

On the Non-linear Development of the Mule Cotton Spinning Machine and the Spinner's "skill" in the Early British Cotton Industry

Kazuyuki MOGI

1 The coexistence relations of various spinning machines

As already simply outlined⁽¹⁾, the Mule machine was a mixed machine(compound machine) which took the advantages of the Jenny machine and the water frame as the name showed. Its roller mechanism which pulled strings out the function of the moving carriage which slid on order, from a roller spinning machine was inherited from the Jennie machine. The spindles fixed to the both-way stand of a Mule machine passed through between rollers, rotating at high speed, and cotton strings were fully pulled, twisted and rewinded. Although the Jenny machine was able to be spun to thread of coarse count cotton yarn, but its difficulty was in the intensity of a product, the water frame was able to spin tough thread, but it was inapplicable only to coarse count spinning, Mule conquerd both defects after all⁽²⁾.

The Jenny machine invented by J.Hargreaves in 1764 was the simple machine in mechanism and was the wooden spinning machine at the beginning stage of development, then its cost of manufactured and assembled was also inexpensive, and could be easily operated, even if it did not use powers except man. Therefore, old independent spinners included women and children of the neighborhood and the circumference engaged in spinning work under the master weavers or his families could purchased it easily, appearance of the Jenny machine would not drive the small producer out of the market⁽³⁾.

The Jenny machine did not necessarily play the role which destroyed the domestic industry thoroughly, and rather in the meaning, was not the production machine system in the classical view of the "Industrial Revolution", but was the spinning machine for domestic production which made small and domestic industry revived at the beginning of development. The domestic manufacture which about 1785 equipped with the Jenny machine was the typical spinning management form of the England cotton industry.

On the other hand, it was already developed by Paul and Wyatt about the middle of the 18th century, the roller spinning machine(water frame) to which many improvements covering several

degrees was added by Richard Arkwright since 1768 needed the power exceeding human power for the driving, and the price was also very high. Unlike the Jenny machine, the roller spinning machine was a spinning machine only for warp cotton strings. In Britain until it appeared, tough cotton strings for warp could not be produced, therefore was not able to produce the all cotton products using domestic cotton strings. In England, until the middle of the 1780s which the water frame generalized, pure cotton goods imported from India or at the most have produced fustian which was mix weaved by the hemp yarn or wool for the warp and cotton string for the weft. The roller spinning machine was a spinning machine for warp depending on this import, then by this machine, pure domestic cotton goods, as the muslin, calico, etc England cotton dealers had been looking forward were produced for the first time⁽⁴⁾.

The roller spinning machine was a spinning machine performed continuously basic spinning works as drafting, twisting, winding so on, by 3 sets of rollers, the flier, and the spindles, and transferred most handmade business by the independent spinners to the machine except operation and maintenance of the machine⁽⁵⁾. In addition, remarkable power been required for operation of the roller spinning machine, therefore the huge powered machine system which also connected many pre-spinning machines such as the carding engines, roving machines equipped with motive power system in the spinning preparation processes, in which these related each other organically by the power conductive system needed the factory buildings which had the space and the solidity were sufficient for the ability of these machines been installed. The man of those days described as follows this roller spinning factory = Arkwright type factory⁽⁶⁾.

" the water frame which Arkwright installed in the last stage, the carding engine, and other productive machines needed the space more than what were installed in a cottage, and the power more than what were offered by man's hand. Those weights required the factory builded strongly they may be installed in, and they were able to be efficiently operated by no power by which it was known other than water power by then."

The specific technical characteristic and restrictive nature involved inevitable in the roller spinning machine, in particular its water power dependability made concentrate the Arkwright type factory to the river side zone of Lancashire or the central districts of England(especially Midland circumference) from the past usual producing centers of cotton goods. Furthermore, rich amount of water required for finish processes, such as breaching, dyeing, and printing, were able to secure easily in the clear stream of these areas, the air current with which the Atlantic Ocean became wet brought moderate moisture required for spinning to the zone of the mountain range western side, agriculture had not fully developed by such climate was not suitable for farming with a degree, therefore regulated a manufacturing industry in these areas, the effective harbors suitable for export the cotton goods and for import cotton flower were located in the West Coast part of

these areas, since former time woolen manufactures were developed from the previous stage, the market was improved comparatively, furthermore, these areas, that there had been almost no medieval industrial regulation in center Manchester of cotton business transactions especially, etc. made the Arkwright type factory concentrate on the southwest slope of the Pennine Chain⁽⁷⁾.

Thus, the Jenny or the Mule, and the water frame were not necessarily competitive production means of production did not compete with each other in the cotton strings market, therefore the appearance in the end of the century of the huge Arkwright type factory was not necessarily that forced the formers expulsion.

In the markets by the product articles, Jenny-Mule and water frames were not stand the competitive relations each other, the former was carrying out warp market and the latter was specialized in the weft market, also it can safely be said that the huge Arkwright type factories and the number of small scale mills were equipped some Jenny or Mule had existed together at least in the stage till the beginning of the 19th century. To put it in other words, " innumerable factories which were especially generated in Lancashire as the [Arkwright] factories having been built when the same were more various in the character. weft spinning remained in almost all fields in domestic operation executed by the single spindle or the small Jenny machine⁽⁸⁾." Professor S.J. Chapman indicated that as compared with the Mule spinning factory having been 'revolutionary' for the generation of a factory system, Jenny mills were nothing but have brought 'gradual evolution', then cotton industry had developed as "two factory systems which was different from each other⁽⁹⁾".

The Arkwright type factory expanded more quickly by appearance of the water frame and the Mule type factory have gradually transited from the cottage system to the factory system had important difference also in any aspects, as production technical systems, power sources, capital scales, investment forms, labour compositions, etc. That it must regard is the point that this had also become the cause of a typical difference in various fields, such as the industrial relations, the labour management, etc. in both, as will be explained in full detail in the next thesis.

2 Technical and economical peculiarities of the early Mule

On the other hand, the Mule machine was known as spinning wheel for muslin from the beginning, was the spinning machine for high-quality-cotton thread which the England cotton manufacturers had great desired for a long time. Mule compensated the defect of the water frame which was not fit for the spinning of high count cotton yarn, and took the role that United Kingdom recovered the position to be in complete control of the high-quality-cotton thread market which had monopolized by India muslin. Namely, it would not also make mistakes to describe that

the appearance of Mule " was the main factor which made the position convert into the West from the East which was making this industry solid from ancient times until now⁽¹⁰⁾".

However, at the beginning of the invention of the Mule(1774), it was technically imperfect, then did not come to have possessed it to practical use until 1779⁽¹¹⁾. Moreover, we also should take notice that the Mule was not what was attached in the large-scale factory from the beginning. It was a working tool for small shops as the so-called cottage machine, and on that account had not been the kind which constituted a large-scale machine system at least not later than the beginning of the 19th century. That is, " in the Jenny or Mule spinning, the small business had fully competed with the large capital for many years, the other way around water power spinning business having been started as large-scale it from the beginning⁽¹²⁾". At the first stage of the 19th century, the Mule machine had been chiefly appropriated in company with distaff, spinning wheel, loom, etc. as a spinning machine for the independent hand weavers⁽¹³⁾. Even though, the initial Mule had not been necessarily installed only in the tenancy workshop. Although it was not difficult to also find out the comparatively large-scale mills which made hand Mule concentrate on one place in the England cotton business of the time of Mule development, but these must be exceptional⁽¹⁴⁾, and there was no remarkable difference with cottage work shop in the aspect of the production technology.

The initial Mule did not so have many spindles, at the most had about 12 spindles in the stage of beginning⁽¹⁵⁾. For example, in the case of M'Connel & Kennedy, had been measured positively to introduce the Mule and became the leading large cotton factory also in Britain, had installed 32 sets of Mule had total number of spindles of 7,464 or 1 set average 233 spindles at 1797, and the arithmetical mean spindles were only 291 till 1805⁽¹⁶⁾, then we can conclude these were comparatively small scale machines. Therefore, the price would also be relatively cheap, so the price of the installed two sets of Mule in the above mentioned factory was only 70 pounds sterling⁽¹⁷⁾ that we may safely say that it was not difficult to introduce Mule for small-scale business. Moreover, for a while after invention, Mule was operated by hand power and "skill" and that use of water power was also rather uneconomical⁽¹⁸⁾ had limited Mule type business to small-scale.

Although it would not able to neglect that there were any channels of the capital which had been accumulated in the merchant dealers or landowners had been invested to manufacturing business, but we can also conjecture that a handful of business started with 1-2 sets of Mule and with the very small capital, had been promoted to the large-scale capital owing to overcome in the crowded competitions⁽¹⁹⁾. The original Mule machine, as well as the Jenny, had not been used for factory scale production processes, rather promoted the master spinners' metamorphosis to the modern independents manufacturing business than prevented these channels of the promotions.

