Spun Silk to Artificial Silk:

the 19th and 20th Centuries Demi-luxe

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Key Words: Silk, Artificial Silk, Rayon, Spun Silk, Demi-luxe

WHAT IS SILK?

Silk always represents wealth, power, luxury and comfort anywhere in the world. Even in China where silk originates from, silk was not for ordinary people but for the elite class. In Japan, likewise, since the introduction of silk throwing, it was produced exclusively at textile mills under the control of the imperial court until the Middle Ages.[1] And it was nothing like commercial products in the sense that cotton has been since the sixteenth century. So, what characteristics of silk distinguish it from other materials? The characteristics of silk fabric lies in its fineness, thinness, softness, strength, warmth/coolness, luster, contrast between shine and shadow on drapes, squeaky sound, and translucency. Some of these characteristics are shared by other natural fibers though, luster that derives from the structure of fibroin, accentuates its difference from others. It was only in the latter half of the nineteenth century, when the fashion that used to stand for silk was copied by something cheaper, spun silk, and fifty years later by rayon. This paper, will examine how this happened and why, based on the documents that reflect the intentions of both producers and consumers.

SPUN SILK

Spun silk is made of silk waste from the throwing process, also unreelable cocoons, and broken or dirty cocoons. So, silk spinning and silk throwing cannot be separated feasibly because most of the resources for spinning were generated during the process of silk throwing, and the mechanization of spinning became possible only because a silk throwing industry already existed.

After being degummed and then combed out into parallel fibers, silk waste fibers are cut into shorter lengths and drawn out into a rope of parallel, overlapping fibers (slivers). The slivers that are drawn further and given a twist become roving and eventually spun silk. The whole process reminds you of cotton or wool spinning, rather than silk throwing.

The first silk-spinning mill was established not in traditional silk areas but in Galgate,

six kilometers from Lancaster, England in 1792. Eight years before that, in Dolphinholme of the same parish, the first worsted spinning mill was built.[2] The process of spinning silk waste was certainly developed on the cotton principle, this produced what is known as short spun yarns. The machinery to produce spun silk could have been identical to that used in wool or linen production as well. Theoretically, looms were suitable for weaving any kind of yarns. So, the silk-spinning industry emerged as a mechanized large-scale industry across national borders, including England, France, Switzerland, Italy, and Germany, in the latter half of the nineteenth century and from the very beginning, was able to use cotton or woolen-spinning machinery. Totally different was the silk-throwing industry.[3]

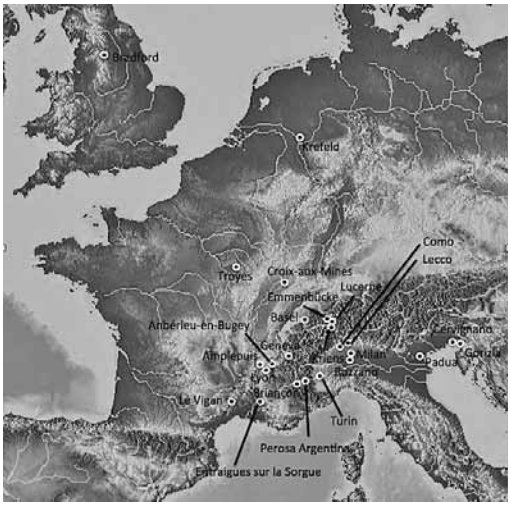

Fig. 1 Silk-spinning Industrial Clusters in Europe

Source: Naoko Inoue, 'Silk waste, spun silk, and Meisen kimono: Technological transfer and emergence of new industry in Japan from the late 19th century to the 1930s' in *Linking Cloth/Clothing Globally: the transformation of uses and value, c. 1700–2000,* ICES Hosei University Publishing, 2019, p. 227.

POPULARIZATION OF SILK AND SPUN SILK

The phrase, 'popularization of silk', implies mainly to a European trend shifting towards lighter, softer, thinner, and cheaper cloths that started, no later than in the eighteenth century, influenced by the influx of indienne, which continued throughout the following century.[4]

This phenomenon was accelerated by the price of silk textiles being cut to less than half during the nineteenth century in France. (Fig. 2) As a consequence, silk and mix cloth use increased among people.[5] There were some other factors, such as; the abolition of social classes, on-going industrialization in Europe and the U.S., emerging consumer societies and the cheaper fashionable products of silk and other mix fibers, the deterioration of silk commodities quality brought about by mass-consumption, and transitory seasonal changes (from 1870 to WWI) in the bourgeois style of dressing in Paris, London, and New

York, and the opening of the Suez Canal.

The popularization of silk was also brought about by the mechanization of silk spinning. Spun silk was less than half the cost of raw silk until the mid-nineteenth century, and was at least 30% cheaper in the 1870s. From 1905 to 1938, the ratio of spun silk (Schappe) output to silk thread output was over 90% in France. In Fig. 2, the price-advantage of spun silk is clearly evident.

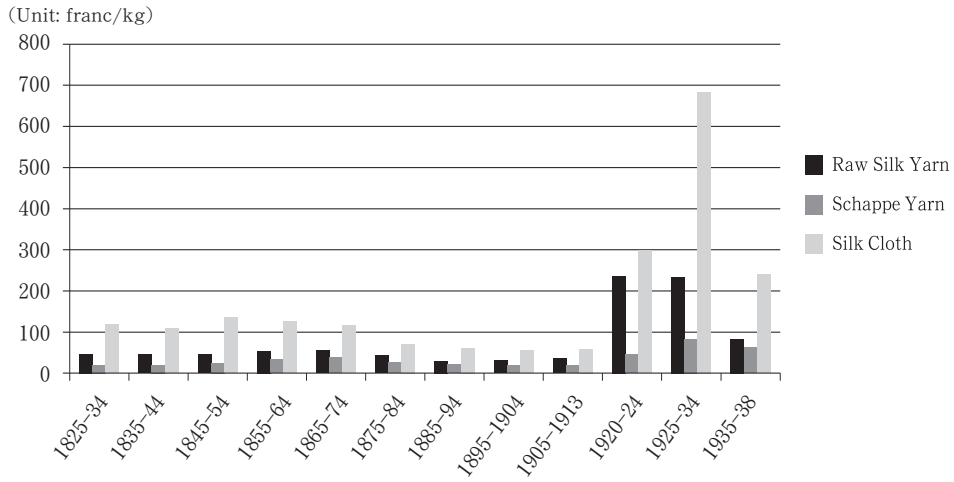

Fig. 2 Price of Silk Yarn and Fabrics in France: 1825–1938

Source: Markovitch, *Industrie française de 1789 a 1964–Conclusions générales, no. 179,* p. 42.

