JOSEPH NASMITH

MODERN COTTON SPINNING MACHINERY, ITS PRINCIPLES AND CONSTRUCTION

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Table of Contents

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PREFACE.

Table of Contents

In submitting the following pages to the judgment of the public, the Author does not pretend to have written an exhaustive treatise. This would require a volume much larger than the present. It has rather been his aim to treat a branch of the subject thoroughly, which has hitherto had scant justice done to it. While the market is flooded with books detailing the rules by which speeds are calculated, and the necessary wheel changes made, those dealing with the construction of the machinery employed are few in number. This is the more singular, because England is, beyond doubt, the true mother of this department of mechanics, and to-day her textile machinists head the lists alike for excellence of production and fertility of invention.

Since the issue of the late Mr. Evan Leigh's "Science of Modern Cotton Spinning"—comparatively a long time ago—no book has appeared which treats the subject from the machinist's point of view. The well known book of Mr. Richard Marsden, "A Handbook of Cotton Spinning," as its name implies, deals more with the operation than the machinery, although the latter is described in considerable detail. In the present work, while it has been impossible to avoid saying something of spinning, the enunciation of the principles on which the machinery is constructed forms its *raison d'être*. On the Continent, more than one ponderous treatise has been published, which possess the peculiarity of foreign technical works in the disproportionate way in which the small details are treated. While this is valuable from the professorial point of view, it is apt to be prejudicial in actual practice, because the operation of these details varies considerably at different times. The avoidance of pedantry is very essential in any book dealing with practical work, and with this in view, the Author has endeavoured, while fully considering every principle involved, to do so in a plain manner, which will be readily understood. It has rather been the aim to suggest the inferences to be drawn than to dogmatically state inflexible rules.

The whole of the machines have been considered fully, and the most important modifications described. The preparation of the drawings has been a long labour, but the Author believes they have not hitherto been so fully given in any English work. In order to keep the book within bounds, it has been almost rigidly confined to a consideration of the art of textile mechanics as applied to the spinning of cotton to-day. It is believed that the book will provide an accurate account of the state of present knowledge, and will be valuable for that reason.

It should be distinctly understood that the mention of any machinist does not imply any approval or otherwise of his particular appliance, but is simply given in order to identify the maker of it, which it is only fair to do. The Author's opinions can be easily gathered, but it is no part of the scheme to enter into controversy about different methods, or to make the book a treatise on comparative textile mechanics.

The Author desires to thank all those firms who have aided him by the loan of drawings, or in other ways. Without

this aid the labour involved would have been largely increased. Thanks are due to Signor Alfredo Galassini and the Director of the Unione Tipografico-Editrice of Turin for permission to reproduce some of the drawings relating to Messrs. Platt Brothers and Co.’s mule, which will be found in Chapter XI. These had appeared in the “Enciclopedia Delle Arti E Industrie,” and were so much in accord with the treatment the Author had resolved to give that machine, that the permission to use them was of great service. The special thanks of the Author are also due to Mr. B. A. Dobson for the permission to reproduce two photographs of a lap, given in Chapter VI., and other drawings from his pamphlet on “Carding.” In conclusion, before leaving the book to the indulgent judgment of his readers, the Author wishes to say that the proofs have been read by gentlemen conversant with the whole of the details, and every care has been taken to make it at once accurate and instructive.

ERRATA.

Table of Contents

The reader is requested to make the alterations enumerated below at once in order to prevent any misunderstanding.

On page 51, end of line 23, for “it” read “is.”

On page 66, line 15, for “Fig. 51” read “Fig. 52.”

On page 162, third line from bottom, for “n = b - 21” read “n = 21 - b.”

On page 163, line 7, for “n = 250 - 2 (250÷40)” read “n = - 250 - 2 (250÷40).”

On page 165, second line from bottom, for “G” read “E.”

On page 210, line 3, for “B” read “D.”

On page 212, end of last line, for “fallen” read “faller.”

On page 267, line 4, for “straps” read “shafts.”

The author is fully conscious of many shortcomings, which are inevitable in a task of this magnitude, but he believes that something has been done to formulate present knowledge and practice. Any suggestions of improvements or enlargements will be gratefully received, so as to enable future issues to be more valuable and useful.

CHAPTER I.

