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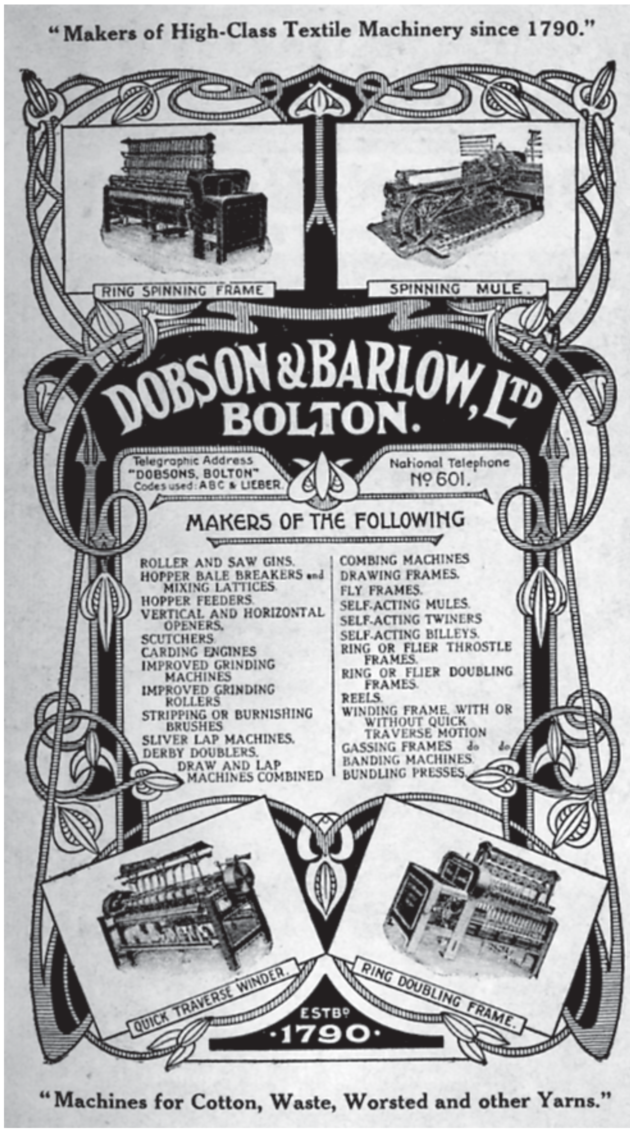
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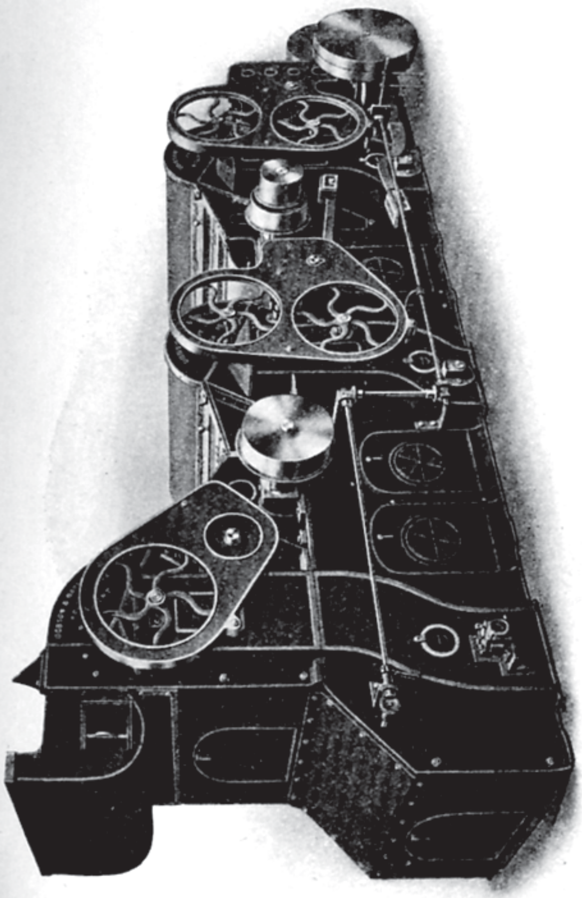

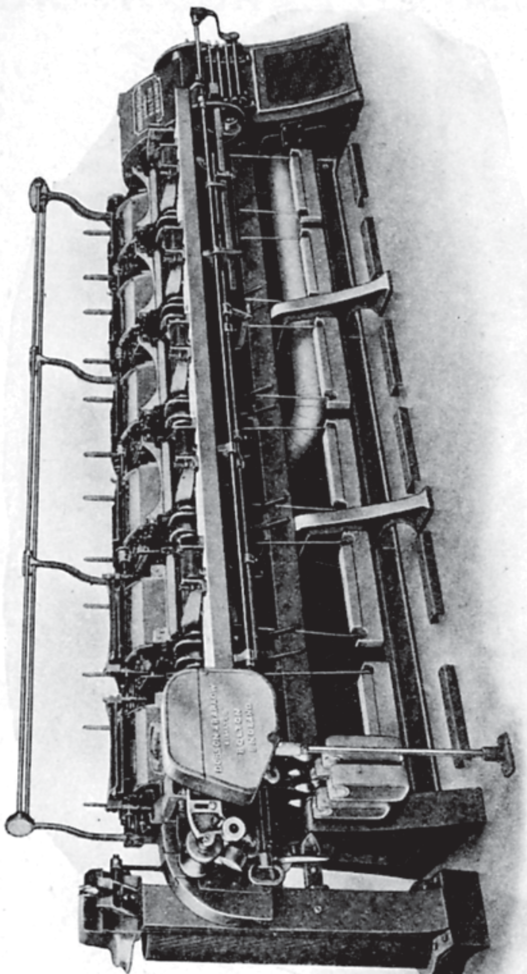

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THE latter part of the 18th century saw the real birth of the Cotton Spinning Industry as it is known to-day.

In 1757 James Hargreaves, a weaver, of Blackburn, Lancashire, perfected his "Spinning Jenny," an invention that enabled the number of spindles to be increased to as many as eighty on one machine.

About this time Richard Arkwright (afterwards Sir Richard), a barber, of Bolton, Lancashire, had for many years been actively interested in Cotton Preparing and Spinning Machinery, but it was not until 1769 that he perfected his "Water Frame" (so called because it was generally driven by water-power). This machine was the forerunner of the modern Drawing and Fly Frames.

These two inventors, with many others, made great contributions to the Cotton Industry, yet the invention of the "Spinning Mule" in 1774 eclipsed them all. Though Samuel Crompton, also of Bolton, combined in the Mule the salient features of the "Jenny" and the "Water Frame" (hence the name Mule), it was the greatest invention of the times, and enabled rapid strides to be made in the spinning of Fine Yarns.

The news of these inventions gradually spread throughout the country, and in the year 1790 Isaac Dobson, the youngest son of an old Westmorland yeoman family, attracted by the possibilities of the new machines, came to Bolton, the home of Arkwright and Crompton, and founded a small works for the manufacture of Spinning Mules.

Since that time over 130 years have passed, but from such small beginnings has grown the vast organisation now known throughout the world as DOBSON & BARLOW, LIMITED.

Having had a continuous connection with the Cotton Industry since its infancy, they have a reputation and experience that is without equal, and while they continue to produce the Finest Modern Textile Machinery they are proud of their long and historical association with the Cotton Industry, and that they can in all truth claim to be "FAMOUS SINCE THE DAYS OF CROMPTON."

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COTTON MILL MANAGEMENT

A PRACTICAL GUIDE FOR MANAGERS CARDERS AND OVERLOOKERS

BY

WILLIAM SCOTT TAGGART, M.I.MECH.E.

AUTHOR OF

'COTTON SPINNING,' 3 VOLS., 'COTTON SPINNING CALCULATIONS'
'COTTON MACHINERY SKETCHES,' 'TEXTILE MECHANICS'
'QUADRANT AND SHAPER OF THE SELF-ACTING MULE,' ETC.

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1923

PRINTED IN GREAT BRITAIN

PREFACE

THIS is a book essentially practical in character. The bulk of the notes, in a condensed form, were prepared for another purpose, but owing to illness were laid aside, and now, having been expanded, are published as a practical and orthodox statement of present mill working.

As the book is intended for persons holding responsible positions in the cotton mill, machines are not described or illustrated, the presumption being that the reader is well acquainted with the various machines and their mechanical details. A further factor that has influenced the writer in leaving out illustrations was the fact that it would not have been fair to have taken any one maker's machines for the purpose of illustrating the notes, and to have included all makers' machines would have made the book too bulky. For those who desire to examine the questions raised, the author's book *Cotton Machinery Sketches* gives over 720 detailed drawings of all types of cotton spinning machinery.

Whilst the book is orthodox, there will be found, throughout its pages, numerous suggestions that offer food for thought to those responsible for supervising the machines, and which tend to economy and improvement.

No book of this character can pretend to an exhaustive treatment, and moreover, since no two mills work alike, it is not possible to make the best of statements included in the book without disagreement arising. The author must bear the responsibility for this, but if serious thought is developed on the points at issue a good purpose will have been served.

Whilst recognising the importance of calculations, the writer has considered it advisable to exclude this branch of the subject from the book. Owing to the various types of machines and their gearing as made by the different machine makers, the subject is one that requires to be dealt with in a separate volume. The author's book on *Cotton Spinning Calculations* will be found to include the gearing of all the machines made by the principal machine makers and practical examples given of all calculations usually required in the mill.

W. S. T.

CONTENTS

CHAPTER VIII

CHAPTER IX

CHAPTER X

CHAPTER XI

CHAPTER XII

CHAPTER XIII

CHAPTER XIV

ILLUSTRATIONS

INTRODUCTION

COTTON spinning is one of the great industries of the world, and out of a purely manual operation it has developed into an almost perfect automatic method of production by mechanical means. Probably in no other manufacturing process do we find so wonderful a result as that of bales of raw cotton entering a mill and being sent away finished yarn, and all this done with an unusually small amount of physical labour. A modern mill is, or ought to be, a perfect specimen of automatic action, from the bale breaker to the mule or ring frame, and yet in spite of this we have the paradox of the same mill being a concentrated example of the highest skill in the workpeople and a heavy responsibility on the management. Primarily, this is due to two main factors, viz. the raw material and the mechanism. Both factors are very elastic in their qualities, and it is only after limits have been fixed to the material, and adjustments made on the machinery to suit these limits, that the automatic work can proceed satisfactorily. Cotton is not, however, a mathematical quantity, and in its raw state it certainly does not seem to possess the qualities that it ultimately attains through the action of mechanism that represents the highest skill and ingenuity to be found in the engineering world.

Organisation.—Throughout the cleaning, drawing, doubling, and twisting processes, the raw material consists of short hairs or fibres. To combine these fibres into a long, strong, and uniform thread represents a high combination of judgment, manipulative skill, organisation, and mechanical knowledge. A manager, in other words, must know his material and his machinery. A manager's qualifications will subsequently be dealt with fully; it is sufficient at this stage to emphasise the fact that a cotton mill is first a huge manufacturing concern to transform a chaotic mass of short fibres into a regular yarn; and, secondly, it is also an engineering establishment in the strict sense of the word, with power and plant of such a character as is to be found in no other industry in the world. In face of this, it seems strange that textile mill managers are ignored in the engineering sense and by our engineering societies. They may be said to live a life apart from the general body of engineers, and yet under their charge work the wonders of mechanical movements and engineering skill, power plant of the highest class, electrical equipment for power and lighting, and a wide field for all improvements that add to the quality, reduce the cost, or increase the production.