THE CHANGE IN 18th–19th CENTURY EUROPEAN FASHION

Next, let us look at exactly how did the fashion changed through the eighteenth and the nineteenth century in England and France. In the 1780s, when women preferred lighter and softer cloths, and men incorporated *l'anglomanie,* the popularization of silk became remarkable.[6] Thanks to the wave of fashion which traveled from Paris to London before anywhere else, Spitalfields clung to the weaving of elegant fabrics.[7] The weaving of silk for handkerchiefs, scarves, and shawls was soon established in Lancashire and Cheshire. In Norwich, the eighteenth century saw the gradual decay of its worsted industry and to counterbalance this, in part, a growing manufacture of silk and worsted mixtures, of camlets, crepes,[8] and bombazines. Expansion into plainer fabrics with simple weaves intended for a wider and less exclusively rich and fashionable market was indeed the essence of the growth in the English silk industry. It owed much to the growth in both population and national wealth and especially to middle class demand. In this sense, for silk still remained the dearest of fibers, there was a limited move away from the luxurious exclusiveness of silk.[9]

After the Berlin Decree in 1807, even in Lyon, they started weaving fabric with silk and cotton/wool[10] and after the 1850s patterned cloth, heavy brocade, damask, and floral woven

fabrics were out of fashion. From 1870 to 1876, taffeta and other plain silk cloth became the most popular. Through the last quarter of the nineteenth century, cheaper 'special textile' (tissus dits spéciaux/divers) such as gauze, crepe, tulle, laces, and mixed cloth of silk-schappe-cotton-wool caught on and became popular. This was, because of the epidemic disease 'pébrine' which caused a sudden rise in silk prices.[11] The export value of the special textile surpassed that of real silk at the end of nineteenth century. At the beginning of the twentieth century, the boom for 'the special textile' (crepe, muslin, gauze, grenadine, tulle, laces, cheesecloth/Victoria lawn) was maintained until WWI broke out.[12]

Regarding the fashion of 'special textile' and mix-cloth in Europe, the use of spun silk furthermore encouraged the purchase of dresses in mode, such as the crinoline, the crinolette or the bustle at accessible prices. And the principal use of spun silk was for manufacturing velvet.[13] The surface of velvet cloth has a beautiful sheen and depth of color. During the renaissance, this luxurious fabric made of silk and precious metal threads counted among the most valuable items. As an expression of power, wealth, and taste, velvet was used in secular dress, religious vestments, and interior furnishings. (Fig. 3) Despite of its luxurious appearance, the basic structure of the velvet is as simple as plain weave. The simplest of velvet cloth can be woven even with a three-shaft loom. Moreover, cut and spread spun silk fibers can offer a soft and fluffy effect on the surface of textile with high density.[14]

Fig. 3 Left: Eleonora di Toledo with Her Son (Agnolo di Cosimo 1503–1573)
Right: Pope Julius II (Raphael 1483–1520)

LISTER

The person who succeeded in completing the mechanization of silk spinning and increasing efficiency in velvet weaving was Samuel Cunliffe Lister of Bradford, who made his nip wool comb for the worsted market.[15] From 1857 to 1865, he devoted himself to converting 'worthless' silk waste into a profitable fiber. At that time fine silk with fiber lengths up to ten inches clogged the rollers and could not be processed.[16] Lister adapted the principle of the nip comb invention to silk waste, even though he had never worked with silk. He successively tried to perfect the velvet power loom, and in 1878, Lister's double

Fig. 4 Plush and Velvet Products of Lister
Source: Bradford Industrial Museum, 2016

velvet power loom wove twelve times faster than the hand-loom, with its continuous cutter, and the cheaper velvet cornered the market.[17]

In 1889 Listers were converted into a joint-stock company, with a share capital of 1,550,000 pounds divided into 60,000 pounds 5% preference shares of 10 pounds each, and 95,000 pounds ordinary shares of 10 pounds each. Samuel Lister, then 74, remained chairman, the other directors being José Reixach, William Watson, Benjamin Gibbins, and Henry Tetley-who would become the first managing director of Courtaulds and dominate the direction of the company for 25 years.[18] The business had grown prodigiously in the previous 20 years and Listers were now world famous for their velvets and silks, imitation sealskins, and mohair plush. They wove woolen dress goods, and night wear, men's shirting, and pyjamas. They were world leaders in sewing-silks, and exports accounted for two-thirds of their sales.[19]

SILK SPINNING IN JAPAN

In Japan, in 1872, silk spinning was introduced by the first minister of internal affairs, Toshimichi Okubo who promoted industrialization with his mercantile policies. The first silk spinning mill was equipped with spinning machines from Lucerne, Switzerland, and a steam engine from Krefeld by a German engineer, who also installed machinery at the first Woolen Factory in Tokyo. So, what did the silk spinning industry bring to Japan? The answer is *chirimen*（縮緬）crepe fabric for Yuzen kimono. Even though *chirimen* crepe has fine wrinkles on the surface and looks luxurious, the basic structure of the textile is plain and relatively easy to weave, like velvet. And its bumpy-texture was convenient to hide the shortcomings of unmatured Japanese spun silk, soon after the introduction of the industry.

Next figure indicates that, until 1924 France produced more spun silk yarn than Japan. For some reason between 1925 and 1934, the center of production moved to Japan.