INTRODUCTORY.

Table of Contents

(1) The rapid growth of the cotton trade is in no small degree due to the exertions and ingenuity of the engineers and machinists who have devoted themselves to the subject. It is remarkable how few of the later inventions, at any rate, are those of persons actually engaged in the operations of spinning or weaving. It is quite true that James Smith, of Deauston, forms a conspicuous exception, and that many others could be also named who were at once manufacturers and mechanicians, but the general fact is as stated. To-day, the spinner, who is in a difficulty requiring a mechanical solution, turns the whole matter over to the machinist, who puzzles it out without, in many cases, getting his due reward. It is, however, a general practice for machinists to originate improvements, and the competition in this respect is so keen, that a spinner is never at a loss for a choice of appliances.

(2) In the early part of the century it was no uncommon thing to find textile machines made in a workshop where engines, machine tools, and other forms of machinery were also constructed. For about the last forty years this practice has ceased, and it is now the universal custom to make textile machines only, in any works where they are produced. This practice has led to a subdivision, not only of

labour, but of procedure, which enables good results to be attained. The machine of to-day, although not absolutely, is comparatively, cheaper, and is constructed in a way that even thirty years ago would have been deemed impossible. When the author was an apprentice, about twenty years since, the fitting of cotton machinery was a byeword to the engineer and tool maker. To-day, it would be difficult to find more accurate workmanship or sounder construction in any machine of whatever kind.

(3) This is a matter of more importance than might be supposed. The cotton spinning machine making trade in England is a very extensive one, finding employment in Lancashire alone for not less than 25,000 men and boys. This does not include the large number of persons employed in the various businesses which are allied to it, such as spindle and card clothing manufactories. The field for spinning machines is ever enlarging, the possible extent of the cotton industry being enormous. The number of spindles at work in Great Britain exceeds 44,000,000; on the Continent the number is about 23,800,000; in the United States 14,500,000; and in India and Japan it exceeds 3,000,000. These figures, which are approximate only, give a grand total of 85,300,000 spindles, which may all be said to have sprung into being during the present century. Assuming the value of a mill to be equal to 21 shillings per spindle in England, the fixed capital embarked in this branch of the trade alone is £44,220,000. If the very moderate amount of 20 per cent be added to this for working capital, the sum invested in cotton spinning concerns in this country is not less than £53,000,000. The cost per spindle in other

countries is much in excess of the amount stated above, being in many cases doubled. In the United States the cost of a fully equipped spinning-mill ranges from 40 to 42 shillings per spindle, and the capital needed for working is also greater than in this country. On the Continent, and in India, the cost per spindle will be less than in America, but the working expenses are also higher than in Great Britain. In thus stating the facts it is impossible to accurately fix the capital employed, but it will probably approach in the aggregate £150,000,000 for spinning mills alone.

(4) The foregoing figures, which are very briefly put, are sufficient to show the magnitude of the industry for which spinning machinists cater. But there is another aspect of the question which is noteworthy, and illustrative of the effect of the work of machine makers. This is the large increase in the productive capacity of the machinery. The production of a self-acting mule in 1835 is given in the following statement, issued by the eminent firm of Sharp, Roberts and Co., and extracted from Dr. Ure's work on "Cotton Spinning."

"Statement of the quantity of Yarn produced on Messrs. Sharp, Roberts & Co.'s self-acting mules in twelve working hours, including the usual stoppages connected with spinning, estimated on the average of upwards of 20 mills: —

	No. of hanks per spindle.	
No. of yarn.	**Twist.**	**Weft.**
16's	4½	4⅞
24's	4¼	4⅝

32's	4	4⅜
40's	3¾	4⅛"

This statement is dated December 23rd, 1834, so that it may fairly serve as a basis of comparison, assuming the number of turns of yarn to be in each case the same. Testing the advance by taking the production of 32's, as stated above, the amount spun per spindle in a working week of 50½ hours—its present duration—would be 18⅔ hanks. Mules at that period were only made 400 to 500 spindles long. To-day they contain over 1,200 spindles, and produce of 32's 32½ hanks per spindle. This is an increase of 60 per cent.