Of course, as already mentioned, in this stage, the investment to the spinning by merchants, rich lenders, warehousing dealers, manufacturers, etc. had already reached the amount equivalent and it cannot be denied that there were the several examples of large-scale investment hold true good for the appropriate evaluation, "in generally, the great portion of capital of cotton industry had been carried from the merchant dealers had already established⁽²⁰⁾". However, in the Mule spinning, at least it would not be able to estimate that the large-scale investment of merchant capital to the spinning factory overwhelmed the course of the accumulation by the tenancy cottage spinners comparatively small-scale capital invested. The initial cost of the hand Mule mills compared with the production system in the Arkwright factory so were extremely sufficient by small scale, therefore this merit had enabled existence of the small-scale spinning business which had been scattered to several places of England. Therefore, probably, it would not be able to take no notice of the course in which the large cotton business had gradually accumulated capital as formed the foundation of the England cotton spinning industry. One well-known figure in those days described on this point as follows⁽²¹⁾.

" many industrious people started an business by only one set of the Mule operated by the hand of himself, gradually increased the machine as his property increased, and extended his business until to eventually reached the honorable status as the most competent and extensive dealing manufacturer".

As is generally known, by the first decade of 19th century, although large-scale factories such as the mills of Robert Owen(number of employees 1,600 ~ 1,700), Belper mill of Strutt(1,494), James Finley & Co.(1,529), A.& G.Hurray(1,215), and M'Connel & Kennedy(1,020) had appeared, but small-scale business even being general up to the first stage of the 1820s⁽²²⁾. In those days, only some capital was required for establishment of such a Mule mill. H.Heaton described "the textile industry was the place blessed with the opportunities for the energetic and eager person although it had only some capital",and he pointed out as the factors that cotton industry's machines were comparatively cheap , materials were able to get inexpensive price, and had the soil with which suitable profits were secured also in that the cotton business⁽²³⁾. In addition, although there were also some examples as S.Oldknow that came up against the serious shortage of funds since the financial market was getting late to stable growth which responded to the enlargement of the cotton industry⁽²⁴⁾, in general, since the demands for fund in the 18th century England cotton industry were comparatively lower level, and that's why it was also exceptional examples to been suffered the shortage of working funds⁽²⁵⁾.

As outlined simply above, although the Mule had not necessarily been quickly enlarged as factory used spinning machine to the degree which had been assumed in the conventional historical studies of England cotton industry, the Mule had gradually exceeded the Jenny and the water frame to the

first stage of 19th century in the equipped number, and had played the roll of main spinning machine until the ring spinning machine spreaded with too late also in United Kingdom up to the end of 19th century.

The Mule came into wide use from the 1790s, and after the steamy power came to be adopted as motive power, the Mule's advantages in comparison with other spinning machines were much more remarkable and the Mule realized to the position of the main machine in the steam powered more large scale cotton factories⁽²⁶⁾. According to the cotton business spinning machine investigation statistics(the census of the cotton industry) which Samuel Crompton inventor of the Mule himself performed in 1811, in those days, the Mule had also reached 4,200,000 spindles to water frame 280,000 spindles and Jenny 240,000 spindles, as already explained in full detail in my published report⁽²⁷⁾. But as this statistics investigation was already analyzed in detail, was not so reliable, the part of Scotland was not added up to the numbers of the Mule and the water frame, and involved some too little evaluation are seen by the whole⁽²⁸⁾. However, it will be clear that the Mule was already the central spinning machine of the England cotton industry in those days. In all likelihood, it does not make an error in estimation that the total number of installed Mule had reached 4,600,000 spindles by the around 1810⁽²⁹⁾.

3 The hand Mule in the early stage and 'operative skill'

For the next analysis based on the above mentioned, we have to pay the attention to that the several relations which the cotton spinning business as the 'cottage industry'⁽³⁰⁾ had inevitably brought had remained rather in the process of industrialization, and these industrialization or the capital accumulations had not progressed as rapid as has been considered to be 'an established theory' in the historical research till then. "It remained for using it as a manual machine in the small workshop", the early Mule "did not become a formidable enemy for any"(the Jenny or the water frame) till the end of the 18th century⁽³¹⁾, and therefore it did not pass to have given material conditions to the reorganization of the home spinning labourer, i.e., the transition of the adult labourer to women or child labourer, then it did not necessarily immediately embodied the dilution that skilled labourers became to redundant human resources but the early Mule requested the concentration of the skillful operatives in the beginning of the industrialization⁽³²⁾.

Especially, in the period before trying application of power to the Mule, so-called hand Mule stage, the hand skill was indispensable for the cotton spinning process. And although we can take cognizance of the existence the exceptions in some areas and some factories, we cannot also overlook this hand Mule stage had generally extended over a long period of time. In the case of the

hand Mule, the movement of the both-way slider was not only dependent on the fine spinner's muscular power, but the winding operation had to be operated and regulated by the hand of skilled operatives, therefore remarkable muscular power and remarkable 'skill' were indispensable⁽³³⁾.

Furthermore, the technical indispensable condition of the skill to operate the Mule hardly changed after the steamy power came to be used for driving the Mule. Also in the case of the power Mule, the spinner's skills and the experiences were indispensable for the operation. Although steamy power came to be used for the drive of the Mule machine, and the movement of the both-way slider was automated and the heavy muscular power became unnecessary, since it was still technically difficult to automatically stop the twist mechanism of a spinning machine after the both-way slider stopped, the winding operation as usual needed for the 'skill' of Mule fine spinners as the hand Mule stage⁽³⁴⁾.

In the stage when the Mule was driven and operated manually, although a fine spinner has generally operated one set of the Mule, since the moving slider was driven by any motive power, it became possible to operate two sets of the Mule by one spinner. Furthermore, in connection with increase the weight of the moving slider according to the Mule became to heavy duty machine since the increase of the number of spindles, the Mule became to be constructed by iron frame, and the operation by human power became insufficient, and any motive power came to be used also for the pull and push of the moving slider. However, the screw had to be regulated by spinner's single hand regulating faller for the winding by another hand ,and the rotation speed of spindles had to be changed delicately. These were delicate operation which needed any quick reactions, and remarkable skill, practical experience, 'mechanical skill', mechanical knowledge, etc. were indispensable to operate the power Mule⁽³⁵⁾.

R. William Kelley, was employed for the staff in Lanark factory of Robert Owen, tried application of the water power to the Mule in 1790 and converted into water power from human power to operate the fly-wheel which moved the slider, then owing to this convert one spinner was able to operate two sets of Mule machines at a time. Although he named this spinning machine improved personally "Self-acting mule", the spinner had to stop the spindles and adjust the faller for winding process, so far as this restriction, was not able to say it as a perfect automatic spinning machine, thus this Mule did not necessarily make transfer the 'skill' completely to a machine⁽³⁶⁾.

As long as this restriction was in existence, before the appearance of the 'self-acting Mule' mentioned behind, it will probably be able to be said that the 'skill' required of spinners for the operation of the Mule was considerable level. It was the skill of any kind which should be called advanced mechanical skill or 'new skill'. Therefore, in the excessive cases, since the Jenny did not need so high level 'skill' as the Mule and any factories could not be operated without the skilled

spinners, as long as the former has competed with the latter in respect of quality, it was said that some of individual mill owners preferred the Jenny.

Of course, the case of the Jenny was also the spinning machine which needs 'skill' more than the water frame currently operated by almost entire unskilled labourer. S.J. Chapman has explained as follows⁽³⁷⁾.

" the Jenny and the Mule could be economically operated only by the skilled spinners, therefore introduction of these were not almost decreased the amount of labour required for given production and since these needed muscular power and durability more than one spindle wheel, it made female and child labourer substitute by adult labourer."

Moreover, Hammonds has also pointed out as following⁽³⁸⁾.

"It was the industry of the woman labourer who borrowed the help of the child in the process of spinning preparations before a series of invention. Now, although factories and mills are administrated by juvenile labour especially prentice labour contains a few unskilled adult male and female. On the other hand, in the case of the Jenny and the Mule,skilled male operatives replaces for a juvenile labourer gradually. It is more economical to employ skilled labourer in the case of the more large-sized Jenny or the complicated Mule machine, although the Jenny of 8 to 12 spindles was operated by the child. Therefore, in addition to exploitation of juvenile labourers, the aristocrat spinners somewhat skilled who entered with the machine became increased."

On account of the appearance of the Mule, the spinning work "had changed to the job which had been monopolized by the new labouring class as called adult fine spinners, and which had required highly skill", therefore female and child labourers were driven out of the spinning shop where female and child labourers who were the family of hand weavers were chiefly engaged in spinning processes in their own house since the first stage of 18th century till then⁽³⁹⁾. The Mule " was not operated without a skilled worker's help called 'spinners' whose task was to conduct the whole operations of the machine⁽⁴⁰⁾".