According to a document of la Société Anonyme de Filatures de Schappe de Lyon, France seems to have already decided to introduce rayon, instead of spun silk, for their 'democratization of fashion' in 1914.[20] On the other hand, Japan showed a unique deviation regarding the silk spinning industry that peaks in the middle of the 1930s, when the rayon industry had already started developing there. When the Japanese spun silk "export

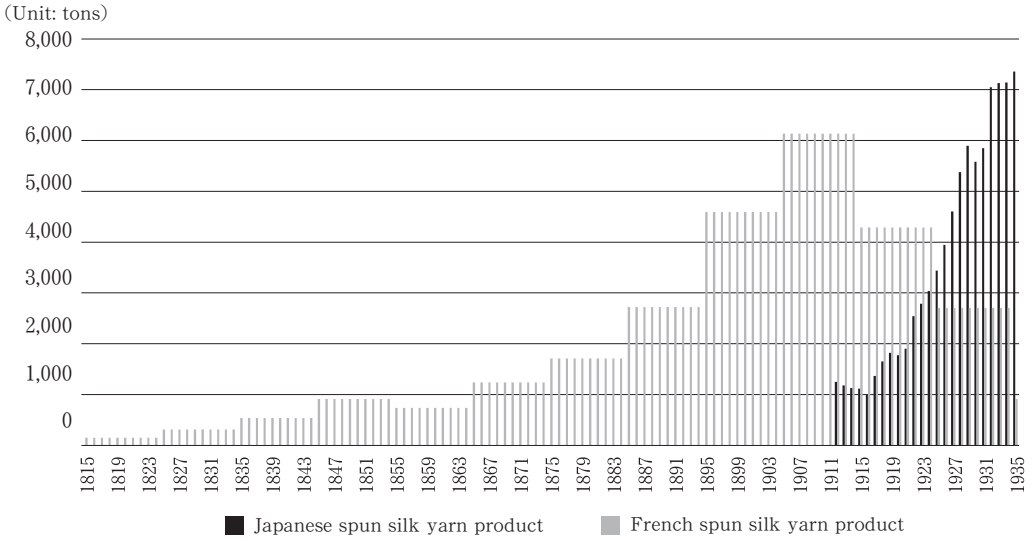

Fig. 5 Japanese and French Spun Silk Yarn Product

Source: Naoko Inoue, 'Silk waste, spun silk, and Meisen kimono: Technological transfer and emergence of new industry in Japan from the late 19th century to the 1930s' in "Linking Cloth/Clothing Globally: the Transformation of uses and value, c. 1700–2000", ICES Hosei University Publishing, 2019, p. 245.

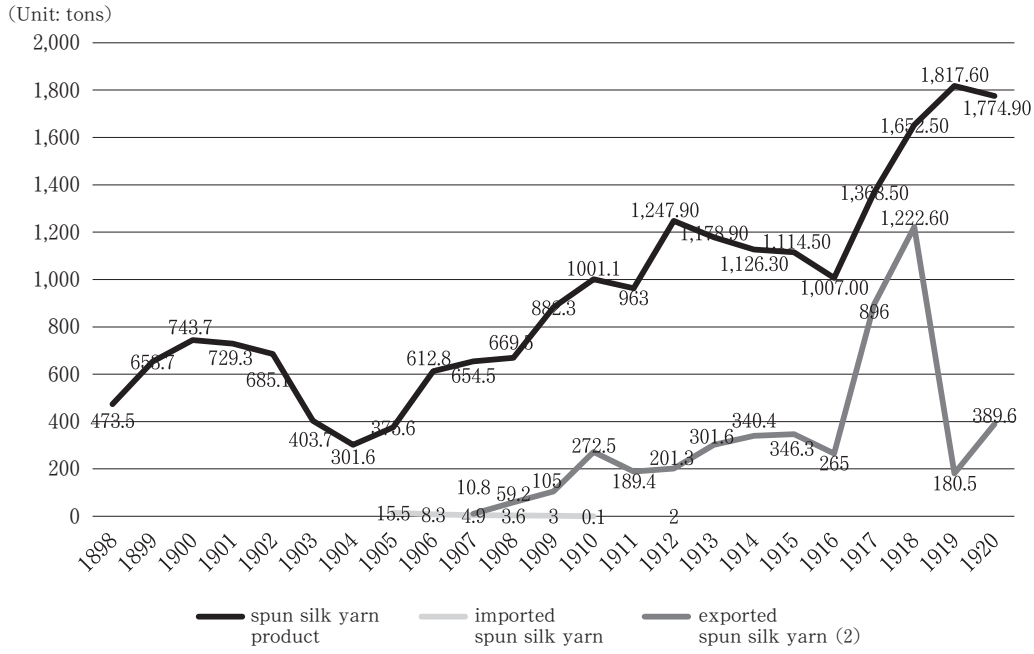

Fig. 6 Japanese Silk Yarn Output and Trade 1898–1920

Source: Naoko Inoue, 'Silk waste, spun silk, and *meisen* kimono: Technological transfer and emergence of new industry in Japan from the late 19th century to the 1930s' in "Linking Cloth/Clothing Globally: the Transformation of uses and value, c. 1700–2000", ICES Hosei University Publishing, 2019, p. 242. Regarding spun silk yarn product, see *Nihon senni sangyo-shi,* 1958, p. 939 and p. 942. The data on imported and exported spun silk yarn is extracted from *Nihon Sanshigyo-shi,* pp. 196–198, and also from *Nihon senni sangyo-shi,* p. 938.

Table 1 Total Demand for Spun Silk in 1932 (by Silk Spinning Association)

Use	Output (Unit: Hiki; 1 *hiki*≒12 m)	Demand for spun-silk yarn (Unit: Hyo; 1 hyo≒60 kg)
Meisen	4,561,051	27,643
Fuji Silk	607,612	25,380
Spun Crepe	204,110	6,967
Velvet	339,299	1,727
Chirimen	123,647	799
Rayon Kabe Crepe	42,951	1,173
Omeshi (Kiryu)	64,935	817
Overcoat Fabric (Kiryu)	120,321	NA
Yuki and others (Ichinomiya)	91,896	419
Nishijin	NA	400
Sewing Thread	NA	2,400
Export	NA	8,237
Others	NA	1,560
Total	NA	77,523

Source: Naoko Inoue, 'Silk waste, spun silk, and Meisen kimono: Technological transfer and emergence of new industry in Japan from the late 19th century to the 1930s' in "Linking Cloth/Clothing Globally: the Transformation of uses and value, c. 1700–2000", ICES Hosei University Publishing, 2019, p. 239.

amount" decreased, the output increased. (Fig. 6) The decrease of the Japanese export was caused by the increasing price of silk waste that was demanded by the steadily growing domestic demand for silk waste.

So, for what reason was there such a big demand for spun silk in Japan? The answer is *meisen* kimono. (Table 1) In 1928, more than 80% of the women passing by in Ginza, T okyo's fashion district, wore in *meisen.*[21] During the 1920s, while both personal consumption expenditures and textile consumption as a whole were stagnating, even sales for cotton products weren't growing, only silk textile consumption increased, just because of the craze for *meisen.*[22] People of that time didn't only seek cheap prices, but they were, actually, in need of 'silk-like' flamboyant kimono with accessible price.[23] The craze for *meisen* symbolizes the arrival of newly nascent consumer society. Even though the silk-spinning industry was taken over by rayon, it caused changes in Japanese society with increasingly cheaper silk cloth until the issue of the wartime regulations. In this sense the spun silk made the modern fashion industry in Japan.

