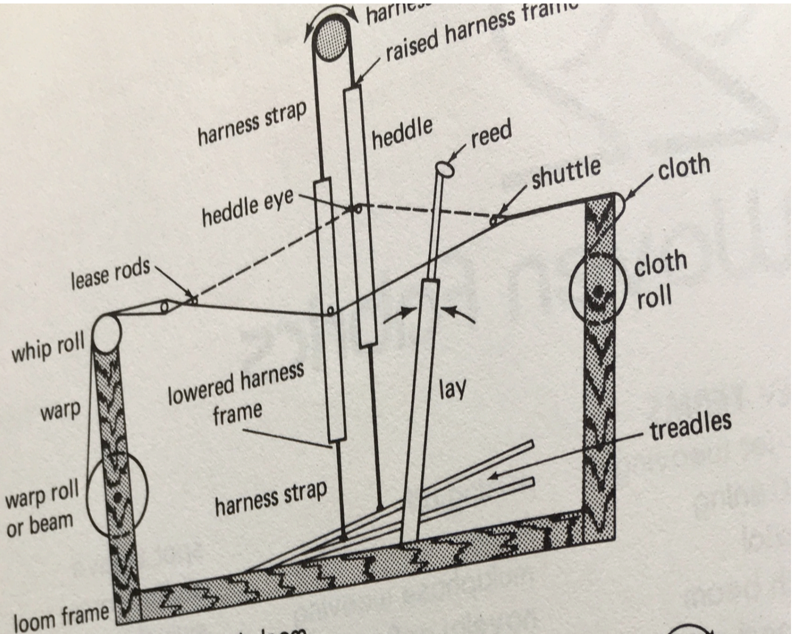
19.9 Stuffer box textured yarns *(above)* and filaments before texturing *(below)*.

The Stuffer-Box Method

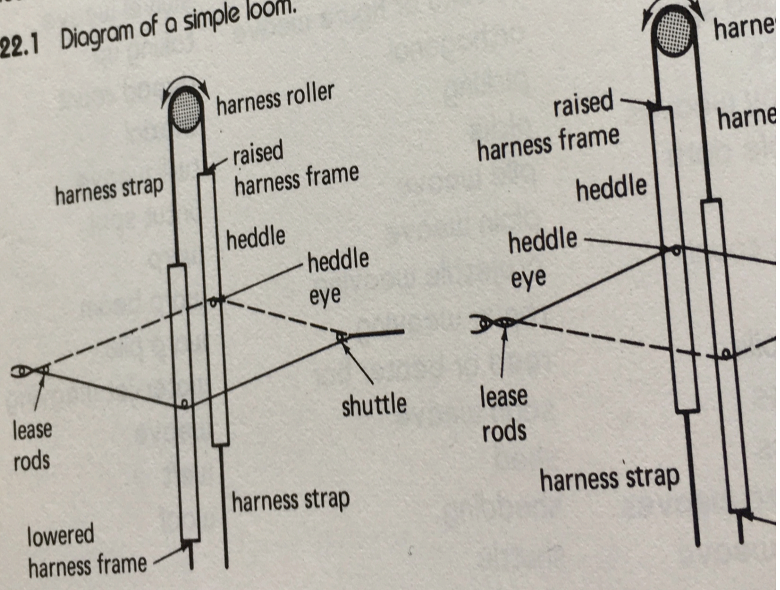
In the stuffer-box method, filament fibers are forced into a stuffing box or tube that causes them to de-

fibers are preferred

staple-fiber yarns.



22.1 Diagram of a simple loom.



22.2 Diagram showing movement of harnesses and warp yarns to form

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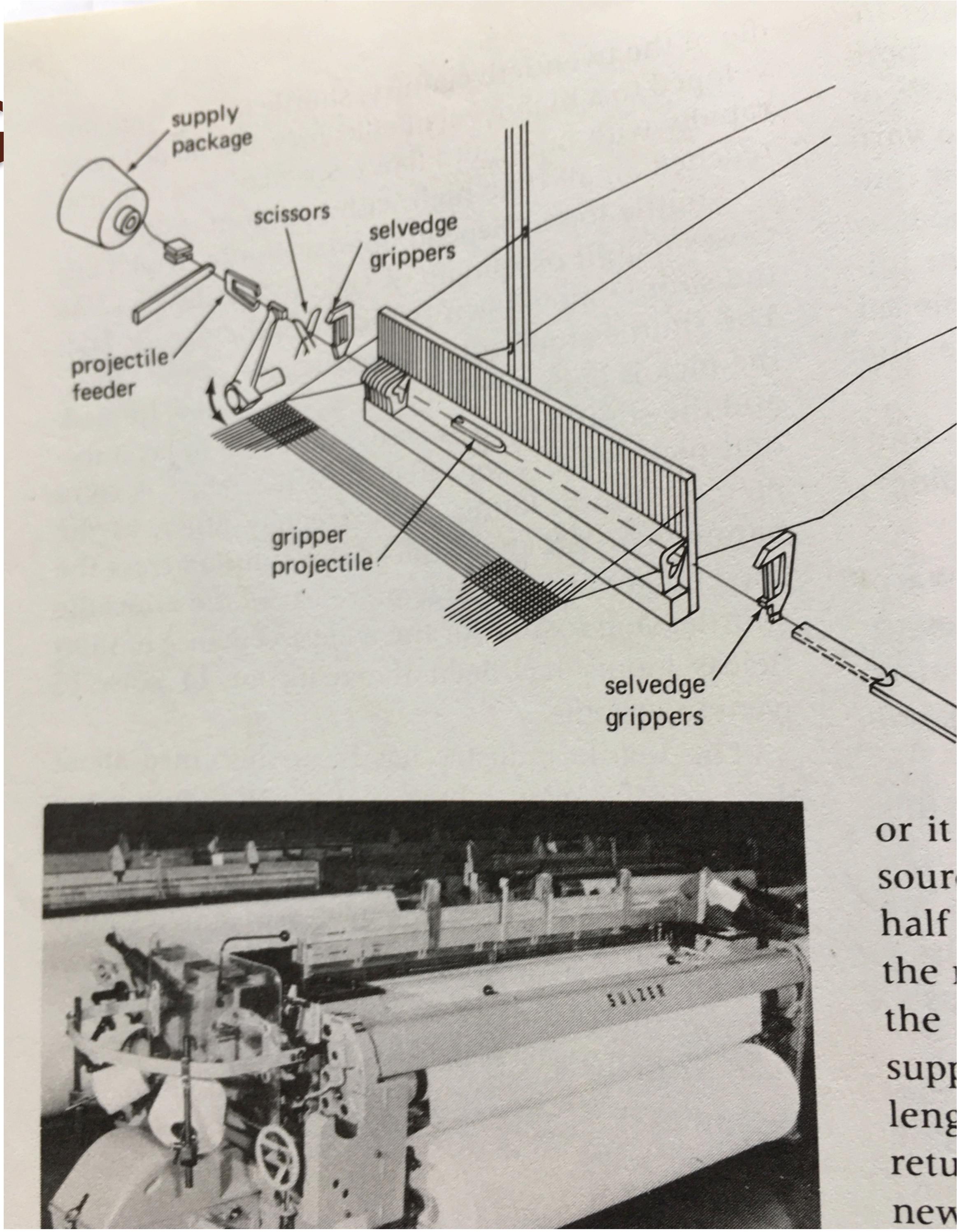