A further aspect of mill management is the commercial side of cotton spinning. Raw material must be bought and finished yarn sold. This is a tremendous field of mental activity in itself. The raw material is an annual product, and unexpected climatic conditions or speculative excesses may upset the most carefully laid schemes in the management of the mill. The wide variations that arise, under normal conditions, in the growth and selling of the raw material are well known, and can be fairly well estimated and allowed for by thoroughly trained management, but unfortunately there is room for the gambler in the business. Cotton growing has become centralised in a few huge blocks of the earth's surface, and its sale in a few centres renders speculation somewhat easy to any one who, possessing the gambling instinct highly developed, is willing to take the risk. The economy of mill management will become a mere byword if this vile disease of gambling in cotton is not prevented from continually harassing the industry. It will be true economy and lead to healthy competition if cotton growing is split up into more numerous areas, owned by combinations of the firms who spin and manufacture it, and whose interest in the raw material, on which their existence depends, is not confined, as at present, to purchases made in Liverpool or Manchester offices. It may be said at once and definitely that the recent experiences have finally settled the conditions under which the cotton industry must be conducted in the future. Money must be spent, and, if need be, sacrificed, to open up new cotton fields in other parts of the world; every master, manager, and workman must take a share in assisting financially this object, otherwise the whole industry will gravitate slowly but surely to the present centres of its principal growth. In the meantime much could be done to prevent the personal gambling element if a combination of spinners would hold a large reserve of raw cotton to be drawn on in case of necessity. If the principle were adopted by individual firms it would be of enormous advantage in times of stress, and, as the Cotton Spinners' Federation at their first meeting placed on record, it would have a great effect in steadying prices and checkmating professional gamblers.

The foregoing remarks refer to palpable gambling on a large scale, but there is in the cotton industry itself a state of disguised gambling that interferes considerably with economic conditions in the business. Responsible men in spinning concerns, and very often they are men who have no intimate knowledge of the inside working of the mill, indulge in the questionable practice of purely buying and selling the raw material; they are backed by the capital of the mill in such transactions, and the mill gains or suffers. The individual concerned is not, as a rule, acting selfishly in this; he simply takes his share of profit or loss, but in going out of the legitimate channel, he is clearly exercising a peculiar phase of his own character and not that of the general body of shareholders or his workpeople. Such conduct, with its alternations of success and failure, is bound to interfere considerably with the economic management of the mill, and while success gives a fictitious appearance of good management, and failure leads to condemnation of another man for bad management, a true balance-sheet would show that a purely speculative element was responsible in either case. The economic management of a mill demands that such a man as described should be eliminated from all responsibility, and the man who has the full and sole charge of making the yarn should also be the one to choose his raw material for making it. This idea is becoming more and more developed, especially in those firms owned by men who recognise that they have not had a thorough training in the mill, or who are gradually losing touch with modern requirements. In any case, if it is not considered advisable to leave the question entirely in the hands of the responsible manager, his side of the question ought to be seriously taken into consideration. This naturally leads up to the question—What is responsible management? It is an extremely difficult question to answer.

Responsible Management.—In a sense every workman in a mill is in a responsible position; intelligence must be exercised in the performance of their duties, and so a multitude of responsible units is created. For purposes of organisation and discipline this force is split up into sections, and responsible heads appointed. With a similar object in view the various heads of departments are gathered into a unit under the manager, and on him devolves the entire responsibility for the working of the mill, with the possible exception in some cases of some portion of the clerical work. If the responsibility for the whole of the mill management is split up into separate units, neither unit can work on economical lines in the true sense. There is such a complete interdependence between the various departments of a cotton mill that divided responsibility would fritter away the possibilities of successful work. A manager who is simply given instructions to carry out and does his work well is not a responsible management, his responsibility is limited, and his economies in working will be cramped; he has no future, for he cannot foretell what his instructions may be to-morrow; he must live from hand to mouth as it were, and do his to-day's work as well as he is able. Some one equally conversant with the mill and all branches of its activities must be its head, and this condition is to be found in many cases of private ownership, but even in such cases managers are being given a free hand, and only a financial control exercised by the owner. In limited liability companies the shareholders have their interests represented by the directors, who may or may not be in touch with cotton mill practice. Such a board of directors will, in many cases, carry the whole responsibility of the mill management, and the question of economy will depend more or less on their average appreciation of conditions, which must be low, for in the majority of cases their knowledge is second-hand and superficial.

Knowledge of Technical Details.—A wise Board gives a free hand to a wise manager, and simply confines itself to the function of controlling the finances. There are far too many cases where a board of directors fritters away responsibility among its members, and in the long run such a policy must be fatal. An occasional genius, financially or technically, among the directors may work wonders in stirring up enterprise, opening up new fields, or adopting new methods; such a man is a decided advantage, and a constant source of encouragement to the management. They are, however, few and far between, and the usual board of directors is generally a body of men who are suspicious of economy that involves spending money. It may necessitate a knowledge of technical detail outside their ken, so conviction comes slowly, and supplies are granted reluctantly. There is a vast difference between the slow and sure method of a man or men who know and the slow and hesitating method of men who do not know. Unless the directors of our mills have a good groundwork of knowledge and experience on which to base a judgment on technical details, true economy will be found in paying some one well to do it for them.

Selling Yarn.—Advertising, in the usually accepted meaning of the term, has not yet been adopted by spinners. As in most wholesale businesses, personal contact between the buyer and seller is relied on chiefly. Severe competition necessitates an army of salesmen and buyers, all acting as keen advertisers of their employers' goods. Manchester Exchange will give some rough idea of the money spent in this direction by textile firms. The spirit of economy must of necessity cause one to often inquire if all that money is spent wisely. One man thoroughly equipped for the purpose and paid well is immeasurably more valuable to a firm than several men who know little and care less, even though these latter were plastered all over with the name of the firm they represent. It is pleasant, of course, to go on 'Change and acquire a superficial knowledge of prices and plume oneself on the business status it gives one, but if it costs the firm money it is a sheer waste and tinkering, and, what is more, to repeat a previous expression, it divides responsibility. A salesman is an extremely valuable asset to a firm—a man trained in business method, a detective for searching out the weak and strong points in his client, a man quick to seize opportunities and gauge the future, he must have a keen business scent and be incessantly on the track, an intuitive knowledge of men, and a very clear idea of what can be done or not done by his firm. There are some good salesmen who are ignorant, in a technical sense, but they are exceptions, and it is becoming a necessity that salesmen should have some training in the mill before undertaking such a responsible position.

The tremendous growth of the textile industry in recent times and the great preponderance of large firms or mills as compared with the numerous small mills of the earlier days have introduced the factor, or rather developed the factor, of competition to its keenest limit. The rule-of-thumb methods of producing a certain class of yarn, with variations of counts confined to narrow limits, associated with almost an absence of competition, gave us a type of manager and salesman now almost extinct. To-day a cotton mill must be equipped for a wide range of work, and the products sold under the keenest competition as regards price and quality, against many other firms making the same yarns. Under such conditions a salesman must of necessity be a keen business man, but it must also be emphasised that he must also be a good practical, technical man. A good mill training is necessary. The success or failure of a concern very often depends on the salesman; the straightforward work can be done by anybody, and most people can receive and deliver messages, but only the man who thoroughly knows his work can deal with difficulties, understand and transmit complicated instructions, and, moreover, one who is in a position to see, in the finished article, if his instructions and the wishes of his client have received attention. Too many secretaries, directors, and inexperienced hands pretend to this kind of work, and it makes for neither economy nor efficiency.

Though it is strongly urged that a manager is the best buyer of his cotton, there is not the same reason for a manager to sell his yarn. Salesmen are a necessity in the majority of cases. It would be to the advantage of the industry if both managers and salesmen were trained alike up to the point when men begin to decide for themselves the particular line of work for which they feel most capable or have special facilities.

The Mill Manager.—A manager may be defined generally as a person chosen by the proprietors of a mill as one whom they consider capable of bearing on his own shoulders all the failures, carelessnesses, stupidity, and ignorance of every one connected with the mill. This is fundamental, and covers all types of manager from the sinecure to the most enterprising. The same statement also gives one a real idea of the responsible position of a manager. A real manager consequently trains himself thoroughly in two directions. He trains his moral fibre, so to speak, and keeps it always in training, to take on himself the full responsibility of all his subordinates' actions; it is an obligation associated with his position. He consciously or unconsciously recognises it as the basis of his duties, hence the above definition.

Arising out of this idea of responsibility, the would-be manager or the actual manager further trains himself to eliminate, or at least to reduce to a minimum, the chance of failure on his own part, and to prevent failure and eliminate its causes in those who work under him. This is the training for the business and technical side of his duties. Out of all this arise some interesting and important thoughts that have a direct bearing on mill economy. In the first place, if a manager does not recognise his full responsibility for all that happens in a mill, chaos or something like it will result, good workmen and good subordinates cannot be kept, discipline and organisation will disappear, and such results will ultimately affect the products of the mill. Such mills quickly become known, and the managers also. On the other hand, directors of companies will take advantage of a manager's lack of appreciation of his responsibility and interfere with his duties; if this is permitted no manager, by allowing it, will escape the terms, expressed or otherwise, of his engagement as given in the above definition. He is the man to be blamed for all failures, and human nature in the shareholders and proprietors must of necessity cause them to condemn the man placed in the position of manager, and so make him responsible for non-success in their affairs.

The student of human nature could easily draw up a scale of managers and mills by an investigation of the effective interference with the manager's duties by proprietors, directors, secretaries, etc., etc. It would be found that that man is the best manager who realises his responsibilities, insists on carrying them, and further insists on adopting such methods as will result in a minimum of responsibility ever materialising. Incidentally, the management of a mill economically includes, therefore, the management of men.

Qualifications of a Good Manager.—The qualities of a good manager may be set down as follow:

Moral fibre.

Trained reasoning powers.

A good technical training.

Ability to cause men to carry out his instructions and requests.

We need only concern ourselves with the second and third factors as coming under the heading of a manager's education. Education in general is, in essentials, the development of our reasoning power. It is certainly not the forcible opening of our craniums and stuffing the same with a mass of indiscriminate facts. In cotton spinning we want men who can think, so education must be a factor: the higher the education the better, and the longer the education the better. (I am now speaking of our embryo manager, the ambitious lad who is destined by his parents, or his own volition, to enter the cotton industry.) Facilities are open to him in this direction throughout the whole of the cotton spinning districts of Great Britain. Our educational authorities have done so much for our youths' encouragement that the technical schools of England are the best in the world, and the paths to them are broad, open, and almost free to those desiring to use them.

Distrust of Education.—Why are the technical schools of England so badly patronised by our youth? A simple answer. Because we flatter ourselves we are a "practical" nation, and cotton spinning doubly and trebly emphasises its practical character. Evening classes are tolerated, but the idea of wasting (*sic*) two or three years of a boy's life in attending day classes at a technical school is looked upon with strong disfavour: he might obtain some certificates of proficiency, or even a degree, and consequently his future ruined. No, he must get into the mill as soon as possible, and trust to evening classes and Providence. How many of our managers realise the sad fact that their real training has been very incomplete? There was some excuse in the early days. Then a manager acquired his knowledge in a laborious way, and stuck to his rules and experience as trade secrets. It is only recently that the calculations of cotton spinning ceased to be set out as written rules and worked out in the form of long division and multiplication sums, and all to be learnt off and retained in the memory. A few years ago it was a revolutionary act when a firm issued a book of rules in a formula and used the letters on an illustration instead of words, and even to-day only one firm has dared to issue rules for its machinery in the form of real algebraic equations. The use of the letter "x" in a cotton spinning calculation is even to-day taboo; its presence indicates theory, and theory must on no account be thought of, much less mentioned, in connection with cotton spinning. There are not wanting, however, signs that the country is waking up, even if slowly, to the importance of a sound scientific basis in the education of those who enter on an industrial career and who hope to make a success of it. Many managers of our cotton mills see the necessity of it, and there is not the slightest doubt that in the near future we shall find the sons of our mill managers and owners filling up during the day the now vacant places in the lecture rooms and workshops of our technical schools.