Silk was the last fiber to be spun on machines. Spun silk is cheaper than raw silk, and is suited to mass-production, thus enabling scale-merit, and it looks good, but not so much as silk products. Up-cycling the waste silk into the mass-consumer goods with a luxurious look, such as velvet, crepe, ribbon, and Japanese *meisen* kimono, the mechanized silk spinning industry brought the demi-luxe[24] both to Europe and Japan in the latter half of the 19th century.

RAYON

As we saw, in France, the center of spun silk production, rayon took the place of spun silk, no later than in 1914. Although since the mid-seventeenth century, the possibility of producing silk-like artificial thread has been recognized, it was only in 1855 the first patent for the semi-synthetic cellulose fiber was registered by the Swiss chemist Georges Audemars in Britain. The regenerated cellulose industry was established at the end of the nineteenth century, and later, together with synthetic fiber, it was called 'chemical fiber'. Though rayon was often considered as a substitute for silk, manufactured cellulose fiber had been considered preferable material for industrial products like filaments in the early stages of its development. In 1884, Louis-Marie Hilaire Bernigaud de Grange, Count de Chardonnet (1839–1924) who had been working with Louis Pasteur on pébrine at École Polytechnique invented an artificial textile using nitrocellulose for garment use and displayed the products to the public at the Paris Exposition in 1889. The next year, the first rayon (la soie de Chardonnet) company, Société anonyme pour la fabrication de la soie de Chardonnet was established in his home town Besançon, and the first plant for commercial production was opened there and another one in Spreitenbach, Switzerland.[25] Having succeeded in reducing rayon's flammability, they generated huge profits and that's why Chardonnet is considered the father of the rayon 'industry'. In the first decade of the twentieth century, his artificial silk became popular for decorative trimming, tassels, and braids, all of which were in great demand for the embellishment of home interiors.[26] At that time the diameter of silk thread was 9–15 micrometers whereas rayon was 45–50 micrometers.[27] There was a huge difference in tenacity and elasticity between them. In Lyon, a synonym for the production center of luxurious silk textiles — 'la chardonne' stood for 'cheap textile' and there was a strong feeling of resistance against it. As a consequence, ribbon weavers from Saint-Étienne and braid weavers from Saint Chamond started proactively utilizing rayon earlier than the Lyon silk weavers. After that time, the rayon and synthetic fiber industry showed tremendous development over forty years.[28] (Table 2, 3)

It was cheaper, and much more suited to mass-production utilizing scale-merit as Chandler suggested.[29] More importantly, at this point, women finally freed themselves from the most desired luxury fabric 'silk', but still maintained a fashionable look.

Table 2 Production, Trade, Consumption of Artificial and Synthetic Fiber in France

(Unit: MKG)

Year	Production	Import	Export	Consumption
1905–1913	18.5	n.	3.4	15.1
1920–1924	237	37.9	12.7	262.2
1925–1934	746	45.4	224.1	567.3
1935–1938	573	27.2	150	450.2

Source: MARKOVITCH, *L'industrie française de 1789 à 1964 — Analyse de faits* (suite), 1966, Tableau XVI.

Table 3 Consumption of Fiber in Lyon in 1957

(Unit: KG)

Silk	800,000
Rayon	1,800,000
Cotton	3,300,000
Staple Fiber	2,700,000
Wool, Copper, Gold, Silver	830,000
Synthetic	3,400,000

Source: G. P. Menais, *Géographie industrielle de Lyon,* Paris, 1958, p. 15.

Rayon is a fiber of regenerated cellulose. In the nineteenth century, all three manufacturing methods for rayon were discovered and established in Europe, and competition only existed among Europeans until 1920. Even in 1929, the world's greatest rayon industry, which was in America, was still composed of subsidiaries of European companies, and up until 1935, all of them were dependent on technological support from the European side, even though they didn't have any financial relationship with the Europeans.

The three major types of rayon were, nitrocellulose rayon, cuprammonium rayon, and viscose rayon. The first nitrocellulose rayon was invented in France, in 1889 for embellishment, such as decorative trimmings, tassels, and braids. But, it turned out to be too flammable and more expensive than the other types of rayon and its production ceased early in the twentieth century. Vereinigte Glanzstoff-Fabriken (VGF) started producing cuprammonium rayon in 1899 near Aachen, Germany. It was known as 'bemberg' or 'cupra', and became fine enough to be comparable to real silk. Viscose rayon was patented by C.