4 The enlarged and self-acting Mule and the improvements in productivity

However, the above initial restrictions of the Mule were gradually eradicated by improvements and enlargement after around 1820. Although the Mule made from cast iron were found here and there, till the 1810s wooden Mule was common⁽⁴¹⁾, but the conversion to iron from wooden progressed in the 1820s, and it was said that even specialization and differentiation in the Mule assembling manufacture were beginning to advance simultaneously. For example, Peter Ewart who was the large cotton factory owner, at the 'Select Committee on Artisans and Machinery' of the Parliament in 1824, gave evidence that 150,000 pound or more per year of cast iron and bar iron were allotted to production for cotton machines in those days, the specialization of spinning

machine makers also progressed, and most spinning machine manufacture factories had become to specialize in production of a single kind and single parts⁽⁴²⁾. It probably means that the demand of the spinning machine had expanded to considerable grade, and it would not be fair to assume that the expansion of such demands of the spinning machine had contributed to generate and to establish the spinning machine manufacture as the fresh independent industrial section.

On the other hand, it will be able to easily assume that there was the necessity for a large amount of fixed-assets investment for introduction of such iron Mule in comparison with wooden Mule. In other words, a small group of the large cotton factory owners who were positive to introduction of large-sized and iron Mule by the means of high level capital accumulation defeated the competition with large numbers of small scale business by the huge fixed capital investment, and expanded their own business scale. In the 1830s, the rate of depreciation reached to no less than 10 to 33.3 percentage⁽⁴³⁾, it means that the fixed capital investment of the England cotton business in this stage was in a high level and moreover the period of the shift and conversion to new machine from existed machine became considerable short.

It is no exaggeration to say that the new factory owners, entered into the England cotton business which had the face as a newcomer, were eager for introduction of the new machine especially new and high productivity model, and were not frugal with own endeavor to assist for the technical innovation and the development of products. The large cotton factory owners in those days, for example, Hews, Ewart, Lee, Kennedy et al. were positive to introduction of long Mule and power Mule, etc. One of them, John Kennedy had been said that " all inventions for mechanical technology received his support. the prominent people of the science community whom he could not know in his whole life were very few. he has carried on his enterprise for the attachment to improve the favorite machine industry⁽⁴⁴⁾".

In this way, in connection with iron and long size Mule, the character as a cottage machine accompanying the initial stage of the Mule had been gradually eradicated, and the cotton factories had also enlarged. In the Lancashire district where the enlargement had made relatively progress by the end of the 1810s than in other districts, the number of the arithmetical mean employed labourers per one factory had reached to approximately 180 persons so that clearly Table No.1. If we follow the opinion was indicated by Sidney Pollard that the factory employed 200 or more labourers in those days was the large one had no choice but to encounter the serious 'management problem', we will be able to conclude the Lancashire cotton factories had already reached the 'large factories' even in the average scale.

The large-scale town factory equipped with the steam engine had already appeared in 1816, for example, Manchester ; Adam & George Murray(1,215 employed labourers), McConnel &

Kennedy(1,020), Philipps & Lee(937), Thomas Houldworth(622), Ancoats Twist Co.(376), Thomas Marriot(649), Preston ; Horrokses(704),Blackburn ; Birley & Hornby(549)⁽⁴⁵⁾.

Although the Arkwright type factories were contained in part of above list and the labourers of the weaving section were contained in the above employed numbers, besides not all of employed labourers of these factories were the Mule spinning labourers in the final analysis, it will be able to comprehend that the very large-scale Mule cotton factories had already appeared in that time. Of course, although that these did not show the average scale of a Mule factory of those days, and it seems to be common knowledge that the small and medium-size mills had grown gregariously except these, but it should be pay the researching attention to the actual conditions of the competition between spinning capitals in these days when such large scale factories had already appeared.

Table 1. Scale of the Lancashire Cotton Factories

district	factories	labourers	av. labourers per factory
Manchester,Salford,Eccles	80	19,923	249.03
Ashton-u-Lyne and district	34	4,470	131.47
Oldham	19	1,643	86.47
Bolton	19	3,262	171.68
Preston	15	1,898	126.53
Chorley,Blackburn	9	1,219	135.44
Bury	7	1,111	158.71
Rochdale	7	796	113.71
Wigan	8	616	77.00
Warrington	5	648	129.60
total	203	35,586	175.30

<SOURCE> This table was created from the original table in
 Fitton,R.S. and Wadsworth,A.P., *The Strutts and the Arkwrights 1758-1830: A Study of Early Factory System*, Manchester,Manchester University Press, 1958, p.196.

Furthermore, the competitions of technical-innovation had been motivated by the intensification of the competition between capitals and the eager desire for the reduction of production costs had promoted inevitably automation and enlargement of the Mule. The 'self-acting Mule' by the second patent of Richard Robert he had spent 1,200pounds on this development had made the sliders possible to be driven by power, in addition had applied power to the inversion of spindles in order to automate return of spindles, thus the speed of winding had improved by leaps and bounds, and had come to hardly need the operation by hand on winding. Then, an almost perfect automatic spinning machine had eventually appeared by this improvement of Roberts⁽⁴⁶⁾.

This self-acting Mule had gone into the utilization stage in the middle in the 1830s had transferred the operation of the adjustment of faller and screw had been dependent on 'skill' of

spinners in the stage of hand or semi automatic Mule to the machine, and it was said that this had improved the labour productivity in 15 times as compared with the early Mule⁽⁴⁷⁾. Moreover, the self-acting Mule of Roberts had not been inferior to hand Mule even the point of the quality of yarn, therefore had been able to provide the manufacturers with quite good yarn⁽⁴⁸⁾. In this way, the enlargement of the Mule had become remarkable in the 1820s ~ 1830s, and after the second half of the 1830s when the automation of Mule had been progressed we are able to acknowledge the turning point of the very clear improvement in productivity(See, Table No.2, No.3, No.4).

It will be necessary to investigate on how much spinning productivity had rose by the power and enlarged Mule. The enlargement of the Mule, precisely the increase of the number of spindles per set, had pulled up the number of spindles which one spinner taken charge of, and had improved the labour productivity in proportion to the number of spindles as a result.

On the "Factory Inquiry Commission" in 1834, John W.Cowell was one of investigation committees had estimated as follows about the enlargement of the Mule had decreased the required spinners. In short, although one factory which had installed 25 Mules of 336 spindles each and had produced No.170-210 threads had employed 36 spinners(adult male),88 child labourers and 29 females for scavengers, when 13 Mules of 636 spindles would be installed per set and produce same the amount of cotton yarn and same number of strings, while on the one hand this factory would be compelled to increase 3 scavengers, could save 12 spinners, and therefore could cut down the labour cost considerably as a result⁽⁴⁹⁾.

In the first place, the ground to been introduced the Mule driving out prior spinning machines had been that this machine had fitted for high-class 100% cotton thread spinning and had make it possible to improve the labour productivity. For example, around the second half of the 19th century, the labour cost had taken to carry out the spinning of the No. 36 count cotton strings 1,673 weight pound by operation 58 hours for week also had been 53 shillings by the self-acting Mule, while 90 shillings had been required in the case of 2,686 throstle-spindle of 5,000 rotations per 1 minute⁽⁵⁰⁾. In the meantime, the Mule that labour productivity had been high from the first had raised the productivity further more by iron-making, enlargement and automation⁽⁵¹⁾.

Table 2. Transition of the Cotton Spinning Productivity

Mule of an India hand spinning (the 18th century	5,000 O.H.P.
Crompton's Mule (1780)	2,000
100 spindles Mule	1,000
Power Mule (ca 1795)	300
Roberts' self-acting Mule (ca 1825)	135
Today's Most efficient spinning machine (1972)	40

* O.H.P. = the Number of Operative Hours to Process 100 lb.of Cotton

<SOURCE> Chapman,Stanley D., *The Cotton Industry in the Industrial Revolution*, London,Macmillan,1972, p.20.

Table 3. Transitions of the Labour Productivities

	cotton yarns (1,000 lb)	spindles (1,000)	employed	annual wage (£ 1,000)	products per spindle (1 bs)	products per man (1 bs)	wage per 1lb (pence)
1819-21	106,500	7,000	110,000	2,931	15.2	968	6.4
1829-31	216,500	10,000	140,000	3,822	21.6	1,546	4.2
1844-46	523,300	19,000	190,000	5,434	26.8	2,754	2.3
1859-61	910,000	30,000	248,000	8,060	30.0	3,671	2.1
1880-82	1,324,900	40,000	240,000	10,608	31.5	5,520	1.9

<SOURCE> This table was created from the original table in
Ellison, Thomas, *The Cotton Trade of Great Britain*, London, Frank Cass, 1886, rep., 1968, p.68.

Table 4. Products by 480 Spindles Mule(No.40 count strings)

	Hanks	labour cost per 1,000 hanks	
1806	6,668	9s.	2d.
1823	8,000	6	3
1832	10,000	3	8

<SOURCE> Babbage, Charles, *On the Economy of Machinery
and Manufactures*, London, Charles Knight, 1831, 4th ed.,
1835, p.338, para.410.