(5) The increase of production has not, however, required a larger number of workpeople to obtain. On the other hand, fewer persons are needed to attend to the long mules named than were formerly required for less than half the number of spindles. The effect of this is seen in the decreased margin between cotton and yarns, which is very striking. The average price of 30's twist yarn in 1832 is stated in Dr. Ure to be 12·7d. per lb., and of cotton 7·1d., leaving a margin of 5·6d. At the time of writing the price of 32's twist is 8 11/16d., and of cotton 6 9/16d. per lb., leaving a margin of 2⅛d. These figures are based upon the assumption that American cotton of middling quality is used in each case. Thus the price of yarn is much less, while that of cotton is little reduced. It is true that a margin of 2⅛d. is barely sufficient to permit of a profit being made, but ⅛d.

per lb. added will do 80, and a margin of 2½d. is considered a large one in these days.

(6) This reduction in the cost of production has not been brought about by any diminution in the wages of the operatives, as could very clearly be shown if it were necessary. Nor is it the result of a lessened cost of erection. A spinning mill of 40,000 spindles, which in 1835 would be looked upon as a large one, cost, at that time, from 24 to 26 shillings per spindle to erect, including the buildings and accessories. At the present time mills are built to contain as many as 110,000 spindles, and these are filled ready for work at a cost not exceeding 21 shillings per spindle, the apportionment of which is as follows: The machinery costs nine shillings, the buildings eight shillings, and the engines, boilers, furnishings, and all accessories four shillings per spindle. Considering the great increase in the productive power of the machinery, the fact that it is so much less expensive to work, and that each machine is of much greater capacity, the figures given show that the tendency towards diminished cost is owing very largely to the efforts of machine makers.

(7) It is not necessary to pursue this matter further, as the present work is not intended as a statistical abstract, but the few facts stated show that in the general march of improvement the textile mechanic has not been idle. A consideration of the methods of construction adopted to-day, as compared with those in vogue even so recently as twenty years ago, will further demonstrate this fact. Formerly the work of construction was very largely if not mainly carried out by fitters who were engaged in manually

shaping the brackets and fitting them to the frames. The brackets were formed with feet, on which were cast nipples or projections. These were used to reduce the labour in filing, and, as the bracket was always fitted on to the face produced in the ordinary operation of casting, it will be seen that anything tending to diminish the work of fitting was valuable. But as the bedding of the brackets was dependent upon the proper shaping of a few points, the tendency to slip was considerable. Although, by being always engaged in fitting a few patterns of brackets, the workmen became extraordinarily expert, the method was at best an uncertain one, and did not lead to the rigidity absolutely essential in high-speed machines.

(8) All this is now changed, and the machine tool enables the work to be at once more expeditiously and economically carried out. The labours of mechanics of precision, like the late Sir Joseph Whitworth, are bearing fruit, and the effect is seen in the comparative excellence of the product. The solidity of English machinery has been sometimes scoffed at by Continental and American rivals, but it would be difficult to find any which runs at higher velocities with greater steadiness and less repairs. It cannot be too often insisted on that the rigidity which arises from mere weight is by no means an unimportant quality. Of course, there are limits to this as to every other principle, but generally it is a true one. Of quite as much importance is the rigidity which comes from sound construction; and in this respect modern spinning machinery is remarkable. Instead of a framing built up by hand with its various pieces manually fitted, it is now made in a much more enduring way. Raised faces are

formed on the framing, which are planed or milled, so as to be quite true. To these the cross-beams or bars, the ends of which are similarly treated, are bolted. Thus, instead of the contact of several narrow faces, two broad plane surfaces are bolted together, and it will be easily seen how much more solid the framing will be in consequence. Again, in lieu of each part being at once like and unlike, as must necessarily happen when it is hand-fitted, it is now shaped by special machinery to templates, thus being interchangeable. The rails or beams to which bearings, brackets, or spindles are to be attached are planed or milled accurately on their surfaces, so that the long and unsatisfactory labour of fitting each piece separately is substituted by a true mechanical process. The advent of the milling machine and the discovery of the wonderful economic power of the circular cutter has had a wide-reaching influence. In brief, the present is an age of an increased development of machine instead of manual treatment, which has gone far to revolutionise the machinery used in spinning. Every student who may hereafter be engaged in the construction of this class of machinery should impress firmly upon his mind the fact that the machine tool is the best instrument for his purpose, and should develop it as far as possible. A special tool is invaluable, and the opportunities for its use are always increasing.