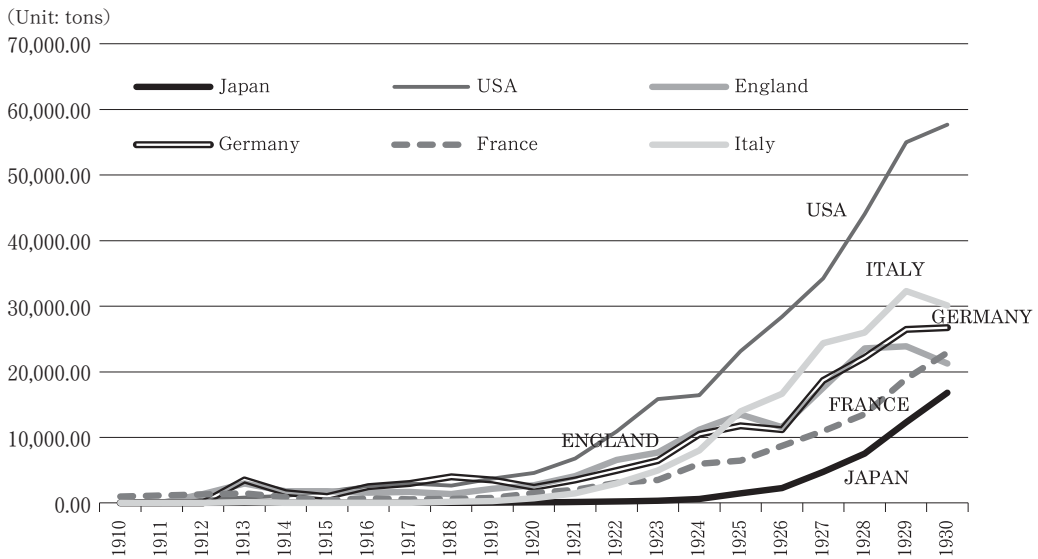

Fig. 7 Global Rayon Yarn Production 1910–1930

Source: Textile Organon

F. Cross and E. J. Bevan in Britain in 1892 for incandescent lamps, linen and curtain fabrics, door handles, valve sheets, cellulose film and artificial leather. In 1904, persuaded by the salaried manager outside of the family, G. Tetley, the patent was acquired by British Courtaulds, a crepe-making family firm, for manufacturing rayon.[30] By 1907 they had put a new plant for trimmings and braids at Coventry, where there was abundant coal, water and female labor force and metal working industry, into full production and had recruited a sales force to market the product at home and abroad. By 1912 the total value of Coventry sales was 686,176 pounds, as compared with the company's total crepe-silk and -fabric sales of 49,606 pounds. Its rayon profit margin that year was 44.4%. In the five years from 1907 to 1912 its rayon output had increased from 157,000 to 2,547,000 pounds. Within the same period, out put per spindle in this one works doubled from 6.8 pounds per week to 12.3 pounds, and the pounds of yarn per worker more than doubled from 9.7 to 22.0, with the biggest jump coming in the first year. Meanwhile, in order to go under the tariff and forestall competition, in 1910 Courtaulds built a plant at Marcus Hook, Pennsylvania, comparable in size to the one in Coventry. The performance of the American plant was as impressive as that of the English one. Not surprisingly, Courtaulds completely dominated rayon production in both countries before WWI. By 1919 it was already the eleventh largest industrial enterprise in Britain in terms of the market value of its securities.[31]

In 1905. In 1910 the American Viscose Company was founded by Courtaulds in Marcus Hook, Pennsylvania. Since then for over 20 years, it was the largest producer of rayon in the world. During 1910s, viscose rayon was the least expensive type of rayon to produce and practically the only kind manufactured in the U.S.[32]

During the whole process of business expansion, the first managing director of Courtaulds, Henry Greenwood Tetley played an important role. Courtaulds originates a silk throwster from Spitalfields, a Huguenot descendent, who started his business in 1775. After the death of the founder, his children returned to Essex to establish Samuel Courtauld & Co. in 1828. In 1830s, they started producing cheap black crepe (crimped and stiff crepe) for mourning attire, which had been imported mainly from Italy until the eighteenth century, and became the biggest producer.

After the success of the crepe manufacturing, Tetley decided to try a whole new direction. In 1904, he visited a mill of Viscose Spinning Syndicate, which was established by Cross and Bevan in Kew,[33] and persuaded the board of directors of Courtaulds to buy their patent for rayon manufacturing, by emphasizing the success which Chardonnet was enjoying with 100% dividend.[34] Early in the twentieth century, rayon was about to be recognized as a cheap substitute for silk as Chardonnet silk or Glanzstoff silk though, at the beginning of the 1920s, viscose rayon manufacturing was started by only some companies and between 1925–1928, no less than 23 companies in which most them are British, and only a few are Dutch and German started operation.

According to Coleman, until the Great Depression, Courtaulds succeeded in expanding their production. Other than the most successful American Viscose Corporation, they gained control of SNIA Viscosa from Riccardo Gualino in 1928 with Glanzstoff.

WHAT MADE THE U.S. THE MAJOR PRODUCER OF RAYON

As we have seen, during the early stages of the industry, the technological development was exclusively seen in European countries. So, why the U.S. could become the major rayon producer? Before WWI, the U.S. imported dyestuffs and chemicals from Germany. But after 1915, they had to change to import substitution of all the dyes and chemical supplies because of the sea blockade on Germany imposed by the British Navy.[35] It was difficult also for Germany to procure all the chemicals and pulp needed. In France the biggest artificial silk company, Soc. de la Soie Artificielle de Give was requisitioned by the Germans. Belgian factories were also damaged by the war. Being short of chemicals and materials, even Britain suffered from the rising price of rayon. Therefore, only the U.S. could meet the increasing demand for rayon. Courtaulds' the American Viscose Company sold 360,000 pounds of rayon the following year of its founding and by 1912 it was making a 77 percent return on its investment[36]. In 1916 artificial fibers was one of many industries that Du Pont considered entering as part of its diversification plan, only because it was probably the most profitable industry in the U.S. and showed "great future possibilities.[37]" Until 1920 the American rayon industry was monopolized by American Viscose Corporation, a subsidy of Courtaulds of Britain.

The key to the success of the industry was 'rapid and ongoing price reduction' realized by drastic advances in technology and achievement of mass production. U.S. rayon consumption exceeded 2 million pounds in 1911 with more than 1,800,000 pounds imported from Europe. Within 2 years rayon production was tripled to 6.5 million pounds with 2,450,000 pounds imported with a price of approximately $3 per pound.

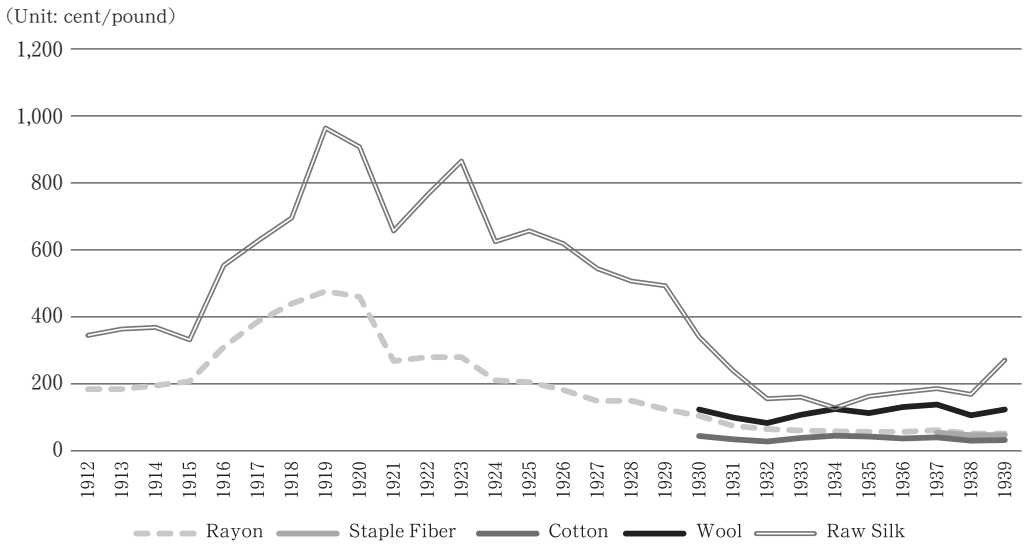

Fig. 8 Yarn Price in the U.S. 1912–1940

Source: Textile Organon (1952, Jan. 1953, Feb. 1954, Feb. 1955, Feb.)