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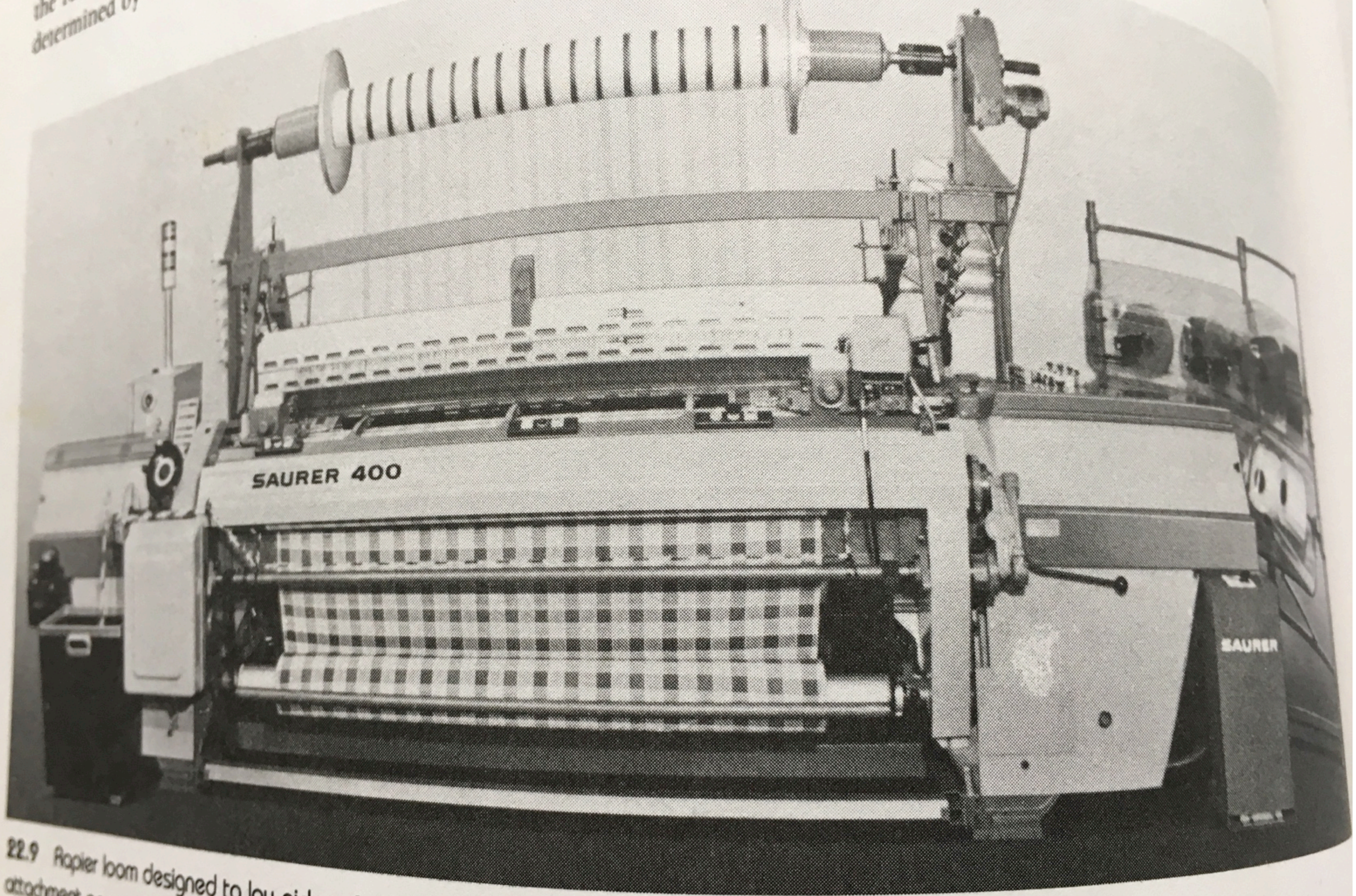