(9) A comparison of the speeds of various machines will demonstrate the value of improved construction. Mule spindles, which in 1834 were run at a maximum velocity of 4,500 revolutions per minute, are now revolved 11,000

times per minute with much greater ease and freedom from vibration. The throstle spindles running at a speed of 4,500 revolutions, are superseded by ring spindles, which rotate from 9,000 to 11,000 times per minute. As shown in Chapter XII, it would be impossible to attain such a velocity unless the spindles were accurately constructed by special tools. Although the mechanism of a ring spindle is much more elaborate than that of a throstle spindle, the cost of the one but little exceeds that of the other. Again, a carding engine cylinder, formerly made of wood, and running 80 to 100 revolutions, is now constructed entirely of iron, and revolved at from 160 to 180 times per minute. In spite of this increase it is more free from vibration than its slower running predecessor. A similar comparison can be made of every machine with like results, but it is not necessary. Enough has been said to show the important part played by the machinist, to whom, as was pointed out in paragraph 1, most of the credit is due. The economical improvement which is noticeable in the condition of the workpeople is largely the result of the improvements made in the machinery. In fewer hours more work can be turned out, and this with a constantly decreasing strain upon the operatives. The breakage of the fibres in the various stages of manufacture is reduced to a very low point, with the twofold advantage of diminished waste and decreased labour.

(10) A modern mill differs from its immediate predecessor, not only in the quality of the machinery but in its general construction. The height and width of the whole building have materially increased, and the result is that the rooms in which the operations of spinning are conducted are

both lighter and more airy. The building is usually made as far as possible fire-proof, and is of very substantial design and construction. The larger number of spindles in a mill necessarily imply greater capacity, but there is no comparison between the low-ceilinged, imperfectly lighted and ventilated rooms of the last generation with the airy and light erections of to-day. The sanitary arrangements are infinitely superior, and there is a noticeable improvement in the health and physique of the workpeople arising therefrom.

(11) Among the features which deserve mention is the improved type of engines used. In lieu of the old-fashioned beam engine, compounded or otherwise, working at a steam pressure of 50lb. or less, the modern engine is of the horizontal type. The favourite class for mill driving is the tandem compound, in which the high pressure cylinder is behind the low-pressure, but on the same bed. Latterly the vertical triple expansion engine has been adopted in a few cases, and there is a continual tendency towards higher steam pressures and more expansions. The introduction of steel boiler plates has rendered the construction of steam boilers for high pressures much more easy, and the author has seen a Lancashire boiler, intended for habitual use at a pressure of 220lb., tested with highly satisfactory results. Within limits, therefore, there is room for a further increase from the normal working pressure of 80lb. The steam-engines used are mostly of the Corliss type, with quick cut-off gear of high efficiency, and they are constructed to develop in many cases from 1,000 to 2,000 horsepower. The water used for condensing purposes is stored in reservoirs

or “lodges,” from which it is drawn as required. It is sometimes difficult to cool it sufficiently to get a good vacuum, owing to the fact that the cooling and storage space is insufficient. For this purpose a type of condenser known as Theisen’s, which has been largely adopted in Germany and is now being introduced into this country, will be of value. It is arranged as a surface condenser, the steam passing through the tubes and being cooled by water surrounding them. In lieu of giving the water a circulatory movement it always remains in one position, any loss by evaporation being replaced. Between each vertical row of pipes cast-iron discs revolve, which are fixed on a shaft suitably driven. As each disc dips into the water—which is usually about 160 deg. F.—it picks up a thin film and carries it round in its revolution. At the upper part of the case, in which the discs revolve, an air propeller is fixed, which sends a current of air past and through the spaces between the discs. This leads to a rapid cooling of the disc and its water film, the heat absorbed by the water being in this way dissipated. The action is one of evaporative cooling, of which many instances abound, and is very effective. An equal weight of water will effectually condense any given volume of steam, and this quantity is not difficult to find in most places. The results obtained by the Union Engineering Company in this country have been satisfactory, and there appears to be no doubt as to the efficacy of the machine. Steadiness of rotation is a *sine qua non* in mill engines, a very slight difference in their velocity having a great effect upon the work of the mill. This is now attained in most cases with certainty, and by means of the Moscrop Recorder—an instrument denoting graphically the changes of speed—a very salutary check is kept upon the engineer. In order to prevent any variations occurring high-speed governors are largely employed, and in some cases their action is aided by special means, such as Knowles's supplementary governor or Higginson's patent regulator. Either of these appliances give good results, and the last named is very simple and effective.