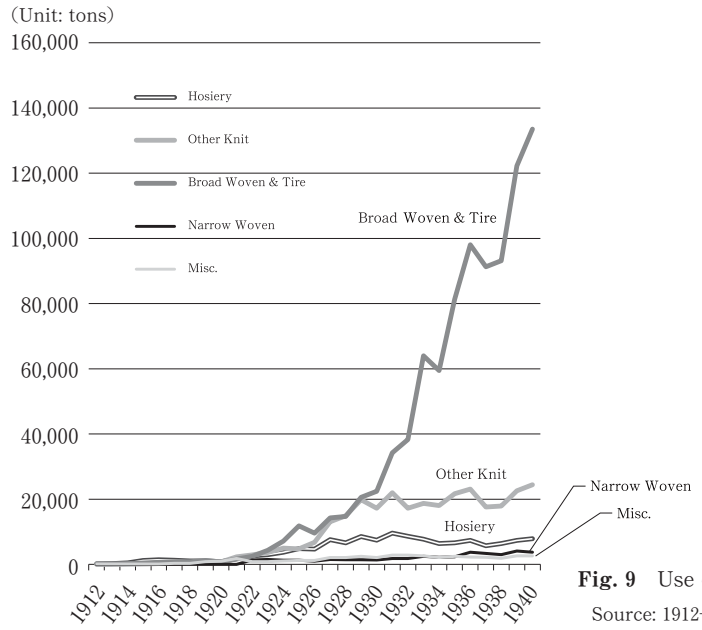

Fig. 9 Use of Rayon in the U.S. 1912–1940
Source: 1912–1940: Textile Organon (1952, Jan.)

Prior to World War I rayon was, at best, regarded as an inferior substitute for silk; by the outbreak of World War II rayon had practically displaced silk in the production of many style fabrics and had made serious inroads in a number of cotton fabric markets.[38]

USES OF RAYON DURING THE EARLY STAGE OF THE INDUSTRY

We have to take into consideration not only the price but also the quality improvement and the product diversification. During the 1920s, almost 75% of rayon was used in cotton mixes, hosiery, and underwear, presumably because of some characteristics of rayon; comfort, softness, absorption capabilities. Hosiery and underwear accounted for more than 50% of rayon production. So "thanks to rayon it was inexpensive to dress, from the skin out, in attractive, silk clothing."[39]

After the latter half of the 1920s, the noticeable increase in the quality of rayon used in the woven-goods industries, since 1930 relative to the knit-goods industries, reflects several developments that altered the nature of rayon and the relationship between rayon and other fibers. Since the weaving industry requires a higher-grade yarn than the knitting industry, steady improvement in the quality of rayon has rendered it increasingly more adaptable to the manufacture of rayon and mixed woven fabrics.[40] (Fig. 9)

EXPANSION OF FASHION USE OF RAYON IN THE 1920S

By 1922, Courtaulds' production of real silk materials had declined to just a third of what it was before 1914, largely because of 'dumping' by foreign manufacturers. Since the Cobden-Chevalier Treaty, the silk trade had been treated badly by the politicians. Britain

was virtually the only free market in the world for silk and was therefore at the mercy of every overstocked foreign manufacturer whose prices were favored by depreciated exchanges and cheap labor. In 1923, no less than 23,000,000 pounds of foreign silk goods came into England scot-free, including 46% of the total French silk exports, and over 50% of the Italian ones, which ruined the traditional British silk industry.[41]

While the state of the original side of the business was depressing, the position and prospects for the viscose spinning and weaving part were encouraging. Indeed, the twenties witnessed a more rapid expansion in the firm's business than any other period in Courtaulds' history. Throughout the nineteenth century, certain values such as duty, respectability and middle-class morality occupied a central position in the Victorian consciousness.[42] However, WWI had turned the world upside down and in nothing was this daring new world more apparent than in women's clothing. In 1919, the skirt hem was about six inches above the ground. In 1920 it was up to twelve inches, then it fell a little, but only to rise to eighteen inches in 1925, and two years later to reach the knee and stay there till 1930. The Paris *couturiers* and the dress material manufacturers frequently predicted an early return to long skirts but it never occurred. The stocking, once revealed, was important as never before. By 1922, silk or 'artificial silk' flesh-colored stockings had ousted the old black cotton ones.

The short skirt was accompanied by a remarkable change in the weight, material and quantity of women's clothing. The boyish figure; slim, hipless, and flat-chested, was every woman's ambition, and between 1913 and 1925, the amount of material required for a complete woman's outfit fell from over twenty yards to ten or less. Underwear, instead of being composed of cotton or wool, was now of 'artificial silk'. Contemporary fashion, epitomized by the sleek and slinky flapper, required a material with the properties of silk. In this early period, rayon was simply the middle-class woman's silk. The girl who before the war had only two day dresses (one for work and one for 'Sunday-best'), now had half-a-dozen, often bought ready-made at prices that were lower in proportion to the smaller yardage of material in them.

The entry of women into almost every vocation, the success of the Trade Union movement in its fight for better wages for industrial workers, and the wider application to industry of mass-production principles learned in the manufacture of munitions, all caused and enabled women to 'dress like a lady'.

'Artificial silk' was in the vanguard of industries benefiting from these broad influences; indeed, as we know it to-day, it largely resulted from them. At Samuel Courtauld and Company's festival of 1846, P. A. Taylor said: 'What on age terms luxuries become in the next age, by common use, the undisputed right of all.' Eighty years later that principle had revolutionized the business he had helped to found.

Within the textile industry itself, the war had brought changes that facilitated the increased use of viscose yarn. It swept away much prejudice against new methods and products, and the depression that followed the post-war 'boom' found many firms eager for anything that would assist them in competing with their rivals, at home and abroad. Also, by the twenties, textile machinery manufacturers had come to understand the particular

requirements of 'artificial silk', and improved spinning, processing, weaving and knitting machinery made it possible to produce fabrics and garments that were only ever imaginary before 1914.

By 1924, many of the company's works extensions and machinery installations, delayed until the cessation of hostilities, were getting into their stride. Where, in 1921, the viscose yarn 'offtake' had totaled 7,750,000 lb., it nearly doubled two years later, and in 1924, it rose to 25,320,000 lb.