The future of cotton spinning demands it, economy demands it, competition against our scientific competitors demands it, and, above all, an intelligent appreciation and understanding of the work we do demands it. With a good education and a scientific training in the work, a mill manager will be well equipped for a good proportion of his duties, so that a good brain at the head of affairs is part of a mill's equipment. We are away in front at present, but the men behind are running hard, and we must not lag. As indicating what is being done at the present time among managers, carders' overlookers, assistants, and the workers in our mills, it may be mentioned that the whole place is honeycombed with institutions attended by men with a keen desire to acquire knowledge and make up for lost, or the absence of, opportunities of youth. Hundreds of lectures are given during the winter months, and by such means these grown-up men are being raised to a higher intellectual status as well as a better knowledge of their work. With workmen setting an example, we shall soon have a type of manager to suit the new conditions, for a manager must, above all things, be considerably above the average of his workpeople.

The technical training of a mill manager, and by this word manager is meant all who are passing on their way upwards to this position, will lay a firm foundation on which they can reason clearly and logically. Experience formerly took the place of a technical training, and even to-day it occupies first place in many cases, but one has only to look around and find very responsible positions occupied by young men whose experience must of necessity be a limited factor in their success. "Experience teaches," but it by no means follows that it must be personal experience; there is such a thing as absorbing the experience of others, and this to such an extent that it must always occupy an important place among the qualifications of any one holding a responsible position. A more important aspect of experience must, however, be mentioned which is often overlooked. One's own or other people's experiences must not be merely considered as so many facts; in other words, the result must not be accepted simply because it has happened. To obtain the full advantage of experience there must be a capacity to investigate the causes, and find out why such and such a result has been obtained, and this, of course, cannot be done unless the mind has been trained, the observing faculty developed, and there exists a natural aptitude in applying reasoning and principles to practical purposes. Many industries have been started on experience or experiment, or even an accidental occurrence, whereby certain valuable commercial results were obtained, and they are continued under the same conditions to-day. Investigation on scientific lines would probably show that better and cheaper results would be obtained by alterations in method and material, and, indeed, this is what is being done by our scientific competitors, and causing us to realise our weak spots. Cotton mills are notorious in the perpetuation of old-time conditions. There is some reason for this when one remembers the complications of the whole system of a cotton mill. There is the raw material and its wide variations of staple, not only varying in itself, but varying from crop to crop. There is the large number of different processes through which the cotton passes to the finished yarn. There is the complicated mechanism used in the process, and there is the large number of individual factors in each different machine, all of which have a bearing on the ultimate result. Progress calls for men as fully equipped as possible, so that success or failure can be traced, not to some general idea as to the cause, but to the actual spot that produces any given abnormal result. It is a very common saying that if the card produces bad work it cannot be remedied afterwards; this is true, but the same remark applies to the other processes as well. In any given faulty yarn there will be indications that point to the cause if a little reasoning is applied and an investigation made on right lines.

The Importance of Details.—Too much is taken for granted in cotton spinning; it is a case of copying *ad lib.*, and it leads to endless trouble and loss of time and money simply because some small but essential detail is overlooked. This matter will be gone into more fully when discussing the question of testing; the object at present in view is to emphasise the fact that, though the preparing and spinning of yarn is largely a question of repetition work, the result depends on such a wide range of factors that knowledge, wisely selected experience, and infinite pains are necessary to the man who would produce the best result. Leaving aside the personal factor, one good method to adopt is the constant use of a note-book. There are note-books and note-books. Anybody worth his salt will have a note-book, but note-books, like experience, will be worthless unless organised and arranged on some system that enables reason to be applied to their contents. Books ought to be obtained, with printed questions on every matter connected with the essential factors on each machine in the mill. Spaces left for answers can readily be filled in by each department on separately loose sheets, and then entered up in the manager's complete book and a book kept in the office. All changes whatever made in any process or machine in the mill will be recorded, and will afford a guide to repeat orders, and a guide on which to reason out variations without going through the usual method of getting results by repeated trials. If carefully systemised, such a book will tend to considerable economy in mill management, but it will have a far greater value for the manager than for any one else in the mill. Such a book mentioned will record bare facts, but the manager's book will, or ought to, have notes of all his deductions from these stated facts. He, if he is wise, will reason on them, supplement them by observations suggested by his own trained mind, and arrive at conclusions that cannot of necessity become the property of any one other than the man himself. It is his personal matter. Such matters cannot be taught; it is a question of training, and may be some natural aptitude in the man himself. If he has decided for himself by careful observation, and tests that the breaking weight of a scutcher lap, or a card sliver, or a roving, affords a guide to him as to the quality of the yarn he is going to produce, or the efficiency of the work being done on those machines from which the material is taken for the tests, he is exercising one of the qualities for which he was chosen as manager. He may produce better yarn and obtain a better price; he may use cheaper cotton and produce equal or better yarn. In any case he is a good manager if he is capable of utilising his reasoning powers on details (one out of many), such as are given in the case just mentioned.

Better Work and more Production.—A note-book also ought to have remarks put down showing exactly what time is taken to piece up and to doff when working any given class of cotton or yarn; an hour's observation spread over several doffings, etc., would be an excellent guide as to conditions existing. It is not sufficient to have merely a statement that broken ends are more frequent than previously; there is something wrong long before workers complain or a casual observation is attracted to it, and hundreds of pounds of material may be spoiled in price before the fault is discovered. Actual times are necessary, and these afford much information to a manager who will take the trouble to think seriously about them. One could enumerate a host of what appear to be small details in the working of the mill that make for success and economy. Drafts in the fly frames, that cause stretching between rollers and flyers, for instance, are bound to produce bad, uneven yarn. Perfect cleanliness everywhere. Absolute freedom from rust; no roughness on rollers, combs, wires, etc.; exact gauges to be used, and used frequently; roller settings to be tested; the weighting of all rollers carefully adjusted, and their effect tested by trying with gauges of thin steel; careful notes made of the humidity, and the effect on the preparing and spinning processes noted, and adapting the multipliers for twist to the characters of the cotton. This last factor is a peculiar one, and has an important effect both on the yarn and the production. A noted machine firm issued a book containing a list of productions some time ago, and the multiplier for twist in the fly frames was the same for all purposes. Now this is a great mistake. Many carders and managers will be under the impression they are using a certain multiplier for twist, but as a rule they do not know. The writer, finding such a divergence of, or ignorance of, this particular factor in our mills, was fortunate enough to be able to visit a large number of mills, and in practically all cases the twist was different than the authorities thought, and it was somewhat easy to suggest alterations that made for better work and more production.

All mills ought to be kept up to date in equipment, but there must of necessity be a wide difference between new and old mills. Old mills are handicapped by short machines, slower speeds, and insufficient power; they have advantages on the capital account and reputation, and as a rule make specialities. There is a great scope for a good manager in such a concern, and while it is good advice to say, "leave well alone," he will be on the alert to gradually and judiciously improve matters by renewals of worn bearings, re-setting for more production and speed, replacement of cut teeth on wheels, and a variety of other improvements that will enable him to compete with the modern mill.

New Mills.—In the case of new mills, the proprietors have the first say as to what their intentions are. They set out for a certain marketable product and fix the limits. When this is done and the general scheme is settled, the manager must be appointed. Too much is usually left to the architect and the machinists in settling the important details of a mill. It is clearly a manager's duty to have the mill designed perfectly for the work it has to do, and for this he ought to have some knowledge of architecture, so as to understand the architect's work and to be able to make reasonable suggestions as to details of the mill's design. In regard to the machinery itself, the deciding factor is the manager, and he ought to be able to set this out for himself on paper both as to number of machines and their best arrangement.

Any given set of machines in a cotton mill will produce a certain quantity of material when all are perfectly balanced. Alterations of conditions will destroy the balance, and while some machines are working all the time, others may be stopped. The point must be settled as to the probable requirements, and consideration given to the future, and it is much the best plan to arrange matters so that extension of the preparation machinery can be made by leaving vacant room in this department. It is a constant source of annoyance to the management to be under the necessity of working under cramped conditions through rearrangement of machines and squeezing in extra frames, etc. Cotton machinery is wonderfully elastic in its production when handled by men who understand matters, and though our machinists publish statements of production and base their plans on them, there is a fairly wide range in actual work in the different mills, and one man will be obtaining greater production from similar machines than another man, and yet the conditions are apparently similar. Machinists simply have to strike an average, but competition sometimes compels them to take an excessive production, and as a consequence trouble arises.

An ideal manager will have a thorough grasp of his machinery, he will be able to work out perfectly his gearing, and have a perfect control of the change places. This arithmetical knowledge is of enormous advantage as compared with a man who only knows something about multiplying this and that together, and dividing the product by that and the other multiplied together, and taking the square root of the quotient, etc., etc. When some expert is called in to a mill, improvement follows very quickly as a rule, and by very simple means, very often because he knows very thoroughly his machinery, and especially the gearing. Considerable economies could be effected in many mills if this factor alone was attended to with more care than at present, and it alone explains the great differences often met with in regard to working costs in a mill, production of machines, and better work with inferior mixings.

Prevention and Cure.—Machines and processes have their ills, and constant problems require attention. Ability to cure these ills and solve the problems is a necessary qualification of a manager and his assistants, but a greater and more valuable qualification is the ability to prevent troubles arising. A curer leads a strenuous life, and has moments of exultation at his success in curing, but it is generally a worrying job, and he never knows when and where the next trouble will arise; he also labours under the disadvantage of knowing that when the trouble culminates it is more than probable that considerable damage has been done previously to the moment he is called in to effect a cure.

Prevention avoids the bulk of these troubles by adopting methods that prevent them happening. Any curing, after this, is a simple matter.

The organisation and the supervision of labour in a mill are two distinct factors in its economy. The textile workers of the country are so thoroughly organised in trade unions that the organisation of labour is practically entirely in their hands, and the management must organise almost exactly on the lines laid down in a series of rules recognised by master and man as a basis upon which they must work. These rules have almost the force of laws, and they apply chiefly to the number of people to be employed, their duties, and their remuneration. The question as to whether an increase or decrease of wages is necessary may lead to labour troubles on a large scale. Strikes and lock-outs may result, and a vast industry disorganised as a consequence. Such a cause and result, however, are entirely outside the rules that regulate the labour in the mills. The rules concern themselves with details and eliminate anything of a general character. A Brooklands Agreement does not make these rules; it simply provides, among other things, a mode of procedure to be adopted when either side thinks an infraction of a rule or rules has taken place. In essentials such rules are a great advantage both to master and man, and a mutual agreement to interpret them in their true spirit leads to general satisfaction in the mill. No set of rules, however well devised, can control a man's actions or his desires; human nature demands latitude and room for development in directions outside the fixed boundaries of set rules, so that workmen on their part very often wish to step beyond the confines of their fixed duties and qualify for higher posts. They can only do this surreptitiously among fellow-workmen who look with an indulgent eye on the side play that is going on. The management on its part is often desirous of helping on a promising man, and so add to or vary his duties, and frequently the efforts of both sides in this direction are done in such a manner that no break whatever occurs to mar the relationship between the master and his workmen. Such a set of conditions are clearly of a purely personal character, a spirit of trust pervades both sides, and toleration is the guide in the performance of their duties. This happy state may continue for long periods, and custom may establish certain actions and duties; but new officials, new workmen, or new management may bring the whole organisation back into the fixed boundaries of the written rules, with the threat of penalties for their infraction. Jealousy, favouritism, carelessness, stupidity, or an overweening idea of importance exhibited by officials, workman, or master, instantly produce a state of siege and cause the workmen to retire behind the bulwarks of their rules. Here is the place to emphasise the vast importance of good management, a recognition of a set of fixed conditions established after a long and dreary warfare between master and man, and the clear exhibition to his workmen of his intention to abide by these conditions.