(12) Up to within 15 or 20 years ago the most common mode of transmitting the power developed by the steam engine was by means of toothed gearing. About that period the American method of driving by a series of broad belts was introduced and for a time was largely adopted. When toothed gearing was used the power was conveyed to the various flats or storeys of the mill by means of an upright shaft, on which were bevel wheels gearing with others on the line shafts. The introduction of belt driving led to a system of transmitting the power to the main shaft in each room independently of its fellows, and this system found further development when driving by a series of ropes was adopted a short time afterwards. In this case the power is taken off by a number of ropes working in the grooves of a large pulley on the engine shaft and of smaller ones fixed on the line shafts. This is now the favourite method of driving and is more extensively adopted than any other. The reason for this is principally the ease with which breakdowns can be guarded against. If a rope breaks it falls into the race, and in rare instances does it become entangled. It is only necessary to replace it, and any delay thus caused is not great.

(13) As the question of driving is a somewhat important one a few remarks may be made on it. There is no doubt that toothed gearing properly constructed forms the most economical method, the loss of power in transmission not exceeding 2½ per cent. In constructing wheels for this purpose care should be taken that the tooth is not too long, ⅝ths of the pitch being a sufficient length. Next to toothed wheels for economy belts may be placed. The loss in transmission varies, if the belts are properly applied, from three to five per cent. A good speed for leather belts is 3,000 feet per minute if they are single, and 4,000 feet if double. Rope driving is the least economical of the three methods, this arising from a variety of causes. Chief among these is the difficulty of maintaining an equal diameter in every rope of the series, which leads to a difference in their driving power, owing to their unequal engagement with the V grooves. Another cause of this loss of power is found in the fact that they jam in the grooves and have to be forcibly extracted as the pulleys revolve. The following rules laid down by Mr. Alexander Rea in a discussion, at a meeting of the Manchester Association of Engineers, on the subject of the comparative merits of the three systems of driving, are worth reproducing.

"The ropes should not be too large in diameter; it is much safer to use 25 1¾ inch ropes than 20 2 inch diameter ropes. The tension in the several ropes should be kept as low as possible. The power should be subdivided to different points. The centres of the several shafts should be kept well apart. The pulleys should be large in diameter. The best speed for the ropes is from 4,000 to 6,000 feet per minute. Care should be taken in turning the V groove pulleys; the best angle for these is now found to be 45 degrees."

(14) As this subject of rope driving is an interesting one, it is worth noting that Mr. George Goodfellow, of Hyde, who has had a wide experience in this matter, confirms the advice as to small diameter of ropes. In the same discussion he stated that he did not now use larger diameters than $1\frac{3}{4}$ inch, and had ropes running successfully, the diameter of which was only $1\frac{1}{4}$ inches. Mr. James Hartley also bore out this experience. By the reduction of ropes from 2 inches to $1\frac{1}{4}$ inches diameter the friction diagram from the engine had been materially reduced, indicating a saving of power. Mr. J. H. Ratcliffe, of Dukinfield, has recently revived a method by which, instead of using a series of ropes, he uses one only, this being endless, and being wrapped spirally on the pulleys. At one point the slack is taken up by a compensating apparatus, so that the whole of the coils are tight back and front instead of having one side slack and bellying. For this arrangement Mr. Ratcliffe claims that it materially reduces the friction diagram, inasmuch as there is no necessity to drag the rope forcibly out of the grooves at each revolution. It is not necessary for a detailed examination of this subject to be made, but the hints given will probably prove useful to many readers.