STAPLE FIBER

Lastly, to consider the important role that rayon played in the popularization of fashion in the early stage of its industry, again let's see the recycling process of the industry. In the early 'artificial silk' yarn factories it was the problem of disposing of waste which led to the manufacture of short staples from this material. At Courtaulds' Coventry factory, waste viscose filaments -dirty waste from the floor or 'clean' waste from the godets- were sometimes knee-deep, and thousands of tons were dumped on nearby vacant land between 1905 and 1910.

Henry Tetley, as early as 1907, saw clearly that the day would come when this by-product would be turned into profit as S. C. Lister did fifty years before. Chemists even then were seeking a means for making a cut staple material from viscose that might be spun and woven on cotton and wool machinery. In 1907, with this objective in mind, a Frenchman, A. Pellerin, took out a patent covering the manufacture of discontinuous cellulose filaments of predetermined length (F.P. 41776)[43], but his methods were not commercially practical, and, anyway, Courtaulds and the other viscose spinners were struggling to win a way for the continuous filament yarn and had little time to devote to research in a new field. These factors have tended to increase the relative importance of the weaving industry as a market outlet.[44]

CONCLUSION

In conclusion, After the 18th century, the desire for cheaper, lighter, thinner fabrics brought new capital-intensive technologies; mechanized silk spinning and rayon manufacturing. The spinning technology itself was compatible with different fibers (e.g. cotton and linen) and made it possible to create cheaper resource combinations. Among those natural fibers, silk was the last fiber to be spun on machines. Spun silk is cheaper than raw silk, and is suited to mass-production, thus enabling scale-merit, it still looks good as silk commodities/products. Up-cycling the waste silk into the mass-consumer goods with a luxurious look, such as velvet, ribbon, crepe, and Japanese *meisen* kimono, the mechanized silk spinning industry brought accessible luxury both to Europe and Japan in the latter half of the 19th century.

At the beginning of the 20th century, Rayon took the role of spun silk. It was cheaper, and much more suited to mass-production utilizing scale-merit. More importantly, at this

point, women finally freed themselves from the most desired natural fabric, silk, still keeping a look which was fashionable. The keys to the success of the industry were 'rapid and ongoing price reduction', 'novelty', and 'diversity' realized by drastic advances in technology and achievement of mass production. Together with the birth of department stores, the invention of synthetic dyestuffs, the dissemination of the sewing machine, and the development of the ready-to-wear products, the decreasing price of shiny silk-like textiles resulted in consumerism based on appearance rather than function, accelerating the fashion cycle with planned obsolescence and advertising.

The rise of the staple fiber industry was suggested in this paper lastly. Cleaned and baled rayon waste was being put on the market in Europe and America, during and after WWI, as 'artificial cotton' or 'imitation schappe' to compensate for the lack of cotton and wool.[45] When rayon waste could be spun, human beings finally got predestined to forever seek the best balance of fiber combination to gain maximum utility, and this will be the primary focus of the next paper.

Acknowledgements: This work was supported by JSPS KAKENHI Grant Number 17H07060 (2017–2019), 15H03233 (2015–2019) and the President's Research Grant of Josai University (2017–2019).

Notes

1 Cf. The winter padded garments of silk floss from unreelable cocoons were worn even by peasants after the dissemination of sericulture in Japan.

2 Frank WARNER, *The Silk Industry of the United Kingdom. Its Origin and Development,* London, 1985, p. 67.

3 Naoko INOUE, 'Silk waste, spun silk, and Meisen kimono: Technological transfer and emergence of new industry in Japan from the late 19th century to the 1930s' in *Linking Cloth/Clothing Globally: the Transformation of uses and value, c. 1700–2000,* ICES Hosei University Publishing, 2019, p. XXX.

4 Beverly LEMIRE, 'Revising the historical narrative: India, Europe and the cotton trade, c. 1300–1800' in Giorgio RIELLO and Prasannan PARTHASARATHI, eds, *The spinning world: A global history of cotton textile, 1200–1850,* Oxford, 2009, p. 222.

5 Other than the influence of machine-spun silk post 1875, the popularization of silk in France was brought about by three main causes; mix-cloth of cotton/wool and silk became popular from 1859 (see Bouvier, p. 277. The production revenue of silk textiles decreased from 811,000,000 Francs in 1875 to 125,000,000 in 1880, while mix-cloth production increased from 35,000,000 to 169,000,000 during the same period of time.), special textiles (tissus dits spéciaux/divers) such as crepe, tulle, and lace, got popularity (Special textiles production increased post 1877 and in the 1880s the ratio was nearly 15% of all products. According to *Tableau décennal du commerce de la France,* 1867–1896), raw silk was applied as 'warp' in weaving-machines (see Pariset, *Histoire de la fabrique Lyonnaise,* pp. 367–68.).

6 Michel LAFERRÈRE, *Lyon ville industrielle, essai d'une géographie urbaine des techniques et des entreprises,* 1960, pp. 103–104.

7 Donald C. COLEMAN, *Courtaulds : an economic and social history,* Oxford, 1969–1980, v. 1, p. 22.

8 Crepe derives from crespo (It.) and crêpe (Fr.), both from the Latin crispare, to curl. In the middle ages, the word came to mean a gauze-like fabric woven wholly of silk, with a creped, crimped, or curled effect in its texture which was dependent on the use of a highly thrown yarn made, in one way or another, to untwist itself after weaving. Over the course of time, two main

types of crepe were developed: soft and hard. In eighteenth and early nineteenth-century England, the former category included fabrics which were called Canton or China crepe, French crepe, and Norwich crepe; in the hard category was Italian or Bologna crepe. Both sorts were woven from hard silk, but whereas the former ended up as a soft and usually colored fabric, the latter was subjected to various dressing and finishing processes and ended up as a stiff, and usually black fabric. The manufacture of the soft type later developed on the continent of Europe, particularly in France; the manufacture of the hard type slowly moved away from Italy and became a peculiar speciality of England. Both sorts of crepe, when dyed black, were at one time or another associated with mourning, but especially the Italian, and later, the English type. Consequently, the word crepe alone came eventually to mean 'mourning crepe'. *Ibid.,* p. 24.

9 *Ibid.,* p. 23.

10 LEROUDIER, *De la decoration de tissus,* Lyon, 1910, p. 23.

11 Y. LEQUIN, *Aspects économiques des industries lyonnaises de la soie 1870–1900 : la fin de la Fabrique des Lyon,* 1958, pp. 172–185., Pariset, *Histoire de la fabrique Lyonnaise,* p. 384, n. 1.