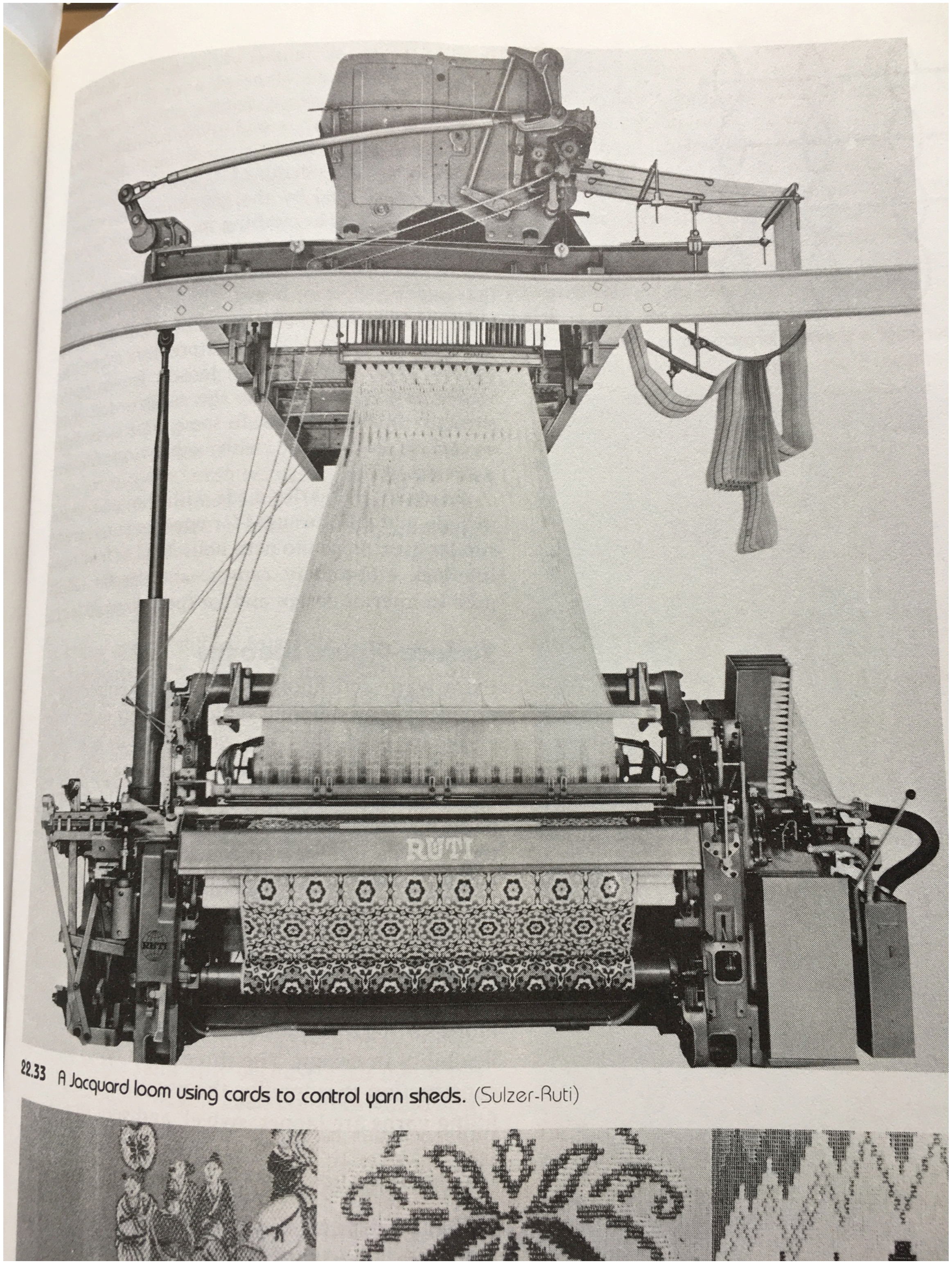
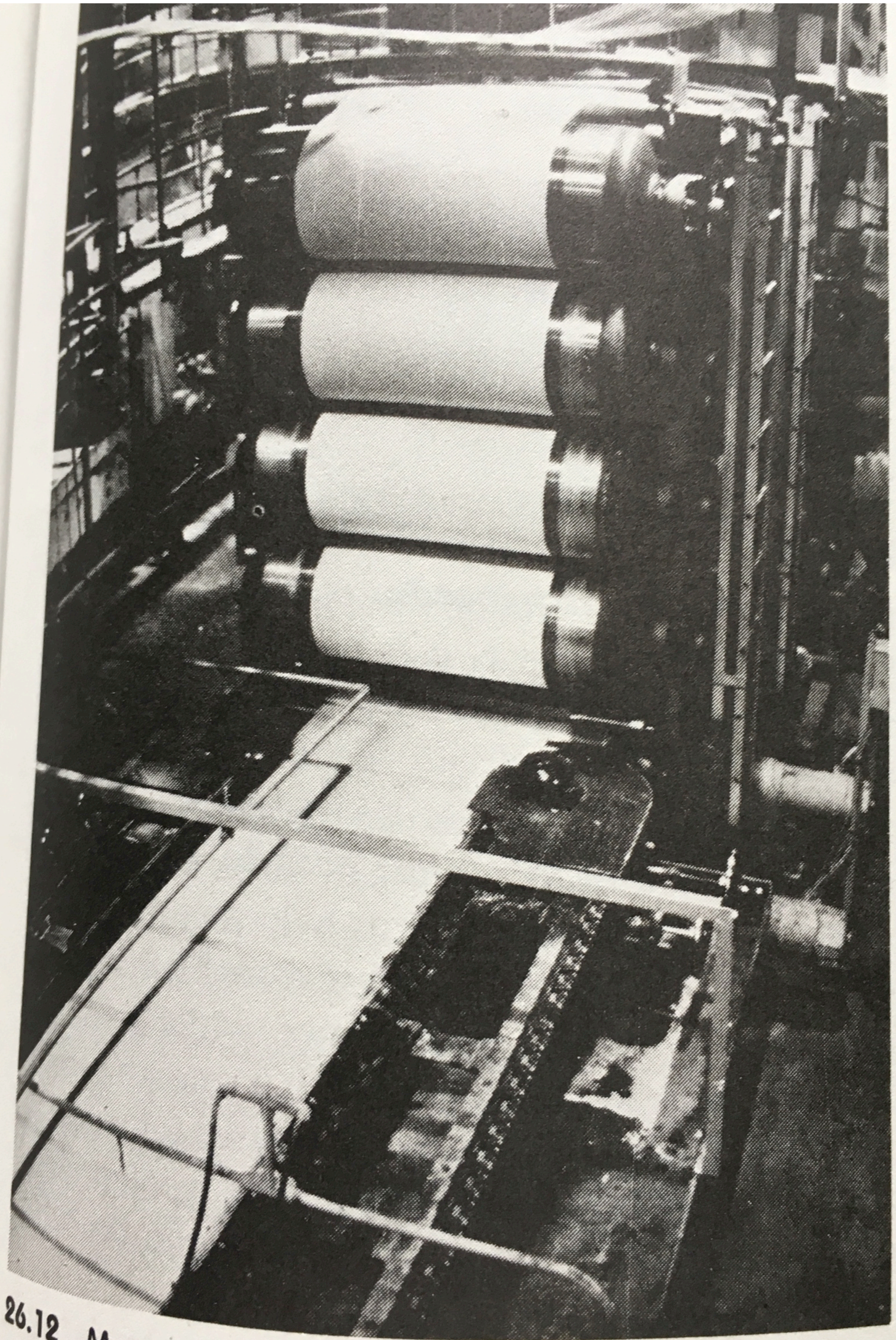