(15) It is essential, owing to the peculiar structure of the cotton fibre, to which reference will be made in the next chapter, that the rooms in which spinning is conducted should be heated to a certain temperature. Closely allied to this question is that of humidification. It is not only essential

to have heat, but that must be accompanied by a certain amount of moisture, a point which is often neglected. Spinning rooms are often heated to over 90° F., which is quite unnecessary, and is, moreover, detrimental to good work. At such a temperature much of the natural moisture of the cotton is extracted, and the fibre becomes harsh and brittle. A temperature of from 75° to 80° F., with a humidity of about 75 percent, is absolutely the best condition for spinning. The question is an important one, and deserves greater consideration at the hands of spinners. The artificial heat required is now obtained by the use of wrought-iron steam pipes, through which high-pressure steam is passed. The radiation from these is much greater than from cast-iron pipes of larger diameter filled with low-pressure steam.

(16) Having thus briefly glanced at some of the chief features of modern practice, it is now only necessary to say that the utmost cleanliness is absolutely essential to good working. The manipulation of the cotton is now so largely automatically performed that there is much less difficulty in keeping a mill clean than formerly. It should be the aim of every spinner to diminish the handling of the material as much as possible, and students of this subject should remember that it is never too early to begin to deal with the cotton so as to prepare it for subsequent treatment. Efficient purification at an early stage is a great help towards economical and efficient spinning. In conclusion, it may be remarked that one of the worst faults in studying a subject of this sort is any kind of crystallised thought. The conditions of work vary from day to day, and there are wise variations in procedure which can easily be discovered by

the observant mind. This watchful attitude is the proper one to cultivate, and the succeeding pages are written in the hope that they will lead some reader to a deeper and closer observation of the facts which are discoverable in the actual work of construction or spinning.

CHAPTER II.

THE STRUCTURE OF COTTON.

Table of Contents

(17) The cotton plant is indigenous to many tropical countries, in which it is often found in a wild state. The product of the wild plant is, however, quite unsuitable for manufacturing purposes, and, even in cases where cotton is produced by cultivation, the value of the fibre varies very largely. Into the question of the growth and structure of the fibre it is not necessary to go in detail, as this is a subject which has a literature of its own. The student who is desirous of obtaining a thorough knowledge of the subject can find it fully treated in the "Structure of the Cotton Fibre," by Dr. Bowman, and in a recent work by Mr. Hugh Monie, jun., of Glasgow. It will suffice for present purposes to state briefly the characteristics of cotton, which are of essential importance in its subsequent treatment mechanically. The cotton fibre is a hollow tube of cellular construction, and is of an oval or flattened cylindrical shape. Ripe or fully matured fibres of the best cotton are convoluted or spirally twisted on their axis, and the edge of such a fibre presents a corrugated appearance. The regularity of the convolutions, or twists, is greatest in the highest class of cotton, and reaches its lowest point in the poorer grades. One important effect of such a formation is that each fibre naturally tends to coil round its neighbour,

and thus lends itself to spinning. The outer sheath of each fibre is apparently continuous, and the diameter is greater at the end which is attached to the seed. The diameter of the fibre varies from $^{1}/_{1562}$ of an inch in the case of Sea Island cotton, to $^{1}/_{1185}$ of an inch in Indian cotton. In length a similar variation is observable, reaching a mean of 1·8 inch in Sea Island, and being as low as 0·8 inch in Indian cotton. The length of the fibres in any particular class of cotton is known as the "staple," and this is one of the chief commercial merits of the better kinds. The strength of cotton fibres varies very materially, and on the authority of Mr. Charles O'Neill, of Manchester, the order in which the various classes ought to be placed is as follows:—Surat (Comptah), New Orleans, Queensland, Surat (Dhollerah), Pernambuco, Egyptian, Maranham, Upland, Sea Island. It does not necessarily follow that the possession of greater strength by one class of fibre over another involves an advantage, for the greatest strength is possessed by a fibre which is the most deficient in regularity of the convolute form and length, which are much more important than strength. Again, the diameter of Comptah cotton is much greater than that of longer stapled varieties, and this is important in determining the value to be placed upon the strength. Viewed in this light, Egyptian cotton is the strongest, and this fact, in conjunction with certain other qualities to which attention will afterwards be called, renders it of high value. It only remains to be said that a waxy covering is found on the outside of each fibre, which requires to be softened by heat during spinning so that the flexibility of the fibre may be fully maintained. Where it is intended to dye fabrics it is necessary to remove the whole or the greater part of this wax, and so permit the dye to penetrate the fibre. Having briefly indicated the chief characteristics of the cotton fibre, a detailed account of some of the principal varieties may now be given.