12 *Ibid.,* pp. 146.

13 P. CLERGET, *Les industries de la soie en France,* Paris, 1925, p. 27.

14 Interviewed with Mr. Yoshihito Fujimoto, the president of Nihon Velvet Industry Co.（日本天鵞絨工業株式会社）on 13th June, 2016, in Sonobe, Kyoto.

15 Mark KEIGHLEY, *A fabric huge — The story of the Listers,* 1989, pp. 16–18.

16 *Ibid.,* p. 19. Picket, 'Deceptive textiles: Lister's velvet loom, resilitex, decoys for WWII, Britain', *Textile Society of America Symposium Proceedings,* 2012, p. 2.

17 *Ibid.,* pp. 20–22.

18 It was until about the middle of the nineteenth century that the word 'crepe' came to have the immediate identification of a particular type of mourning fabric. See COLEMAN, *op. cit.,* p. 24, p. 182.

19 KEIGHLEY, *op. cit.,* p. 22.

20 Société anonyme de Filatures de Schappe（Lyon）Lyon Soieries. Archives de la Société Anonyme de Filatures de Schappe de Lyon et de Rene Franc. 1912–1933, Class R, 1914, MS. 0492–3. I sincerely appreciate Mr. Courmat's generosity of showing his private documents to promote this scientific project.

21 Wajiro KON, *Kogengaku Nyumon*（Introduction to the study of modern societies）, Chikuma Bunko, 1987, p. 128. Kon also points out that women not wearing kimono were only 1% of the total. *Op. cit.,* p. 124.

22 Yuki YAMAUCHI, 'The Expansion of the market of meisen and the structure of fashion communication in the 1920s', in *Business History Review,* 44–1, June 2009, p. 5.

23 Regarding the price range of *meisen,* see Yuko ANZO, 'On Meisen（Japanese Everyday Silk Cloth for Kimono）as seen in early Showa newspapers and journals', *Gakuen*（bulletin of Showa Women's Univ.）, 863, p. 4, 7, 8, 14, 15 16, 17, 53, etc.

24 Neil McKendrick and John Brewer proposed the idea of 'Consumer Revolution' for eighteenth century.（See MCKENDRICK and BREWER, *The birth of a consumer society. The commercialization of eighteenth-century England,* London, 1982）In the following four decades, in a number of studies, observed how consumption at all levels of society increased in the eighteenth century. Cissie Fairchilds underlines how cheap copies of expensive and fashionable goods（'populuxe'）such as parasols became part of the consuming habits of Parisians. Maxine Berg, in contrast, emphasized the creation of demi-luxe（semi-luxury）as a part of the broader history of invention and industrialization.（See C. FAIRCHILDS, 'The production and marketing of Populuxe goods in eighteenth-century Paris', in *Consumption and the World of Goods*（J. Brewer and R. Porter, eds.）, London, 1993, and M. BERG, 'From imitation to invention: creating commodities in eighteenth-century Britain', *Economic History Revew,* LV, 1, 2002, pp. 1–30. In this context fashion flourished. Consumers were no longer content with using the same old things

until they fell apart, but increasingly aimed at 'the latest fashion' or something 'fashionable'. Cf. Giorgio RIELLO & Peter MCNEIL, 'The fashion revolution: The 'long' eighteenth century', in *The fashion history reader: Global perspectives,* Routledge, 2010, pp. 173–177.

25 GUÉNEAU, *op. cit.,* p. 19.

26 David A. HOUNSHELL & John K. SMITH, Jr, *Science and Corporate Strategy,* Cambridge University Press, 1988, p. 161.

27 GUÉNEAU, *op. cit.,* pp. 248.

28 According to Laferrère, it was only after the Great Depression that Lyon silk weavers structurally deteriorated their product quality to average. See M. LAFERRÈRE, *Lyon, ville industrielle; Essai d'une géographie urbaine des techniques et des entreprises,* Paris, 1960, pp. 217–234.

29 Alfred D. CHANDLER, Jr., *Scale and scope: The Dynamics of industrial capitalism,* Belknap Press (reprint), 1994, pp. 306–309.

30 While still with Lister & Co., Tetley had looked into two of the nitro-cellulose processes according to his own later account. See COLEMAN, *op. cit.,* p. 25.

31 CHANDLER, *op. cit.,* p. 272.

32 BJORKLUND, p. 381

33 Calvin WOODINGS, *Regenerated Cellulose Fibres,* Cambridge, 2001, p. 8. In 1898, Tetley commented in his notebook on the possibilities of using viscose for 'an exceedingly waterproof dress for crapes and fancy goods'. See COLEMAN, p. 26.

34 COLEMAN, *op. cit.,* p. 27.

35 Jacqueline FIELD, *Dyes, Chemistry and Clothing: The Influence of World War I on Fabrics, Fashions and Silk,* Dress 28, (2001): 77–91.

36 HOUNSHELL and SMITH, *op. cit.,* p. 162.

37 *Ibid.*

38 Jesse W. MARKHAM, *Competition in the Rayon Industry,* Harvard University Press, 1952, pp. 27–34.

39 Jacqueline FIELD, *Dyes, Chemistry and Clothing: The Influence of World War I on Fabrics, Fashions and Silk,* Dress 28, (2001), p. 86.

40 In Fig. 9, automobile tire yarn is included in broad-woven goods. Tire fabrics have changed in response to the constant demand for better performance. According to Carbone, continuous filament viscose rayon was introduced in the late 1930s. (See Maria Giovanna PASTORE CARBONE, *Investigating mechanical behavior of cord-rubber composites by multi-scale experimental and theoretical approach,* (Ph.D thesis), Università degli studi di Napoli, Dec. 2011, p. 36.) The increasing significance of rayon in tire fabric construction is evident from the data.

41 See C. H. WARD-JACKSON, *A history of Courtaulds,* London, 1941, p. 134.

42 Felicia APPELL, 'Victorian ideals: The influence of society's ideals on Victorian relationships', *Scholars,* issue 18, McKendree University, mckendree.edu/academics/scholars/issue18/appell.htm, viewed 18 December 2018.

43 COLEMAN, *op. cit.,* vol. 2, p. 185.

44 C. H. WARD-JACKSON, *op. cit.,* p. 148. After 1939, hosiery as a use of rayon decrease, because of the development of nylon industry.

45 COLEMAN, *ibid.*