CHAPTER I

COTTON

Grading of Cotton.—The grading of cotton is an art requiring a long experience. It is the basis upon which the material is sold in the markets of the world, and therefore the grades into which cotton is divided are standards. Since "feel," colour, bloom, cleanliness and, to a certain extent, length of fibre are the main factors in grading, it is readily seen that there is an entire absence of a scientific attitude in the minds of those responsible for the grading. No scientific indicators have been evolved that would enable any one to identify any cotton or any grade of cotton. Soft, mossy, silky, sticky, wasty, fuddy, nippy, lustrous, fine, coarse, rough, heavy or light-bodied, etc., are terms that mean something, and they settle grades and prices. It is not surprising that the expert men who grade cotton are often deceived in regard to the spinning properties of cotton, and it frequently happens that cottons are put into lower grades that are far superior to those that are graded higher, and *vice versa*. It is recognised that mere grading, by simply passing the cotton under the judgment of the expert grader, is not final, and new cottons are now usually submitted to more scientific tests and to a practical demonstration in the mill.

The experienced manager can take advantage of this weakness in the methods of grading, and sometimes obtain more uniform length of staple and stronger yarn by the purchase of a lower-graded cotton that possesses good spinning qualities but is perhaps somewhat deficient in one or more of the grading factors.

Irregularities of Cottons.—A field of cotton plants usually contains a wide variety of plants. The fibres from individual plants vary considerably from each other, and in addition to this variation the fibres from any one plant have a wide variation. This absence of uniformity of plants and absence of uniformity of fibres on each plant are grave defects from the spinner's point of view. When judging cotton with the intention of purchase, a sample might easily have been taken from a batch of longish staple, whilst samples from other parts of the same bale may be considerably shorter, and this in spite of the fact that the whole bale may have been gathered from the same field. A mixture of, or separate bales of, top, middle, and bottom crops are frequent in mill deliveries, and, as the cotton differs in quality in these pickings, this fact may account for some of the difficulties met with in passing the cotton through the mill.

Improvement of Cottons.—Highly trained agriculturists and botanists are constantly at work to discover how uniformity may be obtained of length of staple, the best kinds of plants, the most suitable conditions for growth of the plant, and the development of the fibre as regards its convolutions, etc. Hybrids, both artificially and naturally produced, are constantly arising. Promising specimens are isolated and cultivated to obtain pure strains of fixed characters. Some of these are eventually put on the market and displace other kinds that may happen to have deteriorated. All kinds of cotton deteriorate and give place to newer kinds, and recent years have seen many such displacements. To speak of using American, Egyptian, etc., cottons often means little unless supplemented by other information. New cotton-growing districts are growing cottons previously associated with some country or continent; other cottons are being transplanted to other districts, whilst such improvements are being effected in diverse regions that they become great competitors to well-known kinds grown in other parts of the world. Purchasers of cotton require to be alert to note these changes, and not to hesitate to make spinning tests for themselves when new cottons are put on the market or a grower is desirous of obtaining information as regards the spinning qualities of a cotton before submitting it to the professional grader.

Linters.—This is the very short downy hair left on the seed after ginning. It became a valuable product during the war, and gins were designed to clear it from the seed. Normally the saw gin failed to detach this downy hair, but improvements have been made which detach a large proportion of it, and of course it goes forward with the regular staple to the press. Any mill which keeps a record of its cottons, waste, etc., will have noted the increased waste, much of which can be traced to the inclusion of linters.

A good system of recording all waste made at the various processes will prove valuable to the management in tracing causes of difficulties, and lead to correct method of buying the cotton, or adjusting his machines to deal with this increase in shorter fibres.

Length of Fibres.—A very long list would be required to give what is frequently termed the "length of the fibres" of the commercial cottons of the world. The lengths usually stated are deceptive, inasmuch as they only give a rough approximation to some individual cotton, and are based on the measurement of comparatively few fibres, and these generally of the longer specimens in a sample.

Actually, the fibres taken from any sample of cotton before or after entering the mill represent a wide variation in length, so that whilst it is permitted to say that Indian, American, Egyptian, and Sea Island cotton show an ascending increase in length, none of them have a fixed average length.

The hand-pulling method is the basis on which length of fibre is judged, and upon this judgment depends the drafting and setting of rollers. The chief point to observe is that each cotton bought is tested for length by the buyer, and no presumption is made that because it is an American or Egyptian cotton, therefore its length must be a fixed one. Several methods are in vogue in order to obtain a clear view of the lengths of the cotton fibre.

1st Method.—Mount a sample of cotton between lantern glasses, and throw a view on a board on the wall. Go over the enlarged view of the fibres with a small wheel measurer. The scale of the measurer can be obtained by drawing a two-inch line on the slide, from which the scale of the enlargement can be readily obtained.

2nd Method.—Take a sample of cotton and detach each fibre along a glass plate smeared with glycerine. A pointed needle can be used for this. The fibre will be easily straightened out and can be measured by a glass scale laid over it.

3rd Method.—Dr. Lawrence Ball's sledge apparatus for stapling cotton.

4th Method.—Henry Baer's apparatus for stapling cotton.

The tabulated results of the measurements obtained by all these methods can be drawn in the form of a graph similar to those given in Figs. 1, 2, and 3.

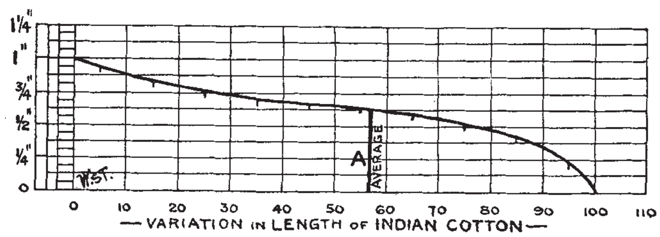


FIG 1.

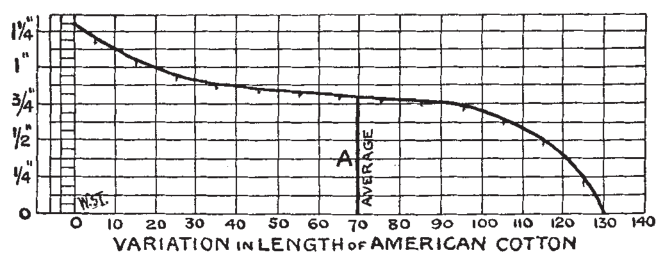


FIG. 2.

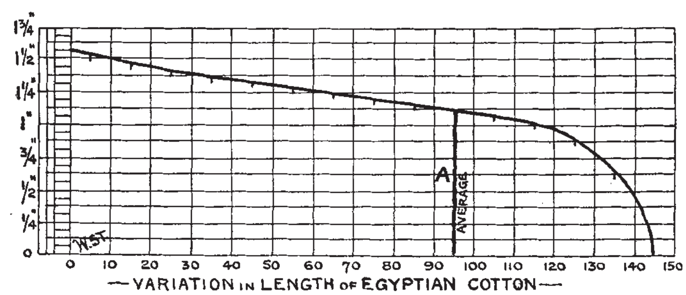


FIG. 3.

It will be understood that the cotton in bulk will contain immense numbers of fibres of every length shown on the graphs. If carefully carried out it may be assumed that there will be as many long as short fibres, as well as those of the intermediate lengths.

Very useful information can be deduced from graphs of this kind, and samples taken from any of the machines in a mill will indicate quite clearly any change in the condition of the fibres as regards their length. A girl can easily carry out the tests and make the graphs.

In some mills this examination of cotton is carried out on all samples of cotton submitted.

The lack of uniformity of the fibres naturally interferes considerably with the problem of drafting, as well as introducing a weakness in the subsequent yarn due to the large number of short fibres allowing slippage to occur when strains are put on the yarn. When slippage occurs among some of the fibres in yarn, the longer fibres that can be twisted sufficiently to prevent slippage simply break under the strain. This is one of the main causes why yarn is never as strong as the total strength of the individual fibres.

The average length of the fibres in such graphs as Figs. 1, 2, and 3 can be easily found by taking the sum of the lengths of the vertical lines between the base and the curve and dividing by the number of measurements thus taken. This method is similar to that used in obtaining the average pressure on an indicator diagram. The average length is shown by the dark vertical line in each diagram.

Samples need to be carefully taken to avoid the loss of the short fibres in any process. A glass placed under the card web and covered with another glass will ensure a good sample. A similar method for slivers, rovings, and yarn ought to be taken just as the cotton emerges from the roller nip and before any twist is inserted.

It need scarcely be added that all examinations of the cotton should be carefully recorded with full details for future reference or comparisons.

Microscopic Examination.—This useful instrument ought to be in every mill as well as a camera. By its means fibres can be examined for the natural indentations (the so-called natural twists or convolutions) and their number, pitch or absence, all of which are indications of quality. Photographs or micro-photographs give a permanent record and enable an examination to be made at leisure.

NOTE.—A complete series of drawings to illustrate the remarks in above chapter is given in the author's book, *Cotton Machinery Sketches.*

CHAPTER II

BALES

On arrival at the mill, the bales should be checked for marks and weights and these entered in a special book provided for that purpose. The columns should indicate invoice weights and actual weights at the mill; condition of the bales, such as broken, wet, stained, etc. It is an advantage also for columns to contain weight of wrappings and bands. Test the cotton at once to see if it agrees with the sample on which it was bought, and draw several samples for this purpose.

Officially, cotton is supplied in pounds and not as formerly in cwts., qrs., and lbs. It is quite common, however, for the cotton to be purchased as so many bales, on the supposition of a bale weighing an average known weight.

The average weight of bales is as follows:

American bale	480 lbs.
Egyptian bale	560 lbs.
Indian bale	450 lbs.
Peruvian bale	100 to 600 lbs.
Brazilian bale	300 to 450 lbs.
African bale	400 to 450 lbs.

Opening a Bale.—When opening a bale, the bands ought to be cut by special shears made for that purpose.

An axe is frequently used to break the bands, but this is bad practice, as it not only damages the wrapping, which is valuable, but loose and weak rivets fall out, due to the blow of the axe, and drop into the cotton, thus introducing a source of damage to machinery and the possibility of fire. Bits of hemp and jute also are driven into the cotton.

Bands and Wrappings.—Weigh all wrappings and iron bands and enter into book.

Officially the weight of bands must not exceed 11 lbs. for 10 bands, whilst 4 per cent is allowed for wrappings after deducting the weight of bands. A claim can be made for over-tare, as it is termed, if this percentage is exceeded.

EXAMPLE :

100 bales weigh	50,660 lbs.
Less 600 bands (10 weigh 11 lbs.) .	660 ,,
	50,000 ,,
Less 4 per cent tare and draft . .	2000 ,,
Net lbs. of cotton =	48,000 ,,

In the above example the bales have been weighed complete, and the weight of the bands has been deducted. Four per cent for tare is allowed off the resulting weight and the final result is the net weight of the cotton.

A record should be kept somewhat as follows :

No. of Bales.	No. of Bands.	Actual Weight of Bands.	Calculated Weight of Bands.	Difference.
24	120	148 lbs.	132 lbs.	+16 lbs.
24	120	126 lbs.	132 lbs.	−6 lbs.

The difference may be in favour of or against the purchaser, but the probability is that it is against, and although the difference may be small for a few bales, a year's consumption of, say, 10,000 bales may easily be equal to £250 per year.