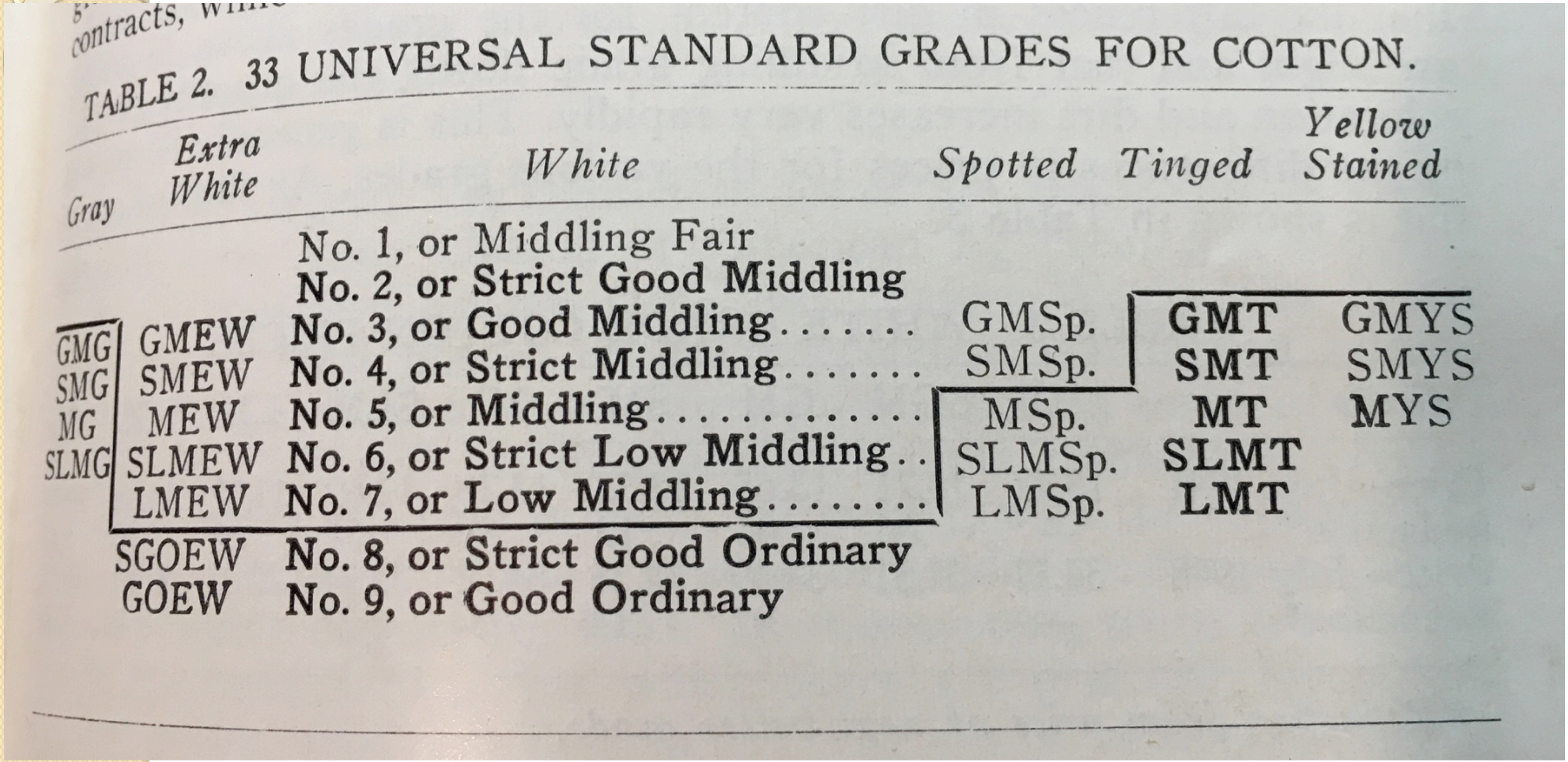
22.9 Rapier loom designed to lay picks of different colors. Design is controlled by a dobby attachment operated by electronic controls. (Saurer Textile Machinery)