Anyway, we can also conclude without committing any major blunders that the England cotton spinning industry had rushed into the mass-production stage of pure cotton thread in the end of the 1830s, coupled with the cotton factory construction boom and factory scale expansion. However, this development and popularization of the machine system its kernel had been the Mule had necessarily transferred the England cotton industry to specialize for the fine cotton spinning, so the Mule had been really high quality cotton spinning machine that this specialization had retarded the introduction of the more productivity ring spinning machine. In this connection, United States of America had 17,900,000 spindles of the ring spinning machines within 23,100,000 spindles of the total cotton spinning machines in 1905, but there were only 10,400,000 ring spindles as compared with 45,200,000 Mule spindles in United Kingdom in 1913, then it became clear that United Kingdom was outstripped in the international competition of the cotton spinning technical innovation⁽⁵²⁾. So that the establishment of the production technical system in the England cotton spinning industry had depended heavily on the Mule and its long term stagnation had created the firm foundation caused the progress, the specialization and the outstripping of the England cotton industry and had brought the physical basement to stipulate the peculiar character of industrial relations and labour management in England cotton industry that is the mainly subject in this series of study.

However, it will be to excess impatience to regard that these enlargement and automation of the Mule had realized immediately the eradication of the small and weak capitals by large businesses. Of course, in the environment of the intensive competition between cotton factories, it will not be

able to deny the improvement in the productivity by enlargement and automation of the Mule had come to press remarkably the competitive condition of small and weak mills equipped only with the low productivity old model hand Mule.

Nevertheless, gregarious small and weak mills had remained quite in back, absorbing such a productivity gap by the reduction in wages, extension of working day, reinforcement of working strength, etc.⁽⁵³⁾. We have to pay our attention to that the small business with comparatively poor capital power had remained for long period in spite of the progress of innovation and enlargement of the factory scale by large scale capitals, and therefore the competition between individual businesses had been so long and severe that had brought the malformation of the structure of the British cotton industry and industrial relations in that time.

5 The factors of the delay of the self-acting Mule pervation

As already mentioned briefly, the power driven Mule combined with steam engine had made cotton factories again concentrate in the Lancashire southern part. However, the establishment as the full automatic machine of the Mule had been after the second half of the 1830s, and the Mule spinning factory before it had remained in the stage of manual or half-automatic Mule factory since the Mule had located in the kernel of the machine system had been still dependent on 'skill' of spinners in spite of the automatic mechanization in the spinning preparation processes, such as carding, roving, and drawing, had been already realized by a certain grade⁽⁵⁴⁾.

Already in 1792, although the patent of elementary automatic Mule had been gained by William Kelley had been employed as the manager at New Lanark factory in Dale, but it had hardly expanded after that since its lowness of the economic efficiency. Although various types of the power Mule, for example by John Kennedy et al. had been cultivated by way of experiment after the first stage of the 19th century, all had been seldom generalized before the spinners strike in 1825⁽⁵⁵⁾. The self-acting Mule of Roberts which had gone into the utilization stage at last the late of 1830s had not become into wide use like it as the power loom since the price had been extremely expensive, spinners unions had make a strong stand against its introduction and the self-acting Mule had accompanied several technical defects⁽⁵⁶⁾. It is even said that the period of the self-acting Mule had driven out the hand or semi-automatic Mule, although had been attended with remarkable local gaps, had been generally after the 1840s, especially in the some areas or in the some sections of cotton string had been delayed to the 1860s or the 1880s⁽⁵⁷⁾.

The most important problem is also what the factors had been delayed the spread of the self-acting Mule as thus. I'd like to enumerate some of main factors hereafter.

[price factor]

I think to able to point out the affair that the self-acting Mule had been quite expensive as compared with hand or half automatic Mule as one of the factors with the comparatively slow introduction of the self-acting Mule. Although the self-acting Mule had been superior in the aspect of labour saving as already mentioned, on the other hand, it had needed a large amount of fixed-assets investment⁽⁵⁸⁾. Therefore, many small and weak businesses which had not been able to make well a large amount of fixed-assets investment had made to delay or had given up the self-acting Mule in the stage which these had been able to compete through wages reduction, extension of working day, etc., even sacrificing labour productivity, and as the results of this, 'skilled' spinners indigenous to the stage of the hand or semi automatic Mule had remained for the long time.

An unconceivable fact of that the self-acting Mule had been very expensive will be able to be easily assumed with remarkable fixed-capital dropping having been required for the introduction even in the half-automatic Mule stage before the automation. For example, the amount of the initial costs of the working machines in the Mule spinning mill except the buildings and the power machines had been calculated by James M'Connel cotton mill owner in the end of the 18th century had been over 2,400 pounds on a scale of 30 sets of 180 spindles Mule. The detailed items seem to be the Table No.5.

Table 5. Initial Costs of Powered Mule Factory(1797)

machines	number	price per one (£)	total (£)
carding engines	12	27	324
drawing rovins	1	75	75
90 spindles stretching frame	2	57	114
180 spindles mule	30	54 *	1,133

* In the original table, although this section was 57 pound, it would be also an error.

<SOURCE> This table was created from the original table in

Lee,C.H., *A Cotton Enterprise 1795-1840 ; A Hisory of M'Connel and Kennedy Fine Cotton Spinners*, Manchester,Manchester University Press, 1972, p.21.

[international competitions factor]

It will be able to indicate that one of the factor had make to delay the introduction of the self-acting Mule was British cotton industry had been specialized to the high quality yarn production for the international competitions. As already described, in the section of the high quality cotton yarn it had been provably technically difficult to use the self-acting Mule even if after the 1850s, therefore it had not been easy to substitute the spinners for unskilled labourers, and the degree of the dependence to 'skill' of spinners had still been high level⁽⁵⁹⁾.

The high-quality-cotton yarns production had been able to desire high profits relatively as

compared with low and coarse cotton yarns, and the coarse cotton spinning in the continent countries and the sternway capitalism countries which had enjoyed relatively cheap labourer although there had been nothing expanded accumulations of 'skill' but had become superior to the competitive power of the England's coarse cotton yarn production, then these had made high-quality-cotton spinning in Britain to preserve for a long period, and had made to remain the 'skill' in greater degrees⁽⁶⁰⁾.

For example, as seen in Table No.6, the added-value gap of No.40 count yarn and No.100 count yarn had been expanded to 1 : 3.96 in 1830 from 1 : 2.43 in 1779, and it had not particular changed in the relative predominance of the high-quality cotton yarn as 1 : 3.67 till 1882. The such high added-value nature had made the England cotton spinning business which had been developing intense competitions in and outside the country to decline to more high-quality-cotton thread spinning , and then not to eradicate 'skill' of spinners so quickly.

Table 6. Added Values in Cotton Yarn Production

	No.40 yarn (per 1lb)			No.100 yarn (per 1lb)		
	sales price s. d.	cotton flower s. d.	wage, profits s. d.	sales price s. d.	cotton flower s. d.	wage, profits s. d.
1779	16 0	2 0	14 0	38 0	4 0	34 0
1784	10 11	2 0	8 11	19 0	3 6	15 6
1799	7 6	3 4	4 2	7 2	3 0	4 2
1812	2 6	1 6	1 0	5 2	2 4	2 10
1830	1 2.5	0 7.75	0 6.75	3 4.5	1 1.75	2 2.75
1860	0 11.5	0 6.88	0 4.63	2 4	0 11	1 5
1882	0 10.5	0 7.13	0 3.38	1 10	0 9.63	1 0.38

<SOURCE> Ellison, *op.cit.*, p.61.

[labour supply factor]

On the other hand, unique economic historian H.J.Habakkuk was taken as that labour shortage had been eased in or after 1815 by the enclosure, collapse of the domestic industry, rapid increase of Ireland emigration and improvement of agricultural technology, etc., and this had made subside the motivation to spinning mechanization⁽⁶¹⁾. However, it is difficult to bundle the labour market of this stage collectively as already stated, and it will even be meaningless to conceive that the general drift of labour market in this stage had not been in labour shortage. The labour market in this stage had been subdivided by various kinds of industries, areas, times, labour supply resources, and the supply-and-demand relations in the labour market had been also various.

In addition, in the case of Mule cotton spinners, though had been influenced by the economic fluctuation etc., the supply-and-demand relations had generally tighten, and the spinners union had also taken the supply restriction policy of labour. Moreover, the influence of the enclosure, Ireland

emigration, an agricultural revolution, etc. had become obvious chiefly in the unskilled labour market, it will be dangerous to emphasize the easing of labour shortage at least in the skilled labour market.