The wrappings ought to be recorded also, so that the actual tare can be compared with the calculated and allowable tare. Overtaring is not uncommon, and consists chiefly of moisture and patches. Claims for overtare are not easily settled, as both moisture and patches are illusive factors. Moisture dries up between sending in claims and an official inspection, and if evaporation is prevented a suspicion is aroused that moisture has been added in the mill. Patches are generally put on to cover torn parts, and extra heavy pieces of wrapping are stuffed in frequently. No marks are on these patches, so that identification is difficult when claims are made. Reasonable claims are, however, always met by reputable dealers, but purchasers of "spec" cotton must take their chance of fraud in overtares.

Dimensions and Density of Cotton Bales.—It is of interest to know, or at least to have a clear idea of the size of a bale and the density of the cotton. The degree of pressure used in compressing a bale has some considerable influence on the amount of *opening* the cotton must undergo in the mill. The more the cotton is compressed the more opening will be required. The cotton may be clean, but if it is packed hard the opening processes must be correspondingly thorough.

Job Lots.—If a collection of bales come into the mill, presumably of one mark and of varying sized bales, they are probably a "job lot," or, in other words, a collection of spare bales that have been left over from stocks. A careful examination should be made of each bale and graded for use, otherwise, if all are lumped together, serious difficulties will occur in the progress of such a mixture through the mill processes.

Kind of Cotton.	Size of Bale.	Weight in lbs.	Density per cu. foot.
American	4 ft. 6 in. × 3 ft. 4 in. × 2 ft. 3 in. to 6 ft. 6 in. × 3 ft. × 2 ft.	290 to 878	23 lbs. on a 480 lb. bale
Egyptian	4 ft. 3 in. × 2 ft. 7 in. × 1 ft. 10 in.	672 to 840	35 lbs. on a 720 lb. bale
Surat	4 ft. 1 in. × 1 ft. 10 in. × 1 ft. 4 in.	400 to 531	39 lbs. on a 400 lb. bale
Madras	4 ft. 1 in. × 1 ft. 10 in. × 1 ft. 4 in.	460 to 486	
Tinnivelly	4 ft. 1 in. × 1 ft. 10 in. × 1 ft. 4 in.	499 to 531	
Brazilian (pressed)	4 ft. 1 in. × 1 ft. 10 in. × 1 ft. 5 in.	367 to 428	
Brazilian (impressed)	2 ft. 10 in. × 2 ft. 9 in. × 1 ft. 4 in. to 5 ft. 6 in. × 2 ft. 6 in. × 1 ft. 3 in.	100 to 419	
Peruvian	2 ft. 6 in. × 2 ft. 1 in. × 1 ft. 8 in. to 5 ft. 6 in. × 3 ft. 4 in. × 2 ft. 10 in.	100 to 600	
African		100 to 450	28 lbs. on a 400 lb. bale

For official statistical purposes the American bale is reckoned as 500 lbs. The average bale is 480 lbs. The density of the bale in the above table is a varying factor, the figures given being an average.

Rule for density of a bale :

$$\frac{\text{Total weight in lbs.}}{\text{length} \times \text{breadth} \times \text{thickness}} = \frac{\text{total weight}}{\text{cubic feet}} = \text{Weight per cu. ft.}$$

Example :

$$\frac{400 \text{ lbs.}}{4 \text{ ft. } 1 \text{ in.} \times 1 \text{ ft. } 10 \text{ in.} \times 1 \text{ ft. } 4 \text{ in.}} = \frac{400 \text{ lbs.}}{\text{say } 10 \text{ cu. ft.}} = \frac{40 \text{ lbs. per}}{\text{cu. ft.}}$$

As a comparison to the density of cotton in the bale it may be mentioned that

A cubic foot of water weighs 62·2786 lbs. at 62° F.
A cubic foot of loose dry sand weighs 88 to 106 lbs.
A cubic foot of cork weighs 15 lbs.
A cubic foot of white pine weighs 30 lbs.

Bag-pickings. — In the aggregate, a considerable amount of cotton sticks to the coarse wrapping of the bale, and in detaching this cotton a quantity of jute fibres and short bits of the threads of the wrapping are picked away. Damaged wrappings increase the chances of these impurities getting into the cotton. Great care should be taken in clearing the cotton from the wrappings, and any cotton with loose jute fibres in it should be put aside in the bag-pickings. Marks are sometimes painted on the exposed cotton in a torn bale, and this paint must also be carefully removed. Badly damaged, strained, and otherwise useless pieces of cotton in the bale should be removed and put in the bag-pickings.

Moisture in Bale Cotton.—A standard has been recognised for the amount of moisture allowable in the raw cotton. Cotton when in a dry state and then exposed to the atmosphere is assumed to be capable of absorbing $8\frac{1}{2}$ per cent of moisture from the atmosphere. This means that 100 lbs. of dried cotton will absorb $8\frac{1}{2}$ lbs. of moisture and thus become $108\frac{1}{2}$ lbs. If this $108\frac{1}{2}$ lbs. contain $8\frac{1}{2}$ lbs. of moisture, the moisture contents will be 7·834 per cent. The $8\frac{1}{2}$ per cent of moisture is called the *regain*, but the actual standard condition is when cotton contains 7·834 per cent of moisture. This standard applies also to cotton in any of its stages up to and including yarn. Custom permits a spinner to assume that the raw cotton bought contains 7·834 per cent of water, and that he has the right to replace this water if all or any of it is evaporated during the passage of the cotton through the mill. Suppose that a set of cops is perfectly dry when doffed. This yarn is conditioned by allowing it to absorb moisture, and the absorption may continue until $8\frac{1}{2}$ lbs. of water have been absorbed by every 100 lbs. of yarn. If the yarn from the mule already contains say 5 per cent of moisture, then the conditioning is arranged so that the moisture contents is brought up to 7·834 per cent.

The absorption of moisture by cotton varies according to (*a*) the bulk of the sample, (*b*) the temperature of the air, (*c*) the amount of moisture in the air, (*d*) the length of time the cotton is exposed, (*e*) the barometric pressure. In any case, the absorption of moisture is rapid, and even any yarn will readily absorb 3 per cent of moisture in as many minutes.

In making tests for comparative purposes, the invisible loss or regain may have important effects on the result of the test if the cotton is subjected to varying conditions.

In testing for moisture, the cotton should be exposed to a temperature of 212° F. for 2 to 3 hours, a sample of one to two pounds requiring only 2 hours. The weighing ought to take place whilst the cotton is in the oven; its mere withdrawal from the oven will destroy any pretence at accuracy.

A common practice in the mill is to weigh a few pounds of cotton and then place it over a steam pipe or in the boiler-house for a few hours. On weighing the dried cotton, an estimate is made as to the amount of moisture it had contained. Such a method, of course, leads to very erroneous results, and ought not to be tolerated in a well-managed mill. It is quite common for cops to be tested in the same way.

If cotton contains, say, 8 per cent of water when it is bought, this water is paid for at the same price as the cotton, but, on the other hand, since the water can be put back into the yarn, the water is sold at the price of yarn. In a mill using, say, 60,000 lbs. of Egyptian cotton per week at 17½ pence per lb., and the yarn sold at 30 pence per lb., the profit on the water contents, at an equality ratio, would amount to almost £6000 per year. The drier the bale cotton is, and the wetter the yarn, the greater will be the profit out of water (see Testing).

Cotton coming into the mill with, say, 10 per cent of moisture will probably lose half of this in the mixing and blowing rooms. From here onwards it may gradually regain moisture, this depending on the humidity (natural or artificial) of the Card and Spinning rooms. In most mills a careful record is kept of cotton passed into the mill and of yarn from the spinning machines. If the visible waste is added to the yarn weight, some idea is obtained as to the amount of regain required in the conditioning room. This method is useful at stocktaking times, but the importance of the question of moisture is too great to be left to a quarter or half year's interval. A systematic method of frequent testing should be instituted.

NOTE.—A complete series of drawings to illustrate the remarks in above chapter is given in the author's book, *Cotton Machinery Sketches.*

CHAPTER III

MIXING

IN mill practice "mixing" is usually meant that section where the cotton is mixed direct from the bale and preparatory to passing it to the openers. It is still the practice for the long-stapled cottons to be made up in stacks or bins, and either distributed in layers or mixed at the bale breaker and then passed to the mixing stack. The cotton is raked downwards from the stacks, and presumably a good mixture is obtained. Other advantages are claimed for the stack mixing in addition to the intermixture of the fibres. A species of conditioning occurs, and the fibres have an opportunity of recovering from their bale condition, and also to part with or absorb moisture according to the state of the atmosphere. Benefits of this kind imply laying down a mixing some time before it is required, and therefore stocks of cotton are necessary, both in bales and in the bins, in order to meet contracts for yarn.

Mixing Lattices.—The usual practice is to pass the cotton to the mixing stacks by travelling lattices, so arranged that each bin can have its special mixture delivered to it. A good deal of dust and light hairs are flying around, and the vibratory motion of the lattices causes the loose heavier impurities in the cotton to fall between the spaces of the lattices on to the floor, and on to the cotton lying in other bins over which the lattice travels. This latter evil can be prevented by arranging the lattices so that no lattice passes over any bin other than its own.

Pneumatic Mixing.—A method that is meeting with success is one in which the cotton is carried along piping to each stack by air currents created by an exhaust fan, and the air passing through a cage placed over each stack.

All dust and free impurities are drawn through the cages, and the cotton drops from the surface of the cage on to the mixing. A purer atmosphere and cleaner cotton is thus assured.

Objects of Mixing.—To ensure a thorough mixing together of the fibres. To distribute the faulty fibres among the better fibres. To obtain uniformity of tint. To obtain some desired tint. To increase strength by incorporating a better cotton. To reduce strength by incorporating a lower cotton. To obtain a smoother or rougher yarn. To obtain a cheaper yarn by mixing a lower grade cotton with a better grade, or *vice versa*.

As already indicated in a previous chapter, cotton is a very irregular material even when gathered as a top crop from a field of the same plants and picked at the same time. Enormous quantities of cotton are gathered carelessly, fully and partially matured bolls are gathered, and the crop from various plantations lumped together at the ginnery. The top, middle, and bottom crops are also mixed. Some cotton has more moisture than others, and cakes more readily under pressure of baling. Linters are dumped in bales of good cotton.

This patchy and irregular mass of material must be thoroughly mixed up in order to distribute the faulty portions equally among the good fibres. It will be seen that mixing is necessary even for cotton confined to one class or mark.

Mixing also gives the opportunity for obtaining a darker or lighter tint, and of course any of the other objects of mixing incidentally can be attained.

The usual precautions to be taken in mixing are the obvious ones of not mixing long- and short-stapled cottons; slight differences in length are not of much importance. Keep the colour as near equal as possible for general purposes, but this is of little importance if the yarn or cloth is to be bleached. A knowledge of the purpose for which the yarn will be used must dictate the mixing as to colour. A rough and smooth cotton ought not, as a rule, to be mixed unless for some special purpose.

Other Methods of mixing Cottons.—Mixing always takes place as the earliest process in the mill. This mixing may be a kind of standard one for the generality of yarn spun by the mill, or there may be several mixings of a standard type. It frequently happens, however, that some particular quality is required in some yarn, either as regards strength, feel, cost, colour, etc. The standard mixings are not suitable for the desired variation, so other methods are adopted. For instance, a mixing can be made by using a combination of laps at the scutcher. Another method is to introduce one or more slivers at the draw frame. This last method of mixing depends upon the large amount of doubling and drafting for its success. It may be stated that the mixing resulting from doubling and drafting is the most important mixing factor in spinning. The carding machine is also an excellent mixer of fibres, chiefly through the differential movement of the web as it passes from the doffer to the calender rollers (see Carding).

Mechanical Mixing.—Formerly bale cotton was pulled to pieces by hand and put into a bin. The next step was to use a machine with two or more lines of large blunt spiked rollers, with a draft between them. This pulled the large lumps asunder, and the teeth of the rollers penetrated the lumps and permitted a free access of air so that a loosening effect was started that developed to some extent whilst the cotton was in a mixing stack.