22.33 A Jacquard loom using cards to control yarn sheds. (Sulzer-Ruti)



26.12 Mercerizing machine. (Sonoco Industries, Inc.)



contracts,

TABLE 2. 33 UNIVERSAL STANDARD GRADES FOR COTTON.

Gray	*Extra White*	*White*	*Spotted*	*Tinged*	*Yellow Stained*
		No. 1, or Middling Fair			
		No. 2, or Strict Good Middling			
GMG	GMEW	**No. 3, or Good Middling**	GMSp.	**GMT**	GMYS
SMG	SMEW	**No. 4, or Strict Middling**	SMSp.	**SMT**	SMYS
MG	MEW	**No. 5, or Middling**	MSp.	**MT**	**MYS**
SLMG	SLMEW	**No. 6, or Strict Low Middling**	SLMSp.	**SLMT**	
	LMEW	**No. 7, or Low Middling**	LMSp.	**LMT**	
	SGOEW	**No. 8, or Strict Good Ordinary**			
	GOEW	**No. 9, or Good Ordinary**			


HORIZONTAL SWISS WARPER
SIPP MACHINE CO.
PATERSON, N.J.
CIRCA-1920
Gift of George McLoof
THE SIPP MACHINE CO.
PATERSON, N.J. PATENTED


DRAPERY & UPHOLSTERY
FABRICS
CREEL WITH BOBBINS
SIPP MACHINE CO.
PATERSON, N.J.
CIRCA-1920
Gift of C. Wesly Thompson


JOSEPH TESHON
INCORPORATED
Manufacturers of
DRAPERY & UPHOLSTERY
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WITH BOBBINS
PP MACHINE CO.
ATERSON, N.J.
RCA-1920
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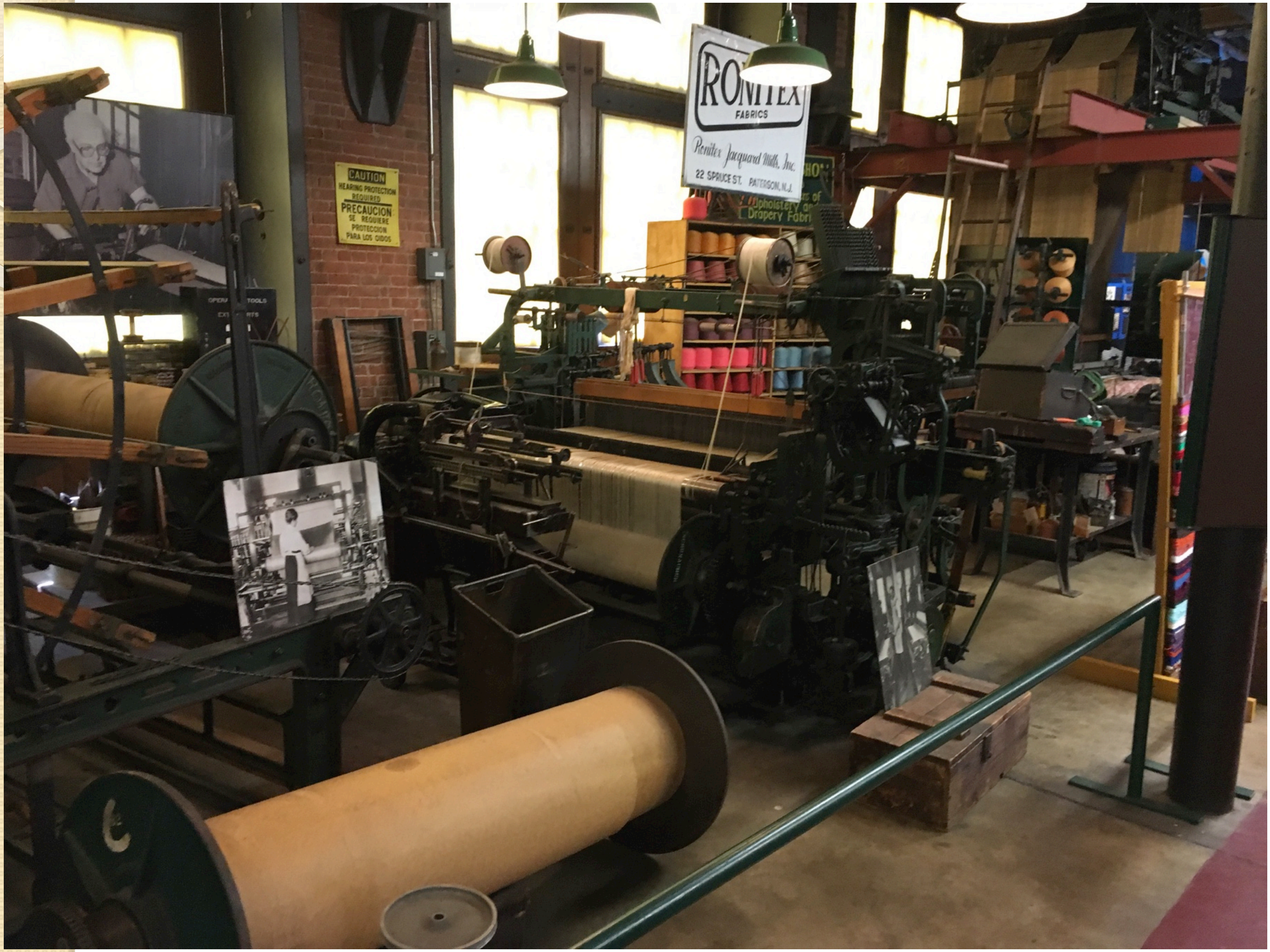
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Upholstery and
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JACQUARD OFS LOOM
CROMPTON AND KNOWLES LOOM WORKS
WORCESTER, MASS.
CIRCA-1970
Gift of F. Schumacher & Co.
JACQUARD HEAD
CROMPTON AND KNOWLES LOOM WORKS
WORCESTER, MASS.
CIRCA-1950
Gift of F. Schumacher & Co.


ROYLE


Engine Co. No. 2
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FIRE DEPT.