[union and labour management]

We have to pay our attention to the resistance movement(not as Machine Breakers or the Ruddism) by the spinner's unions to automatic machine introduction, and the labour management of the individual business which had accepted arbitrarily the union policy. N.J. Smelser divided into two classes the industrial disputes in the cotton industry from the 1820s to the 1840s, i.e., a wages problem, and the dispute in connection with 'rationalization' of production methods, such as the enlargement and the automation of the Mule⁽⁶²⁾. About the former, we can point out, for example, the strikes happened in every place from 1823 to 25, the Preston strike in 1836, the Manchester strike in 1844, and so on. Of course, these disputes cannot be decided promptly that it was the affair only in connection with the wages problem purely. The strikes from 1823 to 25 had been concerned to the abolition problem on Combination Act, and in the Preston strike in 1836 the union had demanded various problems without the higher wages⁽⁶³⁾.

However, it will not be able to be denied that these disputes had originated to the demand for higher wages or to rebound the wage reduction in its base. In almost cases, the cotton industry labour disputes in the first half of the 19th century had been mainly connected to the wage(piece rates) problems although had included the various subsidiary problems.

On the contrary, as been indicated by Smelser's classification, spinners had taken interest in the working conditions, especially the reinforcement of the work by the rationalization in the direct production processes, the collapse of 'skill' and the dismissal, and then they had been holding fast to their policy to tighten their guard against to the transformation of the labourer, the inflow of unskilled labourers, the changes of shop order, the extension of working day and the increase of the spindles of the Mule in charge. The Mule spinners union had opposed to the increase of the charged task by the enlargement and automation of the Mule and the adoption of the unskilled labourers by the automation with strong means containing a strike⁽⁶⁴⁾. Probably, such anti 'rationalization' policy of the spinners union had also become the indirect factor which had make to delay the introduction of the self-acting Mule. Although all will not be able to be connected to the spinners union policy, but it will be important that the labour management functions of the bigger factory owners to keep its equilibrium balance of the industrial relations and to maintain the shop order.

According to above mentioned factors, still like the case of the hand or half automatic Mule, we

have to pay attention that the self-acting Mule by which the spread had been delayed had been gradually introduced showing the remarkable gap between areas, either. Although introduction of the power and long-sized Mule in the Lancashire district had been relative almost favorable, it is said that it in other areas had been slow, for example, in Leeds where the first Mule had appeared at last in 1828, and it had not very spreaded till 1830⁽⁶⁵⁾.

The same is said for the case of the self-acting Mule. The introduction of the self-acting Mule had been comparatively early in Lancashire, but its popularization speed had been also extremely sluggish in other districts. In Yorkshire, the self-acting Mule had not appeared at all till the 1850s, and the self-acting Mule had appeared at length in the England northwest part⁽⁶⁶⁾.

6 Self-acting Mule and the 'skill' dismantling

According to the impassioned explain of Andrew Ure, the self-acting Mule which had become the practical-use stage at last at the last stage of the industrial revolution "was produced by the hand of our Prometheus had been submitted Minerva's own way in the present age", and "established the United Kingdom as the technical empire⁽⁶⁷⁾". In relation to the appearance of the self-acting Mule, We have to pay our attention for the most important point in this research is about the impact which it gave to the substitution of labourers.

If the conversion to the self-acting Mule from the hand Mule would be chiefly observed exclusively from the technical aspects, we could probably conclude that the spinners who had gained relatively high wages and better working conditions in the main processes of the cotton spinning factory had lost their 'skill' which had been physical resources for their status as "the labour aristocracy" by the transition of 'skill' to the machine according to the appearance of the self-acting Mule. And in the spinning process, it will be able to be said that it had become enough to operate total machine system only by the existence of unskilled self-acting Mule minder who had been only equivalent to the surveillance and maintenance of the machine and some piecers who had been entirely unskilled child labourers⁽⁶⁸⁾. Therefore, the cotton factory masters had probably become to expect for establishment of the shop working order before skilled spinners had employed and managed unskilled helpers at their own discretion which in mill owners had directly administrated many unskilled labourers through shop supervisor. Then, the self-acting Mule had "not only progressed useless no less than 60 percent of labourers⁽⁶⁹⁾", but also had been the tool to really recover the workshop discipline formerly held by skilled labourers.

In point of fact, many of adult spinners had been replaced child and female labourers by the introduction of the self-acting Mule. For example, in the case of the one cotton factory of

Stockport, it had been reported that near the 40 spinners had become to be needlessness and 50 pounds labour cost had been reduced per week by the adoption of the self-acting Mule⁽⁷⁰⁾. Thus, the self-acting Mule had been conceived as the automatic working machine which saved labourers especially skilled labourers from the time of its development, therefore had drastically promoted the diversion the 'skill' into machine⁽⁷¹⁾. It will be said more concretely that the development of the self-acting Mule had originated in the direct motivation that to drive away the 'prerogative' spinners from the production process, and to measure curtailment of the labour cost. Therefore, on the other hand, it was pointed that just the high wages of 'skilled' cotton spinners and their strong negotiation had become motive factor to introduce the self-acting Mule. The self-acting Mule had been also developed for the purpose to drive away Mule spinners who had acquired high wages and 'authority' of their own from the first. According to the England science and technological historian, " at the long strike in 1824, cotton mill owners conceived an idea that it was possible to manufacture the Mule spinning machine driven by automatic mechanism and moved properly speed, and for which it did not need to depend the unmanageable labourers⁽⁷²⁾". In this way, although the cotton factory masters of Staley-Bridge had started development of the automatic Mule personally, since they had not been able to get a good result, there had been nothing for it but to do that they had asked Roberts who had been executive in the prominent machine manufacture Sharp, Roberts & Co. in those days to produce it after all⁽⁷³⁾.

In other words, it will be able to be describe that the development of the self-acting Mule had been accelerated by the interest confrontation with spinners who had enjoyed the status as the "labour aristocracy" and the cotton mills owners who had been pressed to reduce the products price in the intense competition between cotton manufacturers had become obvious. Such interest confrontations had been actualized at the time of labour dispute, the spinners strike after the 1830s had become the important cause which had droved the factory masters to introduce the self-acting Mule⁽⁷⁴⁾. The technical character of the self-acting Mule that "had not to depend spinners who had distressed the cotton factory masters with their combinations and strikes⁽⁷⁵⁾" was certainly the motivation of mill owners who had taken great pains to overcome the severe competitions between large numbers of businesses.

And it will be able to suppose that the self-acting Mule had been produced by the mill owner's critical consciousness that "the rapid expansion of the usage the Mule in the situations the sufficient spinners supply had not increased had brought the incompatibility between labourers and employers in a short time. Since labourers had been untrustworthy and haughtiness at that time, this trade would be prevented to progress unless the automation as the water frame⁽⁷⁶⁾".

As a matter of course, the self-acting Mule had to respond the anticipation of these cotton mill

owners, and had brought the demolition of the 'skill' for the individual cotton mill owners. On the substitution of 'skilled' spinners to unskilled labourers as accompanied by the introduction of the self-acting Mule, the real state of the same affairs had thoroughly proved by the letter from one spinner had appeared in 'Morning Chronicle' that had been popular newspaper for labouring class⁽⁷⁷⁾.

"I worked as cotton spinner in Chorlton-upon-Medlock. the privilege-status which I had enjoyed continued up to nearly 1837. The self-acting Mule(machine with steam power) generally came to use in 1837. Only one girl does the same work three males were usually needed before with 15 shillings as a week three males have earned 7 pound 10 shillings in sum total for same work using three sets of machines. No less than 400 in all man and woman's labourers have been driven out of the shop in one week at one factory. Although we had the meeting of the union, but we could cause no action at all, then we were informed that we should return to factory and to operate three sets of machines for 15 shillings at a week as the girl was doing. However, we did not do stripes so. Several persons became the soldier, several persons went away abroad, and several persons left in quest of work to the factory of Stockport where has seldom spread self-acting mule still."

In the fact at Glasgow, in connection with the spread of the self-acting Mule, reorganization of the workshop order by increase of unskilled labourers had advanced, and it is said that the spinners union had received the large blow in the end of the 1830s⁽⁷⁸⁾. In Preston, the conversion to the self-acting Mule had gotten into stride ignited with labour disputes which had lasted to the next year from 1835 as a turning point⁽⁷⁹⁾, and it had been reported that the self-acting Mule had driven out 'skilled' spinners also by Bolton in the second half of the 19th century⁽⁸⁰⁾.

However, since the spread of the self-acting Mule had been quite slow as it was already described, the demolition of the 'skill' and the equalization of the labour market accompanied by the spread of the self-acting Mule had remained in the fragmentary phenomenon of the limited areas and factories in those days. If anything, we have to pay attention to that the self-acting Mule had not immediately expelled the skilled spinners from the workshop. The primary purpose of the self-acting Mule had been the removal 'skill' to machine, but such substitutions had not necessarily advanced at a stroke actually. As an actual occurrence, the latest research indicated "the mechanization in Mule spinning was slow, and after the self-acting mule came to be introduced extensively(in and after 1835), the spinners held the semi-independence-status⁽⁸¹⁾".