A great forward step was taken when a spiked lattice was designed to drag cotton from a bulk and the surplus cotton on the pins of the lattice was struck away, leaving a species of partially combed fibres on the pins. This opened cotton is stripped from the pins and passed on by travelling lattices or a pneumatic system to the mixing bins.

This method is so effective that the fundamental reasons for making a stack mixing no longer hold good for the bulk of cotton, and where mixing stacks are used they are practically only used as conveniences of stocks ready for immediate use when required. Stacks are extensively used for this purpose, and also for complicated mixings where several marks are to be mixed, and carelessness may result in feeding the various cottons in the right proportions to the bale opener or breaker.

On the other hand, enormous quantities of cotton are opened by the bale breaker, which is sent straight to the openers in the blowing room, and no stacking of the cotton takes place. Two or three marks can be readily mixed with ordinary care.

It should be the aim of those responsible to have a minimum of marks to make up a mixing. Careful choice of cotton possessing the desired qualities will reduce mixing to a considerable extent and eliminate what is sometimes presumed to be skilful judgment in purposely using unnecessary marks to sustain the presumption.

Price of Mixings.—Mixing cottons for any purpose does not depend on a few pounds of cotton either way. Large mixings are the rule when made. The mixings are made in terms of bales whether for stacks or direct feeding, and the bales are bought at prices to suit the class of yarn to be spun. A mixture of bales at different prices will produce a certain priced mixed cotton. The price of mixed cotton can be readily found.

(1) Example.—Find the price of the following per lb. when mixed.

20,000 lbs. of cotton A at 10 pence per lb.
30,000 lbs. of cotton B at $8\frac{1}{2}$ pence per lb.

$$\frac{\text{Total cost of cotton A} + \text{total cost of cotton B}}{\text{Total lbs. of A} + \text{total lbs. of B}} = \text{price per lb. of mixture.}$$

$$\frac{20{,}000 \times 10 + 30{,}000 \times 8\frac{1}{2}}{20{,}000 + 30{,}000} = \text{price of mixture per lb.}$$

$$\frac{455{,}000}{50{,}000} = 9 \cdot 1 \text{ pence per lb.}$$

(2) Example.—Find how much cotton B at $8\frac{1}{2}$ pence per lb. must be mixed with 20,000 lbs. of cotton A at 10 pence per lb. to produce a mixture at 9 pence per lb.

$$\frac{\text{Total cost of cotton A} + \text{total cost of cotton B}}{\text{Total lbs. of cotton A} + \text{total lbs. of cotton B}} = 9 \text{ pence per lb.}$$

$$\frac{20{,}000 \times 10 + x \text{ lbs.} \times 8\frac{1}{2}}{20{,}000 + x \text{ lbs.}} = 9 \text{ pence per lb.}$$

$$\frac{200{,}000 + 8\frac{1}{2}\,x}{20{,}000 + x} = 9 \text{ pence per lb.}$$

$$200{,}000 + 8\tfrac{1}{2}\,x = 180{,}000 + 9\,x.$$

$$200{,}000 - 180{,}000 = 9\,x - 8\tfrac{1}{2}\,x.$$

$$20{,}000 = \tfrac{1}{2}\,x.$$

$$2 \times 20{,}000 = x.$$

$$40{,}000 = x.$$

40,000 lbs. of cotton B at $8\frac{1}{2}$ pence per lb. will be required.

It is interesting to note these two examples.

(1) 20,000 lbs. of cotton at 10 pence per lb. }
30,000 lbs. of cotton at $8\frac{1}{2}$ pence per lb. } = 9·1 pence per lb. of the mixture.

(2) 20,000 lbs. of cotton at 10 pence per lb. }
40,000 lbs. of cotton at $8\frac{1}{2}$ pence per lb. } = 9 pence per lb. of the mixture.

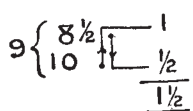
To alter the price of the mixture by such a small amount as $\frac{1}{10}$ of a penny per lb., we require to increase the cheaper-priced cotton by an addition of 10,000 lbs. to the mixing, or alternately to reduce the dearer cotton by 5000 lbs.

The examples may serve to remind one that the small difference between 9·1 and 9 cannot be ignored and dismissed by saying "it is near enough."

(3) It may happen that a purchaser of cotton wishes to know in what proportions two or more cottons must be bought at 10 pence and $8\frac{1}{2}$ pence in order to produce a 9 pence per lb. mixture, and the total of both cottons to be 60,000 lbs., or, say, 120 bales.

This can be done quite easily by the following method. (Alligation or the rule of mixtures.)

Place the two prices over each other and on the left place the desired price.



Proof.

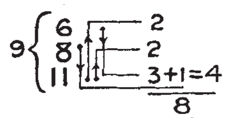
1 lb. at	$8\frac{1}{2}$ =	$8\frac{1}{2}$	pence
$\frac{1}{2}$ lb. at	10 =	5	pence
$1\frac{1}{2}$ lbs. at	9 =	$13\frac{1}{2}$	pence

Draw a line from the lower number than 9 to the number higher than 9, *i.e.* from $8\frac{1}{2}$ to 10. Subtract $8\frac{1}{2}$ from 9, which leaves $\frac{1}{2}$. Place this $\frac{1}{2}$ opposite the figure 10 to which the line has been drawn. Now draw another line from the larger number than 9 to the lower number than 9, *i.e.* from 10 to $8\frac{1}{2}$. Place the difference between the 10 and the 9, which is 1, opposite the figure to which the second line was drawn, viz. the figure $8\frac{1}{2}$. This operation gives us two figures, 1 and $\frac{1}{2}$, and they represent the proportion of the two cottons: 1 lb. of $8\frac{1}{2}$d. cotton to $\frac{1}{2}$ lb. of 10d. cotton, or 1 bale of $8\frac{1}{2}$ cotton to $\frac{1}{2}$ bale of 10d. cotton, or 40,000 lbs. of $8\frac{1}{2}$d. cotton to 20,000 lbs. of 10d.

cotton. As the total lbs. must be 60,000 lbs., according to the question, we simply divide it in the proportion of $1 : \frac{1}{2}$ or as 2 : 1.

This link method can be used for a mixture of three differently priced cottons.

(4) In what proportions must three cottons whose prices are 6, 8, and 11 pence per lb. be mixed in order to produce a cotton at 9 pence per lb.?



Proof.

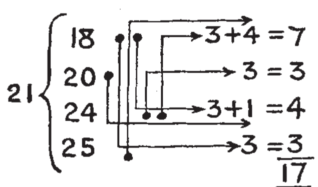
2 lbs. at 6d.	= 12 pence
2 lbs. at 8d.	= 16 pence
4 lbs. at 11d.	= 44 pence
8 lbs. at 9d.	= 72 pence

The proportions are, 2 bales of cotton at 6 pence, 2 bales of cotton at 8 pence, 4 bales of cotton at 11 pence, or as 1, 1, and 2 respectively.

A mixture of four cottons can be found in the same way.

EXAMPLE.—Find the proportions of the following priced cottons that when mixed will give 21 pence per lb.

A cotton 18 pence, B cotton 20 pence, C cotton 24 pence, and D cotton 25 pence per lb.

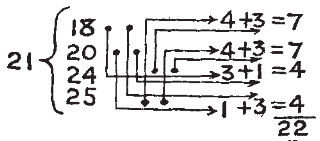


Proof.

7 lbs. at 18d.	= 126 pence
3 lbs. at 20d.	= 60 pence
4 lbs. at 24d.	= 96 pence
3 lbs. at 25d.	= 75 pence
17 lbs. at 21d.	= 357 pence

The dots represent the starting-point of a line, and the arrow gives the difference between the starting number and the required price, viz. 21.

It is evident that lines, or links, as they are called, can be drawn in various ways so that different proportions may be obtained. For instance, another example of the same problem is now given.



Proof.

7 lbs. at 18d.	=126 pence
7 lbs. at 20d.	=140 pence
4 lbs. at 24d.	= 96 pence
4 lbs. at 25d.	=100 pence
22 lbs. at 21d.	=462 pence

It is interesting to note that the above four cottons can be mixed in seven different proportions by the method here given. These seven different proportions are as follows:

3 at 18 pence	4 at 18 pence	3 at 18 pence	4 at 18 pence
4 at 20 pence	3 at 20 pence	7 at 20 pence	7 at 20 pence
3 at 24 pence	1 at 24 pence	4 at 24 pence	1 at 24 pence
1 at 25 pence	3 at 25 pence	1 at 25 pence	4 at 25 pence

7 at 18 pence	7 at 18 pence	7 at 18 pence
3 at 20 pence	4 at 20 pence	7 at 20 pence
4 at 24 pence	3 at 24 pence	4 at 24 pence
3 at 25 pence	4 at 25 pence	4 at 25 pence

In making a mixing of the above four cottons it may be that 40,000 lbs. are required for the mixing. This quantity must be divided in any of the proportions given above. Taking the first case we add 3, 4, 3, and 1 = 11.

Then proceed as follows:

As 11 : 40,000 : : 3 to 10,909 lbs. at 18 pence
As 11 : 40,000 : : 4 to 14,545 lbs. at 20 pence
As 11 : 40,000 : : 3 to 10,909 lbs. at 24 pence
As 11 : 40,000 : : 1 to 3,636 lbs. at 25 pence

40,000 lbs. at 21 pence

NOTE.—A complete series of drawings to illustrate the remarks in above chapter is given in the author's book, *Cotton Machinery Sketches.*

CHAPTER IV

BALE BREAKERS, ETC.

Object.—Primarily to pull asunder and loosen the bale cotton ready for the mixing stack or for direct feeding to the openers. Also some degree of cleaning.

Hopper Bale Breakers.—This is now the standard method of opening out the bale cotton. The cotton is fed, in small pieces from the bale, on to a lattice which conveys it into the hopper space and against the upright spiked lattice. The pins on this lattice drag through the cotton pressing against them and tear away portions from the lumps and carry these portions upwards. If too much cotton adheres to the spikes or pins, an evener roller or evener lattice strike away the surplus cotton back into the hopper space. Owing to the inclination of the pins on the lattice this beating back of the surplus cotton tears away or combs the lumps off the spikes, leaving a combed-out portion still adhering to them. This is the opened portion, and is carried forward and is stripped off by a beater in a position where the inclination of the pins permits this to be done effectively.

As a Mixer of Cotton.—A fairly satisfactory mixing can occur in the hopper bale opener whether one or more different marks of cotton are being used. Arrange several bales around the machine and take portions of cotton from each bale of the series when feeding. In cases of two or more marks, each in some definite proportion, the pieces from each bale must be taken in some kind of order so that they will have a mixed condition in the hopper. The smaller the pieces thrown in to the hopper or fed on the lattice creeper, the more effective the mixing. The constant beating back of the surplus cotton adds to the mixing effect.

Production.—A bale of Egyptian or American cotton can be put through the machine in from five to ten minutes.

Notes.—The opening out of bale cotton has always been a perfunctory operation. Some slight show of an opening effect is all that seems to be desired. The importance of presenting the cotton to the openers in as open a condition as possible, so that it can be thoroughly cleaned, ought to make one recognise that care and supervision is as necessary at the bale breaker as any other part of the mill. Mixing is absolutely dependent on care at this point, and greatly increased cleaning would accrue in the blowing room if attention were given to feeding and setting correctly.

See that slabs of cotton are not thrown into the hopper. Have them pulled into small pieces.

Distribute the cotton in the hopper so that the full width of the spiked lattice can pass through it.