SIPP MACHINE CO
PATERSON, N.J.
MAKERS, PATENT APPLIED FOR


SIPP MACH. CO.
CREEL WITH BOBBINS
SIPP MACHINE CO.
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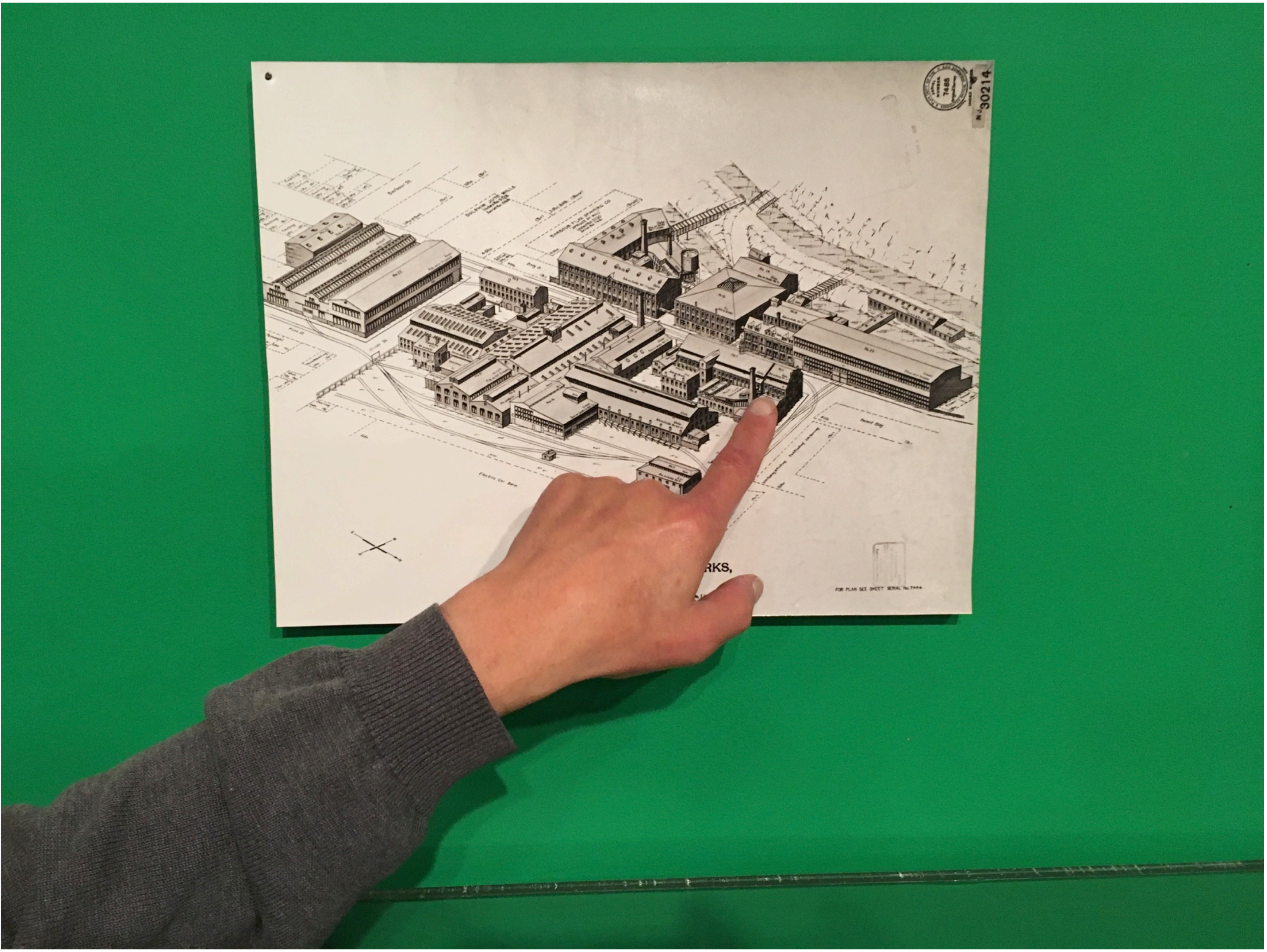
Gift of C. Wesly Thompson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Route Map of the Great Locomotive Chase
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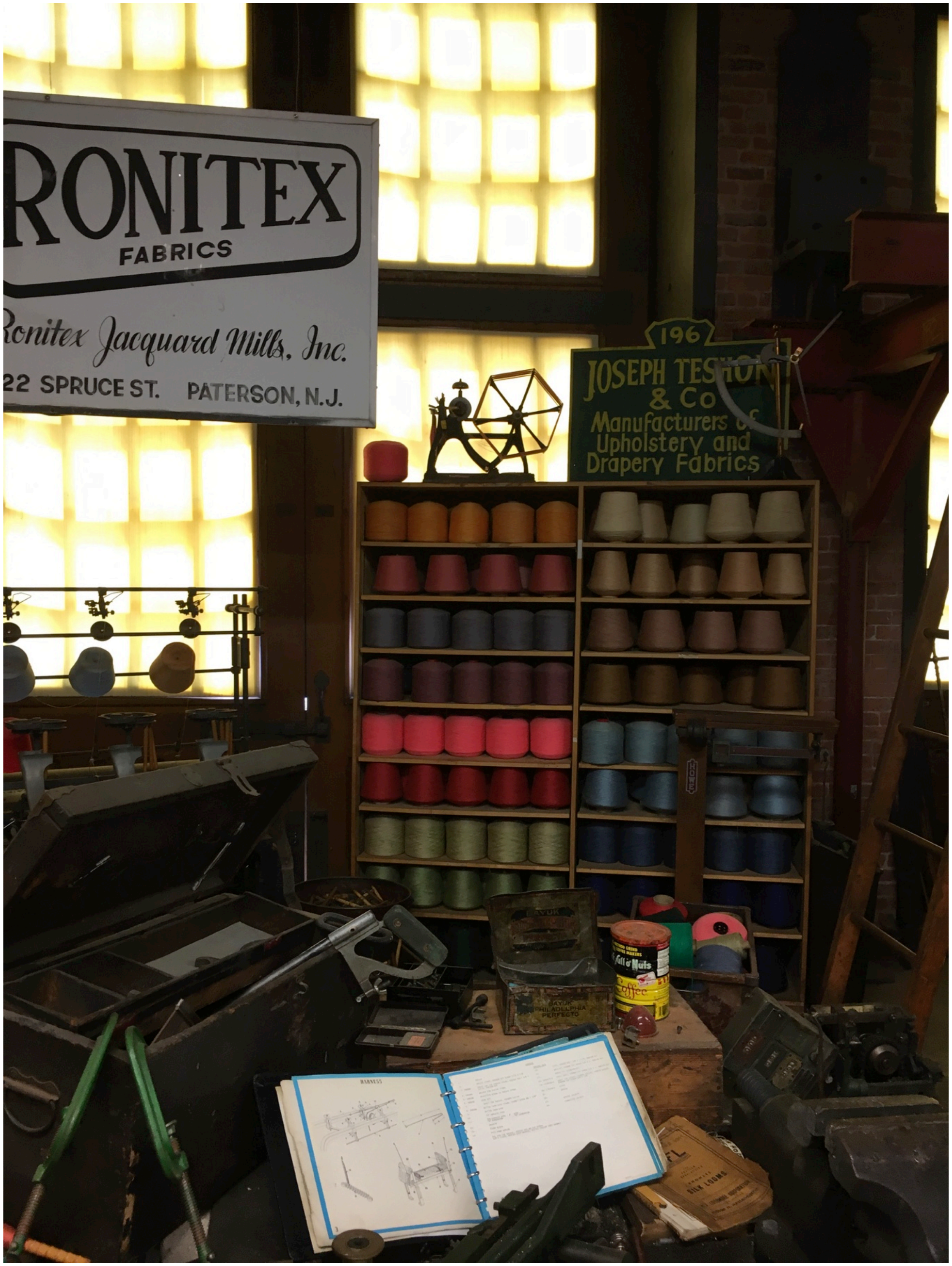
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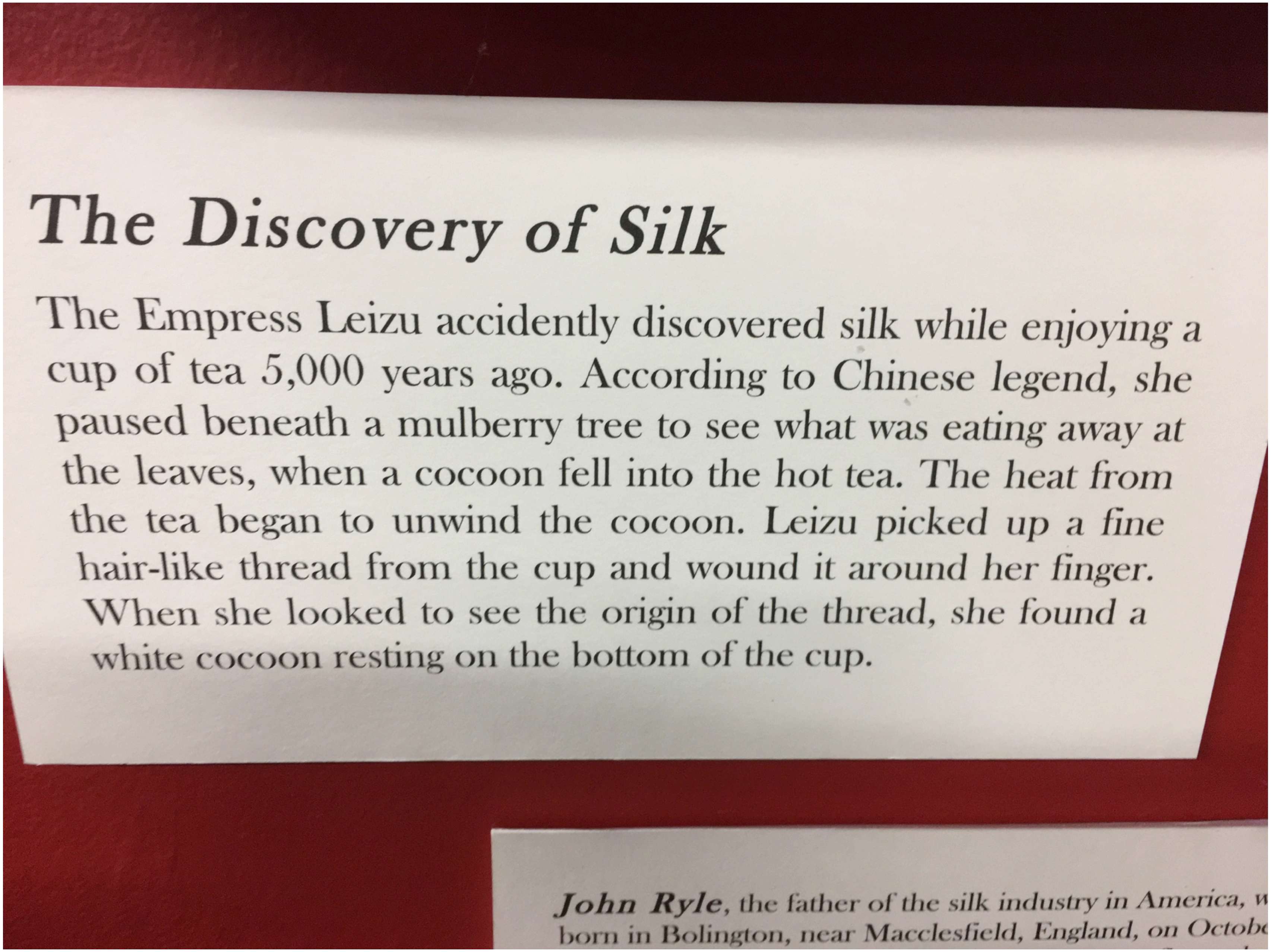
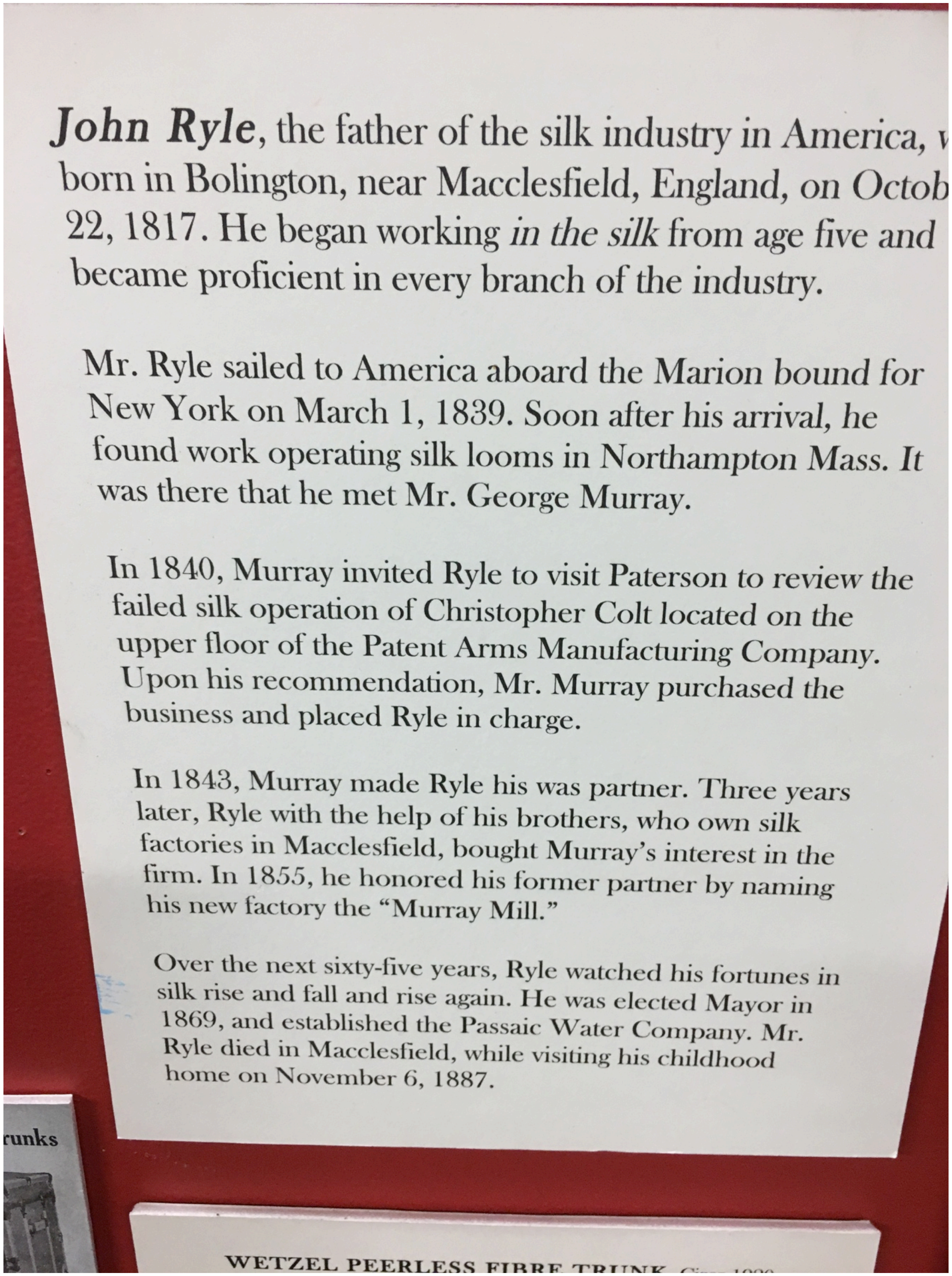
LIFE CYCLE OF SILKWORM
THE JAPAN SILK ASSOCIATION Inc.
Silk and the
The silkworm is not
the silk moth. The
adult stage, is a mere
silkworm phase
When fully grown,
cocoon is a protein-
glands and excreted
liquid solidifies when
takes five days and
3,000 feet long. The
another five days.
Sericulture is
producing silk.
it is the Bombyx
the finest quality silk.
and since it cannot fly
The larvae are fed a
10,000 times their
the cocoons are
to unwind the silk
moth were allowed to
the valuable silk.
After unwinding, the
spinning and weaving.
one pound of silk.
The Discovery of Silk