We can't jump to the conclusion that the appearance of the self-acting Mule had promoted the dilution without delay, since the self-acting Mule had spread at a slow speed, after the automation a certain measure of 'skill' had been indispensable in any section of cotton goods⁽⁸²⁾, and the peculiar industrial relations or labour management in the sub-contracting system had fulfilled its individual functions for a long time. The introduction of the self-acting Mule had made useless the 'skill' which had been indispensable in the stage of hand Mule or semi-automatic Mule, but on the other hand the self-acting Mule needed the new skill, experience, capability, etc. which these had been

seem in the former stage too.

"When the machine came to be automated more, the operative's intelligence came to be collectively demanded for any minuteness. The self-acting machines had complicated mechanism and were more delicate and expensive. The operatives managing it had to understand them in order to obtain the highest result temporarily. Therefore, more perfect machine must extremely accompanied with the demand for labourers that had more discretion, well educated, and paid higher wage⁽⁸³⁾".

But it had become a commonly accepted theory in the past historical studies that the substitution accompanied with the appearance of the self-acting Mule to unskilled operatives from 'skilled' spinners had advanced by the end of the 1830s. For example, it should be supposed that Prof. Sigeyoshi Tokunaga quoted a part of statistics about change of the labour composition in the cotton factory which S.J.Chapman collected from the reports of Factory Inspectors, concluded to recognize the alternative transition to the unskilled labourers from the 'skilled' labourers = dilution in the middle of the century⁽⁸⁴⁾. However, it is as long as the numerical value by 1895 is analyzed as in the original table(Table No.7) of S.J.Chapman, since the labour composition by according to the occupation were not carried, enough data was not necessarily offered, but we can't find out the significant difference by time flow so be represented as the dilution.

Furthermore, we should pay our attention to that the reduction tendency of adult labourers and remarkable advance of female labourers had been seen by these days in the cotton manufacturing sections without the spinning process. According to the "Factory Census Returns" of this time, in the various cotton goods production sections, such as a lace, hosiery, printing, dyeing, and bleaching, female labourers had been also increasing 28% to the adult male labourers of 20 or more years old had decreased 15% or more from 1851 to 1881(see Table No.8, No.9).

If it compares with the actual condition of the dilution in such related many sections, the long time stability and a slight increase of the real number and the percentage of the adult male labourers in the spinning section should be comprehended as the particular tendency. The long time survival of the adult male labourers in the spinning section just was the important evidence for the substitution of skilled labourers had hardly advanced in spite of production technical innovation called the self-acting Mule. If we refer to the statistical numerical value(Table No.10) of the above "Factory Census Returns", we are able to find out that adult male labourers had absolutely increased, and especially the increase rate of the adult male labourers in the spinning factories had been equal to it of the female labourers inversely in the Table No.8 and No.9.

Table 7. Labour Composition in the Cotton Industry(%)

	Under 18 both sexes	13-18 male	Upper 18 male	Upper 13 female	Total
1835	13.2	12.5	26.4	47.9	218,000
1838	4.75	16.6	24.9	53.8	259,500
1847	5.8	11.8	27.1	55.3	316,000
1850	4.6	11.2	28.7	55.5	331,000
1856	6.5	10.3	27.4	55.8	379,300
1862	8.8	9.1	26.4	56.7	451,600
1867	10.4	8.6	26.0	55.0	401,100
1870	9.6	8.5	26.0	55.9	450,100
1874	14.0	8.0	24.1	53.9	479,000
1878	12.8	7.2	25.3	54.7	483,000
1885	9.9	7.9	26.4	55.8	504,000
1890	9.1	8.2	26.9	55.8	528,000
1895	5.8	7.9	27.6	58.7	538,000

<SOURCE> This table was created from the original table in Chapman,S.J., *The Lancashire Cotton Industry:A Study in Economic Development*, Manchester,Manchester University Press,1904, p.112.

<ANALYSIS>

According to the analysis of the said time, the percentage in 1850 was 6.4, 10.3, 27.4, and 55.9%, respectively, and differed from the table of S.J. Chapman (Nicholson,J.S., *The Effects of Machinery on Wage*, London,Swan Sonnenschein,1878,rev.ed.,1892, p.84.). Moreover, Smelser has indexed transition of the rate of labour composition by sex and age in the cotton factories from other historical record, the numerical value in 1847 and 1850 differed from the statistics table of Chapman a little. But, it caused from an easy error for the table of Smelser, others were as the almost same numerical value (Smelser,N.J., *Social Change in the Industrial Revolution : An Application of Theory to the Lancashire Cotton Industry 1770-1840*, London,Routledge and Kegan Paul,1959, p.202.).

If each annual ratio is seen, the reductive tendency of the adult male labourer's proportion and these real number will not be significant, moreover, we will be able to understand that the reduction of the younger labourers had been counterbalanced by the increase of female labourers. And, since the greater part of the female labourers in increase tendency had been absorbed to the power-loom factories which already mentioned, so we can't recognize the under stability tendency of the labour dilution in the spinning section. If it restricts to male labourers, it is difficult to extract any serial direction of the dilution except the effects of the age regulation by the factory acts.

Table 8. Labour Composition in the Cotton Industry(%)

	1835	1838	1847	1850
Under 13, both sexes	13.2	4.7	5.8	4.6
13-18 male	12.5	16.6	11.8	11.2
Upper 18 male	26.4	24.9	27.1	28.7
Upper 13 female	47.9	53.8	55.3 *	55.5 **
total	218,000	259,500	316,400	331,000

* In the field of original table, although it is 55.5%, it will be an error.

** In the field of original table, although it is 55.8%, it will be an error.

<SOURCE> This Table was created from the original table in Smelser, *op.cit.*, p.202.

Table 9. Ratio of the Labour composition in the Various Section of the Cotton Industry without Spinning and Weaving (England and Wales)

	1851	1881	fluctuation
Under 20 male	82,754(15.0)	81,730(13.5)	-1,024(-1.5)
Upper 21 male	76,435(31.9)	148,279(24.4)	-28,156(-15.6)
sub total	259,189(46.9)	230,009(37.9)	-29,180(-11.2)
Under 20 female	121,801(22.0)	141,655(23.3)	19,854(16.3)
Upper 21 female	171,680(31.1)	235,178(38.8)	63,498(36.1)
sub total	293,481(53.1)	376,833(62.1)	83,352(28.4)
total	552,670	606,842	54,172(9.8)

<SOURCE> Ellison, *op.cit.*, p.75.

Table 10. The Ratio of the Labour Composition in the Spinning and Weaving Sections (United Kingdom)

	labourer under 13	female upper 13	male upper 13	Total
<spinning factories>				
1850	6,488	50,108	38,643	95,239
1878	20,766	78,528	56,321	155,615
ratio	220.0	56.6	45.7	63.3
<weaving factories>				
1850	166	20,675	10,724	31,565
1878	12,543	67,360	31,761	111,664
ratio	7556.0	225.8	196.1	253.7
<spinning and weaving factories>				
1850	8,065	104,043	78,179	190,287
1878	28,364	115,460	67,359	211,183
ratio	251.6	10.9	-13.9	10.9
<total>				
1850	14,993	183,912	132,019	330,924
1878	61,923	264,171	156,809	482,903
ratio	313.0	42.1	18.8	46.0

<SOURCE> This table was created from the original table in Ellison, *op.cit.*, p.72.

Moreover, even if it extended the view for analysis till the end of the 19th century, according to the labour statistics by the Labour Department of the Board of Trade, adult male spinners as Mule operatives still had played the central rolls in the spinning process, and wage gap between Mule operatives and scavengers had been remain unchanged(See, Table No.11).

In spite of the gradual spread of the self-acting Mule, at the spinning process, we can find a slight increase of adult male labourers(the most were fine spinners), therefore dependence on the 'skilled' labourers had lasted out for a long time. The series of technical innovations in the spinning process which was already mentioned had not necessarily accelerated " the removal skill to machine" in the right meaning of language, and had not caused the tendentious dilution of labourers.