Keep the hopper fairly full, so that the spikes can pull out the fibres and not simply carry up solid lumps of cotton to be knocked off. There is usually no stop motion on the machine, so care is required in filling so as to obtain a regularity in the opening effect. In many cases even a regularity in the amount fed is a necessity.

Where possible, feed over the top of the hopper and not by the lower feed lattice. When fed by a lower feed lattice the upright spiked lattice passes through such a very small quantity of cotton that it simply carries the cotton upward without having performed any opening action on the cotton at its lower end.

See that lumps of cotton do not get wedged between the laths. Excessive breakages of laths are invariably due to carelessness, and indicate a decided lack of supervision. Hard lumps of cotton must be pulled asunder by hand before throwing them into the hopper.

Don't work the machine at its maximum production.

Adjust the evener roller by setting coarse at first and moving it inwards towards the spiked lattice until the correct effect is obtained. Don't commence with a fine setting and then move it to a wider setting, it will cause damage.

Keep the lattice at an equal tension throughout and prevent the lath ends rubbing on the inside of framing. An effective method of doing this is to use flanged bowls on the top shaft of the lattice so that the lattice is kept from moving sideways towards the frame sides. Keep the dust passage to the fan clear, and frequently brush the grid of the dust trunk.

Examine the evener roller frequently to see that cotton does not get entangled in the teeth and wrap round the roller. Rolled and stringy cotton is often produced in this way.

As the machine is usually driven by belts and ropes it is necessary to keep them at a correct tension in order to prevent slippage. If a belt or rope can easily slip, it will mean that the evener roller, stripping roller, or lattice will stop, or lumps of cotton get wedged; a breakage will result.

Get the best out of the machine; it will make the subsequent machines easier to manage and adjust. Any one not giving his bale breaker constant attention is neglecting an important part of his duties.

Wiper rollers should have their leather strips replaced when worn. Clean out the receptacles below the grids at least twice a day and the whole machine cleaned out once a week.

About every two months it is advisable to take down the rollers and other working parts and attend to bearings and clean out all oiling passages, etc. Lubrication is a matter that ought not to be overlooked. Replace broken laths and pins at once, and don't allow distorted pins to remain in that condition; straighten or replace them.

The question of using closed-in or open-spaced lattices is one of opinion. Closed-in lattices prevent cotton becoming wedged between the laths. Open-spaced laths allow impurities to fall through; in any case, the open space between laths should be as narrow as possible, so that good cotton is not driven through.

Small Porcupine Opener.—This machine is frequently placed between the mixing stack and the opener, or between the hopper bale breaker and the opener. In some mills it is not used, especially in those using clean and open longish-stapled cotton. Another name for the machine is **Lattice Feeder**.

Use.—To open the cotton and to clean it.

Method.—The opening is effected by a built-up beater consisting of discs, around the edges of which are riveted narrow projecting blades. These blades are bent at such varying degrees as will ensure all the fed cotton being acted upon by the blades in one or two revolutions of the beater.

The cleaning is attained by the striking effect on the cotton driving out a portion of the impurities through the first part of the grids, and further impurities falling out or escaping by centrifugal force through a continuation of these grids set close to the path of the beater for a quarter to three-quarters of the circumference. Modern machines are designed to give a maximum of grid surface and closely set grids. As many as from seventy to eighty grid bars are placed around three-quarters of the circumference of a 24-inch beater, thus allowing an average of about three-quarters of an inch space between the bars. The heavier impurities are driven out in the earlier set of bars and the lighter impurities through the remaining ones. The opening effect of the beater on the cotton, of course, enables the impurities to be the more easily eliminated. To obtain this lengthened grid surface, bent or curved trunks or passages are necessary, and the cotton continues its course along the passage or trunk to the opener under the influence of currents of air induced by fans or by a vertical opener.

Setting of Grids.—The earlier set of grids (a dozen or so) are inclined so as to present their sharp edges in opposition to the direction of revolution, but the subsequent ones are set so as not to oppose the passage of the cotton, but merely to allow light impurities such as dust, fine particles of leaf, and larger nip bunches to escape. These grids are designed to prevent the return of these impurities as far as practicable.

It is as well to remember that the bulk of the grids used on any machine are not opening organs but simply cleaning organs ; the beater opens the cotton whilst the grids are set, so that the agitated open cotton in passing over them allow the dust, light hairs, fine leaf, etc., to fall away and escape through the grids. The more grids that are provided the better will be the cleaning.

It will be seen that the small porcupine opener is in reality an additional bale opener to complete the work of the hopper bale breaker.

Very often the machine is provided with a regulating motion, the intention being to obtain a regular supply of cotton to the beater, and also a regular supply to the opener. By the one we correct the invariably irregular opening of the hopper bale breaker, and the other corrects its invariably irregular delivery.

Speed and Production.—Beater 700 to 800 revs. per min. Production 30,000 to 40,000 lbs. per week.

Setting.—Set the top grid $\frac{3}{8}$ in. to $\frac{7}{16}$ in. from the beater blades and increase this distance gradually so that the last grid is about $\frac{1}{8}$ in. farther away from the beater than the first one. The grid circles or carriers enable this to be done easily.

Pedal nose to beater blades $\frac{1}{4}$ in to $\frac{3}{8}$ in. The shorter the staple the nearer the setting.

Examine the blades of the beater to see that none are bent over too little or too far, so that the full face of the fed cotton receives equal beating or combing.

Set stripping rail to just clear the beater blades. Examine the droppings regularly, as from them a judgment can be formed as to the correctness of the settings.

Dust Trunks.—The small porcupine opener usually feeds an opener by a trunk. This trunk may lead direct to a hopper feeder, or to a vertical opener, or to an exhaust opener.

In the case of feeding direct to a hopper feeder, the cotton falls directly into the hopper, but in the other two cases the trunks may be either direct or designed in straight and curved forms to suit the relative positions of the two connected machines. Indirect paths are frequently chosen for the trunk whereby straight and almost horizontal lengths of trunk can be obtained. In these straight portions, dust-trunk sections are placed. These dust trunks are usually 16 in. wide and 2 ft. deep, and filled with deep plates or grids set fairly close together. A free space above the plates is allowed of about 12 in. deep, along which the cotton is drawn. The lighter impurities are shaken out during the passage of the cotton and fall through the spaces between the plates into a vacant space below, from which it can be easily removed at intervals. A length of dust trunk is divided up into say six compartments or "boxes," and each box will contain from 60 to 80 grids. An examination of each box will show the amount of dust, etc., that has fallen out of the cotton, and if the last box contains dust, etc., it is an indication that more dust trunk would be advisable. So effective has this mere passing of opened cotton along dust trunks been that some firms have two or three sets of these dust trunks installed. Of course the percentage of dust, etc., which falls out is small, but this small quantity (say $\frac{1}{4}$ to $\frac{3}{4}$ per cent) would represent a very large percentage of bad work in subsequent processes if allowed to remain in the cotton. The secret of success is to get rid of all impurities and undesirable matter as early as possible.

Travelling lattices are frequently used in the dust trunk in place of stationary grids. These move in the opposite direction to the cotton and carry the dropped impurities to end receptacles. There is no reason for this added complication when grids can be so effective.

It is imperative that all trunks should be free from any rough places inside, and all bends should be of large radius or curvature. Ten inch dia. trunks are advisable. Trunks should be quite air-tight and connections to machines be well made and rigid.

If the small porcupine opener feeds a vertical opener the feed is a direct one, and the trunk, with its dust boxes, is then coupled to the outlet of the vertical opener and carried to the inlet of an exhaust opener. Cotton cannot be carried along trunks except by air currents, for which reason a hopper feeder must be provided with one or a pair of cages in order to create the necessary currents of air. These cages feed into the hopper feeder, and the Buckley or any other type of opener can then be used and have the advantages of dust trunks.

If a small porcupine opener is coupled to a vertical opener and a series of dust trunks, it may happen that some cottons are used that are dirtier than others. For the dirtier cotton the full series may be required, but for a clean cotton the vertical opener may be considered unnecessary. In such a case, valves are placed in the trunk between the machines so that cotton can be passed from the small porcupine opener to the dust trunks without passing through the vertical opener.

See that the machine is kept clean and lubrication efficient. Blacklead all passages for cotton and file smoothly any sharp projections on bars, blades, etc.

NOTE.—A complete series of drawings to illustrate the remarks in above chapter is given in the author's book, *Cotton Machinery Sketches.*

CHAPTER V

HOPPER FEEDER

Objects.—To open the cotton in a regular manner and to feed it regularly to an opener. A slight cleaning occurs.

Operation.—To comb out portions from a mass of cotton in a hopper space by means of inclined pins set in a travelling lattice. To further comb out the fibres by beating away superfluous cotton carried up by the pins. These two actions are assumed to ensure that the whole of the pins of the lattice in action will be equally charged with fibres. The adhering fibres are then stripped and directed in any convenient way to the opener feed.

Production.—As the machine usually feeds an opener, the production will be adjusted to equal the requirements of the opener. The whole machine can be slowered or quickened. Heavier or lighter feeding by adjustments of the evener roller will alter the production. Speeding up or *vice versa* of the spiked lattice will influence the amount delivered.

Feeding.—The machine can be fed in a variety of ways—by hand, hopper bale breaker, lattice, trunk, or by cages. The mechanical feeding methods are all controlled automatically by means of a hinged or swing door or bars within the hopper space. The door acts on the driving mechanism when an excess or insufficiency of cotton is in the hopper space. The control may be a stop-and-start method by moving a strap fork or a clutch wheel, or it may act through a pair of cone drums which speed up or slower the feeding speed without stopping it.

If the machine forms one of a series, any stoppage must automatically stop the machines that feed the hopper, so careful adjustments of levers and rods are necessary.

Keep the hopper about three-quarters full, and set the stop motion for this amount. A more regular delivery is obtained through a well-filled hopper than with one sparsely filled.

Have the lattices equal in tension and adjust them by the tightening brackets whilst the machine is running. The tendency of the upright lattice to rub against the inside of the framing may be overcome by using flanged bowls on each end of the top lattice shaft.

Evener Roller.—Set this perfectly parallel to the spikes of the lattice. Adjust to about $\frac{3}{8}$ in. for normal feeding, and vary the distance for condition of cotton and amount required for delivery. Coarse setting of the evener roller or evener lattice means increased production and decreased opening, whilst fine setting will have the contrary effects. Carefully observe that the roller is free from entangled cotton, and that no stringy cotton is made by it.

Delivery.—The delivery will be irregular unless the spiked lattice is uniformly charged with cotton. One of the chief functions of the machine is to deliver a regular feed to the opener. Keep the stripping roller in good condition, so that all the cotton is cleared from the spikes of the lattice.

The condensing or fluted delivery roller will regulate the thickness or weight of feed required, so its speed should be altered for this purpose.

The back sheet iron plate can be adjusted until a uniform delivery is obtained. The delivered sheet must not have thick and thin places in it.

Notes.—Keep the trunk or lattice well charged with cotton. See that the spiked feeding lattice of trunk is delivering regularly. Half the length of the spikes should project within the trunk space.

Do not permit any slackness of belts, ropes, or of lattices, especially the spiked lattice. Test occasionally whether the swing door acts in its correct position, and note also if the link motions to other machines act instantaneously. Keep the pins of evener roller clear of clogged cotton, and the pins of the spiked lattice from becoming choked. Straighten bent spikes immediately they are noticed. Replace damaged or broken laths at once. Piece leather of lattices so that the joint does not cause a jolt when running.

Speeds.—Stripping roller, 220 to 250 revs. per min.
Evener roller, 80 to 120 revs. per min.

Cleaning.—Remove all droppings from under spiked lattice and dust box under stripper twice per day. Clean whole machine once per week. Every two months take out working parts and clean up bearings, oil holes, and grooves, etc. Lubricate once per day except high-speed bearings, which should be lubricated twice per day.