The Discovery of *Silk*

The Empress Leizu accidently discovered silk while enjoying a cup of tea 5,000 years ago. According to Chinese legend, she paused beneath a mulberry tree to see what was eating away at the leaves, when a cocoon fell into the hot tea. The heat from the tea began to unwind the cocoon. Leizu picked up a fine hair-like thread from the cup and wound it around her finger. When she looked to see the origin of the thread, she found a white cocoon resting on the bottom of the cup.

John Ryle, the father of the silk industry in America, w
born in Bolington, near Macclesfield, England, on Octob



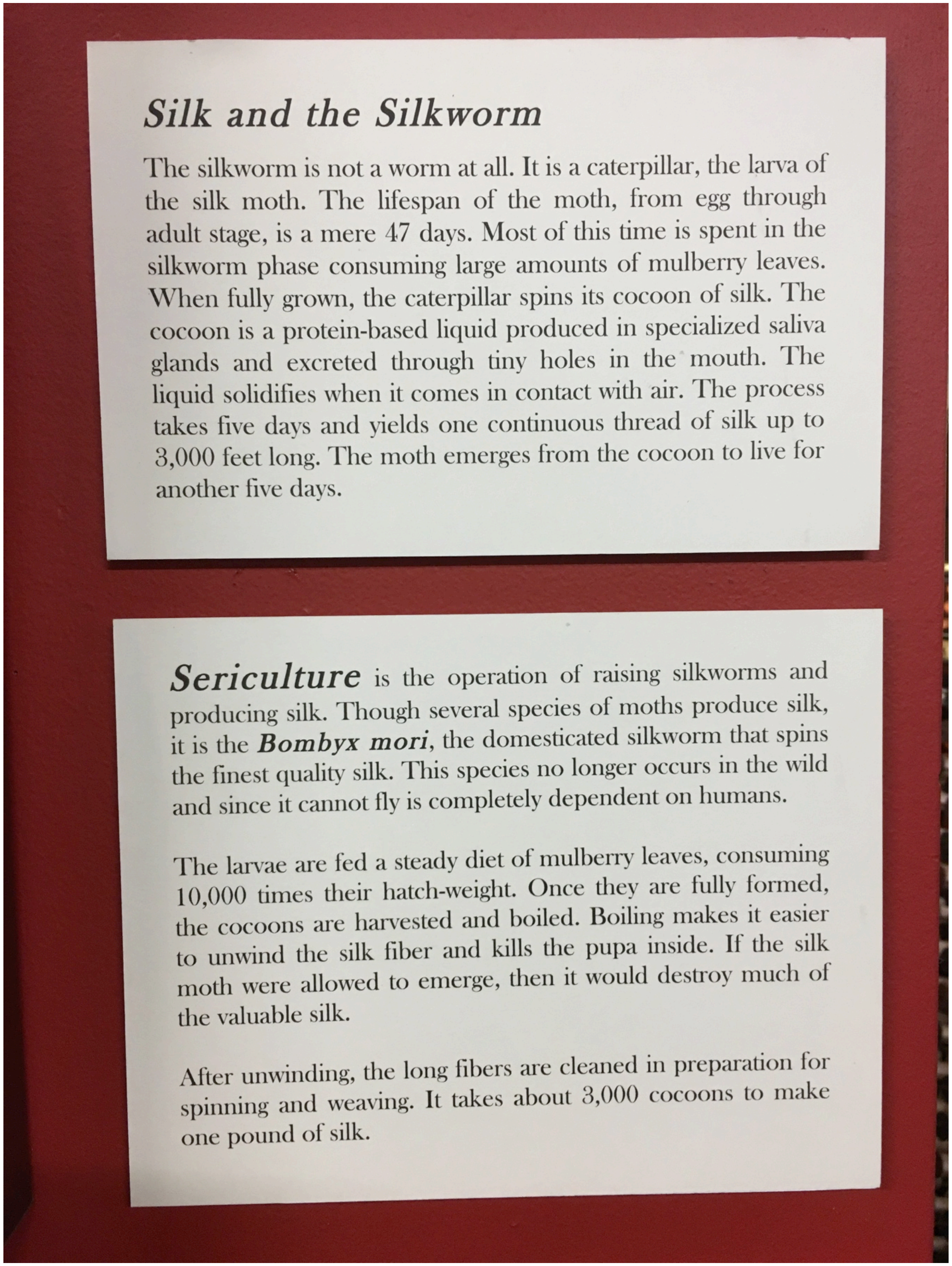
John Ryle, the father of the silk industry in America,
born in Bolington, near Macclesfield, England, on Octob
22, 1817. He began working *in the silk* from age five and became proficient in every branch of the industry.

Mr. Ryle sailed to America aboard the Marion bound for New York on March 1, 1839. Soon after his arrival, he found work operating silk looms in Northampton Mass. It was there that he met Mr. George Murray.

In 1840, Murray invited Ryle to visit Paterson to review the failed silk operation of Christopher Colt located on the upper floor of the Patent Arms Manufacturing Company. Upon his recommendation, Mr. Murray purchased the business and placed Ryle in charge.

In 1843, Murray made Ryle his was partner. Three years later, Ryle with the help of his brothers, who own silk factories in Macclesfield, bought Murray's interest in the firm. In 1855, he honored his former partner by naming his new factory the "Murray Mill."

Over the next sixty-five years, Ryle watched his fortunes in silk rise and fall and rise again. He was elected Mayor in 1869, and established the Passaic Water Company. Mr. Ryle died in Macclesfield, while visiting his childhood home on November 6, 1887.



Silk and the Silkworm

The silkworm is not a worm at all. It is a caterpillar, the larva of the silk moth. The lifespan of the moth, from egg through adult stage, is a mere 47 days. Most of this time is spent in the silkworm phase consuming large amounts of mulberry leaves. When fully grown, the caterpillar spins its cocoon of silk. The cocoon is a protein-based liquid produced in specialized saliva glands and excreted through tiny holes in the mouth. The liquid solidifies when it comes in contact with air. The process takes five days and yields one continuous thread of silk up to 3,000 feet long. The moth emerges from the cocoon to live for another five days.

Sericulture is the operation of raising silkworms and producing silk. Though several species of moths produce silk, it is the ***Bombyx mori***, the domesticated silkworm that spins the finest quality silk. This species no longer occurs in the wild and since it cannot fly is completely dependent on humans.

The larvae are fed a steady diet of mulberry leaves, consuming 10,000 times their hatch-weight. Once they are fully formed, the cocoons are harvested and boiled. Boiling makes it easier to unwind the silk fiber and kills the pupa inside. If the silk moth were allowed to emerge, then it would destroy much of the valuable silk.

After unwinding, the long fibers are cleaned in preparation for spinning and weaving. It takes about 3,000 cocoons to make one pound of silk.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