Table 11 Weekly Wage in the Cotton Factories(1886)

	adult male		nonage	adult female			nonage female		
	a	b	c	d	e	f	g	h	i
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Preston	28 11	21 11	13 7	15 9 x	-	17 11	20 9	8 5	12
Bolton	34 5	18 10	12 9	14 1	13 0	15 9	17 4	6 9	9 7
Oldham	33 2	-	15 2	16 7	13 8	14 0	19 9	8 4	-
Rochdale & Heywood	31 3	19 7	14 11	14 5	12 4	14 9	19 0	8 5	9 8
Halifax	28 6	-	12 10	13 4	12 3	-	-	7 3	-
Manchester	33 11	-	15 3	14 5	11 7	14 9	17 9	7 7	9 11
Stockport	31 2 y	19 8	13 4	14 0	11 1	15 11	18 4	7 6	10 1
Lancashire	32 11	20 0	13 0	14 0	12 9	15 11	18 4	7 5	9 9
Scotland	25 5	-	-	10 1	-	13 2	-	5 11	8 7
Mid-Derbyshire	29 10 z	-	15 3	11 8	-	-	-	7 11	-

x; scavenger y; No.4 ~ 180 spinning z; No.4 ~ 140 spinning

a; Under No.80 self-acting Mule minders(piece rate)

b; weavers(piece rate)

c; self-acting Mule scavenger(payment by time)

d; roving helpers, carding engine operators(piece rate)

e; winders(piece rate)

f; weavers 3 looms(piece rate)

g; weavers 4 looms(piece rate)

h; helpers, dustbinman(payment by time)

i; weavers 2 looms

<SOURCE> This table was created from the original table in

P.P., *Report on the Work of the Labour Department of the Board of Trade (1893-1894), with Supplement Containing Abstract of Labour Statistics*, London, H.M.S.O., Cmnd.7565, 1894, pp.90-91, table 46.

reference

- (1) See, 茂木一之「熟練の解体とイギリス産業革命期の綿紡績工場の排他性～19世紀前半のイギリスミュール型紡績職場における労務管理～」『明治大学大学院紀要』第12集、昭和49年9月(Kazuyuki Mogi 'On the Dilution of the Skill and Exclusive Character of the Cotton Spinners Unions; The Labour Management in the Mule Spinning Workshop in the First Half of the 19th Century', *Bulletin of Post-graduate School of Meiji University*, vol.12, 1974.); 茂木一之「イギリス初期綿工場の類型と規模に関する一考察～サミュエル・クラプトン調査を中心に～」『高崎経済大学論集』第23巻3・4号、昭和56年2月(Kazuyuki Mogi 'The Study on the Types and Scale in the Early British Cotton Industry; Factory Census of Samuel Crompton', *The Economic Journal of Takasaki City University of Economic*, vol.23, No. 3 & 4, 1981.); 茂木一之「初期イギリス綿業における資本形成の特殊性～資本形成・蓄積過程における特殊イギリス的性格～」『高崎経済大学論集』第42巻2号、平成11年9月(Kazuyuki Mogi 'On the Peculiarity of the Capital Formation in the Early British Cotton Industry; the British Peculiarity in the Process of Capital Formation and Accumulation', *The Economic Journal of Takasaki City University of Economic*, vol.42, No.2, 1999.); 茂木一之「綿紡績経営における経営類型の発展と多様化」『高崎経済大学論集』第43巻2号、平成12年9月(Kazuyuki Mogi 'On the Progress and Variety of the Business Forms in the Cotton Spinning Business', *The Economic Journal of Takasaki City University of Economic*, vol.43, No.2, 2000.)
- (2) See, French, Gilbert J., *The Life and Times of Samuel Crompton; Inventor of the spinning Machien called the Mule*, Manchester, Thomas Dinham, 1860, 2nd ed., 1860, p.51; Mantoux, P., *The Industrial Revolution in the Eighteenth Century; An Outline of the Beginings of the Modern Factory System in England*, London, Methuen, 1964, new ed., 1964, pp.234-235; Landes, D.S., *The Unbound Prometheus*;

- Technological Change and Industrial Development in Western Europe from 1750 to the Present*, Cambridge, Cambridge University Press, 1969, pp.85-86.
- (3) Baines, Edward, *History of the Cotton Manufacture in Great Britain*, London, H. Fisher, R. Fisher, R. Fisher and D. Jackson, 1835, p.184.
- (4) See, 茂木一之「初期イギリス綿業における景気変動と競争構造」『高崎経済大学論集』第41巻3号、平成11年2月(Kazuyuki Mogi 'On the Economic Fluctuations and the Structure of Competitions in the Early England Cotton Industry', *The Economic Journal of Takasaki City University of Economics*, vol.41, No.3, 1999).
- (5) Refer to the following about the detailed technical structure of the water frame. Ure, Andrew., *The Cotton Manufacture of Great Britain; systematically investigated, and illustrated by 150 Original Figures, engraved on Wood and Steel; with an Introductory View of Its Comparative State in Foreign Countries, drawn chiefly from Personal Survey*, 2 vols, London, Charles Knight, 1836, vol.1, pp.259-262.
- (6) Baines, *op.cit.*, p.184.
- (7) Baines, *op.cit.*, pp.86-87; Chapman, S.J., *The Lancashire Cotton Industry: A Study in Economic Development*, Manchester, Manchester University Press, 1904, pp.153-154.
- (8) Wadsworth, A.P. and Mann, Julia de L., *The Cotton Trade and Industrial Lancashire 1600-1780*, Manchester, Manchester University Press, 1931, p.492.
- (9) "Like the weaving section, at least two Industrial Revolution happened, and two different factory systems were planted in the spinning section of cotton industry. Only the first it was revolutionary and the latter was gradual evolution. A roller spinning machine was the first it from the first, and the Jenny and the Mule made the factory system other than this introduce."(S. J. Chapman, *op.cit.*, p.53.)
- (10) Unwin, G., *Samuel Oldknow and the Arkwright ; The Industrial Revolution at Stockport and Marple*, Manchester, Manchester University Press, 1924, p.3.
See, Daniels, G.W., *The Early English Cotton Industry; with Some Unpublished Letters of Samuel Crompton*, Manchester, Manchester University Press, 1920, pp.168-169; Wolf, A., *A History of Science, Technology and Philosophy in the Eighteenth Century*, London, George Allen, 1938, pp.509-510.
"Mule yarn, was high-class more than whether cotton yarns it had been produced once in this country, was used for weaving delicate clothes, muslin, and the outstanding goods."(S. J. Chapman, *op.cit.*, p.37.)
- (11) Ellison, Thomas., *The Cotton Trade of Great Britain*, London, Frank Cass, 1886, rep., 1968, p.24.
- (12) S.J. Chapman, *op.cit.*, pp.67-68.
- (13) Gaskell, Peter., *Artisan and Machinery: The Moral and Physical Condition on the Manufacturing Population considered with reference to Mechanical Substitutes for Human Labour*, London, John W. Parker, 1836, p.16; Hammond, J.M. and Hammond B., *The Skilled Labourer 1760-1832*, London, Longmans, 1919, p.53; Hammond, J.M. and Hammond B., *The Rise of Modern Industry*, London, Methuen, 1927, p.183; S.J. Chapman, *op.cit.*, pp.59-60.
- (14) Bythell, Duncan, *The Handloom Weavers; A Study in the English Cotton Industry during the Industrial Revolution*, Cambridge, Cambridge University Press, 1969, p.34.
- (15) Wolf, *op.cit.*, p.509; Usher, Abbott Payson, *An Introduction to the Industrial History of England*, Boston, Houghton Mifflin, 1920, p.384.
- (16) Lee, C.H., *A Cotton Enterprise 1795-1840 ; A History of McConnel and Kennedy Fine Cotton Spinners*, Manchester, Manchester University Press, 1972, p.28.
- (17) *Ibit*, p.193.
- (18) Lilley, Samuel, *Men, Machines and History ; the Story of Tools and Machines in Relation to Social Progress*, London, Lawrence and Wishart, 1965, rev. ed., 1965, p.193.
- (19) S.J. Chapman, *op.cit.*, p.60.
- (20) Dobb, Maurice., *Studies in the Development of Capitalism*, London, Routledge & Kegan Paul, 1946, p.281.
- (21) French, Gilbert J., *The Life and Times of Samuel Crompton; Inventor of the spinning Machine called the Mule*, Manchester, Thomas Dinham, 1860, 2nd ed., 1860, p.71.