(18) Sea Island Cotton. This is the finest class of cotton produced, being long in the staple, very flexible, and having very regular convolutions. If care be taken in ginning, so that the fibre is not broken, the finest yarns can be produced from this variety. The length of Sea Island Cotton is stated by Dr. Bowman to reach 2·20 inches in the case of Florida grown, but Mr. Monie states the average length to be 1·8 inches. Mr. Evan Leigh confirms the higher length, but only in the case of cotton grown on the Edisto Island. Varieties of this grade are grown in Peru, Fiji, and Australia, the average lengths being respectively 1·56, 1·87, 1·65 inches. Fijian Sea Island is spoiled by bad ginning, which breaks the fibres very much. The colour of Sea Island cotton is a light creamy one, and is peculiar to it.

(19) Egyptian Cotton. Egyptian cotton varies considerably in colour, length, and quality. The variety known as Gallini is of a golden colour, the fibres being tough and strong, and the convolutions very regular. It has a mean length of 1·5 inch. Brown Egyptian is, as its name implies, of that colour, and like Gallini, the fibres are strong and tough, but are coarser, the convolutions are less regular, and the wall of the fibre is also denser. The mean length is 1·4 inch and the diameter $^1/_{1325}$ inch. White Egyptian is, perhaps, the most valuable of all this class of cotton when properly treated. It is of a light gold colour, the fibres being strong and pliable,

but only partially spiral. As a result of this, the yarn spun is greater in diameter than that spun from Gallini (weights being equal), the fibres not lying so closely together. This cotton mixes well with American and Brazilian.

(20) Brazilian and Peruvian Cotton. Pernambuco cotton is of a slightly golden colour, and is, comparatively speaking, hard and wiry, being thus well adapted for twist yarn. The twists in the fibre are well developed, and the average length is 1·25 inch. Maranham is of a dull gold colour, mixing well with American cotton. There are several other varieties of Brazilian cotton, which need not be further referred to. Rough Peruvian cotton is very clean, of a creamy colour, and is possessed of an average strength. The fibres are only irregularly twisted, and an average length is 1·3 inch. The smooth variety is fairly regularly convoluted, and mixes well with Orleans.

(21) American. There are several varieties of American cotton, which are grown in the Southern States. Taking them in their order as regards length of staple, the first to notice is Orleans. The better classes of this are very uniform in length, clean and light in colour, often being pure white. One feature of Orleans cotton which renders it very acceptable to spinners, is that it is very flexible, and possessed of a high elasticity. In addition to this, as has been previously noted, its strength is fairly great, and generally its spiral form is well developed. The average length is about 1 inch. Texas cotton is less pliable than Orleans, darker in colour, and is not put on the market so free from immature fibre. Its diameter is greater, and its average length about equal to Orleans. Upland cotton is

clean, and little waste is produced from it. The fibres are well suited for weft yarns, being soft and elastic, and of a very light colour. Spun without any admixture of other cotton, yarns as high as 425’s can be produced, but when mixed with Egyptian or some other strong fibre, higher counts can be obtained. Mobile is similar in colour to Orleans, and is equal to Uplands in strength. It is not so good as either of these for manufacturing purposes, being much dirtier, and having more flattened fibres in it.

(22) Indian. The whole of the cottons grown in India are less valuable than the preceding varieties, owing to the facts that they are not so regularly spiral, and that the staple is more variable. The highest class is Hingunghat, which is more convolute than any other Indian grown cotton. The fibres vary in diameter, but have an average length of 1·03 inch. Broach is brownish gold in colour and is fairly clean, although it is not thoroughly cleaned, and contains a good deal of leaf and nep. It is about 0·9 inch long, and is more regular in this respect than Hingunghat. The spirals are fewer in number, and it is stated by Mr. Monie that the walls are very liable to rupture. Dhollerah is of a white colour, and is best adapted for weft yarn. Oomrawuttee is creamy in colour, being strong but rather short in the staple. A good deal of impurity is found in this quality, but the convolute form is moderately developed. Tinnivelly is grown in the Madras Presidency, and is a fairly good cotton. In strength it is high and is very elastic, its colour being a dull, creamy one. The fibres have a small bore and thick walls, and are, in addition, only slightly