- (22) Chapman, Stanley D., *The Cotton Industry in the Industrial Revolution*, London, Macmillan, 1972, p.32.
- (23) Heaton, Hervert, 'Financing the Industrial Revolution', in Crouzet, Francois (ed.), *Capital Formation in the Industrial Revolution*, London, Methuen, 1972, pp.85-86.
- (24) Unwin, *op.cit.*, pp.147-156.
- (25) Postan, M.M., 'Recent Trends in the Accumulation of Capital', in Crouzet, *op.cit.*, pp.73-76.
- (26) See, Smelser, N.J., *Social Change in the Industrial Revolution : An Application of Theory to the Lancashire Cotton Industry 1770-1840*, London, Routledge and Kegan Paul, 1959, p.111 ; Lee, *op.cit.*, p.28.
- (27) For details, refer to my detail list in Kazuyuki Mogi, 'The Study on the Types and Scale' (above).
- (28) Chaloner, W.H., *People and Industries*, London, Frank Cass, 1963, p.43.
- (29) S.J.Chapman, *op.cit.*, p.58 ; S.D.Chapman, *op.cit.*, p.22.
- (30) Hill, C.P., *British Economic and Social History 1700-1964*, London, Edward Arnold, 1970, 3rd ed., 1970, p.35.
- (31) Chaloner, *op.cit.*, p.42.
- (32) Edoword, Michael M. & Lloyd-Jones, R., 'N.J.Smelser and the Cotton Factory Family : A Reassessment', in Hart, N.B. and Ponting, K.G.(ed.), *Textile Histroy and Economic History; Essays in Honour of Miss Julia de Lacy Mann*, Manchester, Manchester University Press, 1973, p.305.
- (33) Smiles, Samuel., *Industrial Biography; Iron Workers and Tool Makers, London*, Jhon Murray, 1863, p.267; S.J.Chapman, *op.cit.*, pp.54,68-69,83.
- (34) Man, Julia, de L., 'The textile Industry: Machinery for Cotton, Flax, Wool, 1760-1850', in Singer, C. et al.(ed.), *A History of Technology, vol.IV, The Industrial Revolution c1750 to c1850*, Oxford, Oxford University Press, 1958, p.288.
- (35) S.J.Chapman, *op.cit.*, pp.68-69.
- (36) Baines, *op.cit.*, pp.205-207.
- (37) S.J.Chapman, *op.cit.*, p.54.
- (38) Hammond, *Skilled Labourer*, p.58.
- (39) Pinchbeck, I., *Women Workers and the Industrial Revolution 1750-1850*, London, George Routledge and Sons, 1930, pp.148-152.
- "The occupation of new comparatively high wages was brought to the adult male."(Wdsworth & Mann, *op.cit.*, p.404.)
- (40) Ellison, *op.cit.*, p.31.
- (41) P.P., *Fifth Report from Selected Committee on Artizans and Machinery, Parliamentary Papers, Sess.1824, vol. V, 1824*, Minutes of Evidence, p.385, evid. of Henry Houldsworth.
- (42) *Ibit.*, Minutes of Evidence, p.253, evid. of Peter Ewart.
- (43) Pollard, Sidney, *The Genesis of Modern Management; a Study of the Industrial Revolution in Great Britain*, London, Penguin Books, 1965, rep. ed., 1968, p.21.
- (44) Musson, A.E. & Robinson, E., *Science and Technology in the industrial Revolution*, Manchester, Manchester University Press, 1969, pp.100-101. See, Smiles, *op.cit.*, pp.321-322.
- (45) Fitton & Wadsworth, *op.cit.*, p.195.
- See, Loard, John., *Capital and Steam-Power ; 1750-1800*, London, P.S.King, 1923, pp.167-175 ; Hills, Richard L., *Power in the Industrial Revolution*, Manchester, Manchester University Press, 1970, pp.159-162 ; Blaug, M., 'The Productivity of Capital in the Lancashire Cotton Industry during the Nineteenth Century', *Economic History Review, 2nd Series*, Vol.XIII, No.3, 1961, pp.379-381 ; Cooke Taylor, W., *Notes of a Tour in the Manufacturing Districts of Lancashire ; in a Series of Letters to his Grace the Archbishop of Dublin*, London, Duncan and Malcolm, 1842, 2nd ed., 1842, p.115 ; Tann, Jennifer, 'The Employment of Power in the West-of-England Wool Textile Industry 1790-1840', in Hart & Ponting, *op.cit.*, p.210.
- (46) S.J.Chapman, *op.cit.*, p.69.
- (47) S.D.Chapman, *op.cit.*, p.20, table.
- (48) Baines, *op.cit.*, p.207.

- (49) P.P., *Factory Inquiry Commission, Supplementary Report of the Central Board of His Majesty's Commissioners appointed to collect Information in the Manufacturing Districts, as to the Employment of Children in Factories, and as to the Propriety and Means of Curtailing the Hours of thier Labour: with Minutes of Evidence, and Reports by District Commissioners*, P1, Parliamentary Papers, Sess.1834, vol.XIX,1833, Part1, D.1, Cowell's Preface to Tables, p.119j.
- (50) Ellison, *op.cit.*, p.33
- (51) See, Blaug, *op.cit.*, pp.380-381.
- (52) Sandberg, *op.cit.*, esp. pp.120-124.
- (53) See, P.P., *Factory Inquiry Commission, Supplementary Report of the Central Board of His Majesty's Commissioners appointed to collect Information in the Manufacturing Districts, as to the Employment of Children in Factories, and as to the Propriety and Means of Curtailing the Hours of thier Labour: with Minutes of Evidence, and Reports by District Commissioners*, P1, Parliamentary Papers, Sess.1834, vol.XIX,1833, Part1, D.1, Lancashire District, p.66, exam. by John W. Cowell.
- (54) "Although the fully self-acting Mule without the help of skilled operator had come to appear in 1825, but the model which was completely perfect was not realized till 1830."(Lilley, *op.cit.*, p.98.).
- (55) Smiles, *op.cit.*, p.269 ; Mann, *op.cit.*, p.288.
- (56) According to H.A.Turner, the spread of self-acting Mule was not more drastic than the process of the gradual expulsion of the had loom weavers by the power loom.(Turner, H.A., *Trade Union Growth, Structure and Policy ; A Comparative Study of Trade Union*, London, George Allen and Unwin, 1962, p.75.).
- (57) See, Ure, *op.cit.*, vol.2, pp.194-202 ; S.J.Chapman, *op.cit.*, pp.69-70 ; Redford, A., *Labour Migration in England ; 1800-1850*, Manchester, Manchester University Press, 1926, Second ed., 1964, p.37.
- (58) Habakkuk, H.J., *American and British Technology in the Nineteenth Century ; The Search for Labour-Saving Inventions*, Cambridge, Cambridge University Press, 1962, p.142.
- (59) S.J.Chapman, *op.cit.*, p.69.
- (60) S.D.Chapman, *op.cit.*, p.58.
- (61) Habakkuk, *op.cit.*, pp.136-137, 141.
- (62) Smelser, *op.cit.*, pp.231-232.
- (63) Ashworth, Henry, *An Inquiry into the Origin, Progress, and Results of the Strike of the Operative Cotton Spinners of Preston, from October, 1826, to February, 1837 : read at Liverpool, before the Statistical Section of the British Association, Sep.14, 1837*, Manchester, printed by Jhon Harrison, 1838, pp.2-3.
- (64) Smelser, *op.cit.*, pp.231-232.
- (65) Mann, Julia de L., *The Cloth Industry in the West England from 1640 to 1880*, Oxford, Oxford University Press, 1971, pp.187-188.
- (66) Mann, *op.cit.*, p.289.
- (67) Ure, Andrew., *The Philosophy of Manufactures: or An Position of the Scientific , Moral, and Commercial Economy of the Factory System of Great Britain*, London, Charles Knight, 1835, p.367.
- (68) Smiles, *op.cit.*, p.269.
- Please refer to the following evidence of the "Selected Committee on Combination of Workmen" about on the 'dissolution of skill' and the 'arduous work' by the introduction of the self-acting Mule. P.P., *First Report from Selected Committee on Combination of Worker : together with the Minutes of Evidence, and Apendix*, Parliamentary Papers, Sess.1837-1838, vol.VIII, 1838, Minutes of Evidence, p.36, QQ.768-775, evid. of Augus Cambell, pp.273-274, QQ.3688-3706, evid. of David M'Williams.
- (69) Mann, *The Cloth*, p.243.
- (70) Ure, *The Philosophy*, p.23.
- (71) The water power Mule of William Kelley had developed for "the purpose to spinning by child labourers as the water frame"(Baines, *op.cit.*, p.206.).
- (72) Smiles, *op.cit.*, pp.267-268.

- (73) Smiles, *op.cit.*, p.268.
- (74) Webb, Sidney & Beatrice, *The History of Trade Unionism*, London, Longmans, 1920, 2nd ed., 1920, p.169.
- (75) Baines, *op.cit.*, p.208.
- (76) Ellison, *op.cit.*, p.31.
- (77) *Morning Chronicle*, January 17 and 1850 and Letter to Editor (cited in Pazzel, P.E. and Wainwright, R.W. (ed.), *The Victorian Working Class ; Selections from Letters to the Morning Chronicle*, London, Frank Cass, 1973, p.106.)
- (78) Turner, *op.cit.*, p.168.
- (79) About the cotton spinners' strike of Preston in 1835, please refer to the report of J.Lowe in the investigation reports edited by National Association for the Promotion of Social Science. J.Lowe, 'An Account of the Strike in the Cotton Trade at Preston, in 1835', in National Association for the Promotion of Social Science, *Report of the Committee on Trades Societies, appointed by the National Association for the Promotion of Social Science*, London, N.A.P.S.S., 1860.
- (80) Turner, *op.cit.*, p.116.
- (81) S.D.Chapman, *op.cit.*, p.58.
- (82) Mann, *op.cit.*, p.290.
- (83) S.J.Chapman, *op.cit.*, pp.83-84.
- (84) 徳永重良 『イギリス賃労働史の研究～帝国主義段階における労働問題の展開～』法政大学出版局, 1967年, 5-6頁。(Sigeyoshi Tokunaga, *The study on the History of British Wage Labour : the new turn of the labour problems in the Imperialism*, Housei University Publishing, 1967, pp.5-6.)