NOTE.—A complete series of drawings to illustrate the remarks in above chapter is given in the author's book, *Cotton Machinery Sketches.*

CHAPTER VI

OPENERS AND SCUTCHERS

Small Porcupine Opener.—This has already been dealt with in Chapter IV.

Dust Trunks.—See Chapter IV.

Vertical Opener or Crighton Opener.—This machine was considered at one time an opener for short-stapled cotton only. It is now recognised that it can be used for any cotton, and the more it is used the better and cleaner will be the cotton. It is simply necessary to adapt it as to speeds, settings, etc., for its purpose just as any other machine is adapted for various cottons.

Production.—2500 to 4000 lbs. in ten hours. This production, of course, will be adapted, as a rule, to the production of the machine which it feeds or to which it is attached.

Speeds.—For dirty short cotton 1000 revs. per min. is considered usual, but with well-designed beaters and grid bars this is excessive.

For American cotton 500 revs. per min. is sufficient, and for Egyptian cotton as high as 780 revs. per min. These lower speeds depend upon the cotton having had a fair amount of opening before reaching the machine.

Grid Bars.—More attention is being given to these than formerly. As in all other machines where grid bars are used, the object is to get as many bars as possible consistent with suitably spaced openings between them. The number of bars that are suitable for various cottons are:

208 to 188 bars for short cottons,
168 bars for medium cottons,
148 bars for long cottons.

There appears to be no particular reason for these specific numbers or for their variation for different cottons. For instance, 188 bars are quite effective for Egyptian cotton.

All vertical openers ought to be changed to come up to somewhere near 200 bars.

Settings.—In accordance with the rough class of work for which they have been used, settings have not been possible or thought particularly necessary beyond what the machine maker sets. Anywhere from $\frac{1}{4}$ in. to $\frac{3}{4}$ in. are found. Wear and replacement alter the setting owing to the conical form of the beater. To retain any given setting an adjustable footstep, operated through a bearing lever and screw, is used on many machines. Great care is necessary in using this, and then only when the machine is stopped. The adjusting screw should be locked up after setting, so that there can be no tampering with it.

Footstep Bearing.—Keep well lubricated, and frequently see that the level of oil is maintained. Also keep the water in circulation and note temperature of bearing. Ball bearings are the most suitable form if well designed.

Feeding.—With the extended use of the machine for better cottons, uniformity is essential, and as delivery depends on the rate of feeding, regularity must be striven for in the feeding machine.

Delivery.—The cotton is delivered tangentially from the beater at the top, so there is no guarantee of an equal spreading out of the cotton on to the cages. Special plates in the passage to the cages can be adjusted to cause a fairly good distribution of the cotton, especially if a good fan is used and it acts uniformly over the cage surfaces.

The beater itself acts as a suction fan and shoots out air along its delivery passage together with the cotton, so the cage fan must be in excess of this to be effective. All kinds of carelessness in this direction have resulted in ruined cotton through it remaining in the beater too long, and on the other hand poor cleaning by being rushed through too quickly. No two vertical beaters act the same in drawing the cotton upwards, so this must be considered in judging the opening and cleaning effects of the machine. Stringiness is sure to happen if the cotton is left under the influence of the beater too long. Increase the fan speed to prevent this, and sacrifice cleaning rather than produce stringy cotton.

Notes.—Avoid abrupt bends in feed trunks. Repair dented trunks. See that the trunk and inlet do not get choked. Watch for wear and sinking of the shaft. Have the blades and bars perfectly smooth, so that fibres do not adhere to them. Adjust cylinder shaft by packing pieces if an adjusting screw is not provided.

Near the cotton fields of India and China, the machine is frequently used as a bale breaker, or to follow the bale breaker before a mixing is formed. Such cotton is not pressed cotton, and no exacting results are expected other than some degree of cleaning of a rough-and-ready kind. The same remark applies to its frequent use for low cottons even in this country, as a feeder to an exhaust opener.

Double openers are sometimes used, and in such cases the opened cotton from the first machine passes through the second machine very quickly.

Vertical Opener connected to an Exhaust Opener.—This connection is made by trunks, and dust trunks are used in this length of piping. See that all joints are air-tight. The tight closing of the doors in dust trunks is necessary, otherwise the impurities will be drawn back into the trunk. Regular delivery from the vertical opener is essential, in order to maintain the air current at a constant pressure, and so prevent the cotton rolling along the trunk and over the bars.

Cleaning.—Remove droppings twice at least per day. Clean out whole machine once per week. Remove and clean lattice, cages, rollers, etc., every six weeks, and free all bearings from accumulations of fluff and dirt, and renew the leather strips which exclude the air. Lubricate twice per day.

Exhaust Opener.—This is a clumsy type of opener, and only owes its use to the powerful air currents it creates which enable cotton to be carried along trunks. It is a porcupine cylinder machine containing few blades, which only occupy about one quarter to one third of the width of the machine, so its opening and cleaning capacity can be judged. The whole production of the machine passes through this narrow beater, whereas in other openers the full width of the machine is used in opening and cleaning the same quantity of cotton. This again accounts for the peculiar characters of the droppings which are driven through the bars.

If two fans are used, they can scarcely ever be alike in their action, in drawing the cotton from the beater space, so that an equal delivery from each fan cannot be relied upon.

A further feature of the machine is that the fans and beater are often on the same shaft and run at the same speed. If the beater is not opening and cleaning enough, one cannot run it faster or slower, otherwise the fans draw the cotton through the vertical opener or small porcupine opener too fast or too slow. The advice, therefore, is to run the shaft at the minimum speed that will suck or draw the cotton through the preceding machines at a correct speed. Again, the opening method is exceedingly clumsy. Cotton falls freely on to a crudely formed bladed beater, and receives a blow from the blades. It never gets another blow from the blades, but is simply carried or dragged round, over and over again along the bars, until it manufactures a lot of rolled-up flocks which escape into the droppings. The lighter portion of the cotton (the machine is usually fed with fairly open cotton) is drawn away by the fans, and the cage currents of air force them on to the cages. By adjusting cage fan speed and the plates in the passages, some degree of uniformity of cotton on the cages can be obtained, but it must always be of an unreliable nature.

It is a worrying machine to have in a mill, but as a necessary evil in most cases, it is generally left to take care of itself.

Speeds and Production.—Speed of beater or striker from 1000 to 1250 revs. per min.

The production of Egyptian cotton 500 lbs. per hour.

" " " American " 700 " " "

A beater and lap part are generally attached to the machine, and as several machines are working in series with it and preceding it, every stop for full laps means a stoppage of the preceding machines. These stoppages, and they are frequent, cause gaps in the continuity of the process, and are very noticeable; so the best way is to do away with a full lap stop motion, and run the series of machines continuously. It simply means that laps of all sizes will be taken off and put up at the scutchers. This is not a bad method of ensuring half and full lap feeding of the scutchers, and so preventing "single."

Large Horizontal Opener.—The essential feature of this machine consists of a large porcupine cylinder lying horizontally across the machine. The cylinder is partially surrounded by grids. Two types are in use. One of these strikes the cotton from the pedal nose in an upward direction, whilst the other type strikes the cotton in a downward direction. The two types use a cylinder 41 inches diameter.

Upward-striking Type—Buckley System.—The cotton is fed through a pedal regulating motion at about the level of the shaft centre. The cotton is struck in an upward direction, and, for about a third of the circumference, is carried against projections on the inside of the cylinder cover. This action is equivalent to beating the cotton about in a somewhat limited free space, and opens it out further and allows impurities to fall out. The next third of the circumference is covered with graduated grids set across the machine and divided into compartments, each set of grids thus providing a receptacle for differing qualities of droppings. At a point somewhere near a vertical line through the centre of the shaft, the cotton comes under the influence of the currents of air set up by the cages, and make a rather sudden bend along a passage leading to the cages. This passage is also provided with grids, preferably cross grids, through which further portions of the lighter impurities fall. These grids form an excellent dust trunk system.

Double cylinders are sometimes used.

Speeds and Production.—The cylinder runs at 400 to 500 revs. per min., this speed depending upon the class of cotton and its condition.

A single cylinder machine with scutcher and lap part will produce 400 lbs. per hour of Egyptian cotton. A double cylinder machine will pass 600 lbs. per hour of American cotton.

Feeding.—Cotton is fed by a hopper feeder. A trunk system with dust trunks can be coupled to the hopper feeder, if this latter machine is equipped with a delivery cage to the hopper. This enables the machine to be used as an exhaust opener. The hopper feeder must be kept in good order to ensure a regular feed. The pedal motion will further tend to regularise the feeding to the cylinder. Any noticeable variations of the cone drum strap on the cone drums will be an indication that the hopper feeder is not working well; attention should be paid at once to this indication. Watch the passage of the cotton to the cages. If it is moving in an irregular manner and not covering the cages uniformly, adjust the admission of air by the ventilators provided. These ventilators will be found near the feed rollers and in the passage below the cylinder.

Have the strap in the centre of cone drums for normal feeding, and lock the motion so that no one can tamper with it. If the cylinder is covered with a large number of short teeth or blades correctly bent, so that every part of the full width of the feed is acted upon, the speed of the cylinder can be changed over a wide range to suit weight fed and different cottons. Fan design and speed are important factors to create the necessary currents of air for carrying the cotton away from the cylinder space and along the passage.

Settings.—Set pedal feed roller $\frac{3}{16}$ in. to $\frac{5}{16}$ in. to cylinder blades for American cotton and from $\frac{1}{4}$ in. to $\frac{3}{8}$ in. for Egyptian cotton. These settings are arbitrary and only given as a guide for normal working. They depend not only on the length of fibre, but upon its condition, weight fed, and speed of feed.

The grids may be set so that the first grid clears the beater by $\frac{3}{8}$ in. for American cotton, and the last grid may be $\frac{1}{2}$ in. from the tips. The corresponding settings for Egyptian cotton would be $\frac{7}{16}$ in. for the first grid and $\frac{5}{8}$ in. for the last grid.

The stripper rail is set as near as possible to the cylinder, but not too near to touch if wear of bearings occurs.

Notes.—Use as many grid bars as possible. Prevent the return of dust, etc., by having deep bars and a specially deep one every seven bars or so. Replace bent and broken grid bars at once; this remark applies to cross bars. If the cotton rolls along the surface of the passage grids to cages, air must be admitted to prevent it, and an examination made for leakages of air. On some machines air is admitted freely by opening the cover over the cylinder dust chambers; even doors or their panels are removed. Air currents are a factor that give rise to problems that can only be dealt with on each machine, so that no hard-and-fast lines can be laid down. General notes on the matter will be dealt with at the end of this chapter.

See that the pedal knife rail is perfectly straight, and ensure this by fixing the middle support before replacing the pedals.

Have the pedals working freely, yet close to each other, so that cotton does not get wedged between them, and thus cause them to stick when depressed.

Keep the lattice at a uniform tension by the adjusting brackets. Adjust these brackets whilst the machine is running, to prevent the lattice ends rubbing against the framing; flanged lattice bowls are useful in this direction.

Cages, Fans, and Flues.—These features are common to a number of machines and will be dealt with at the end of this chapter.

Cleaning, etc.—Remove droppings twice per day. The whole machine cleaned out once per week. Take out calender rollers, cages, cage rollers if any, pedal roller, pedals, etc., and pick and clean thoroughly once a month. See that all oil holes and oil passages are clear. Grease lightly the wheels. Empty the dust boxes frequently, say four times a day; this must be done when the machine is stopped. Careful supervision should be exercised in seeing that no accumulations of fibres, dust, etc., remain on cages, cage linings, covers, grids, etc. These should be removed at once, when noticed, without waiting for any periodical cleaning.

Down-striking large Horizontal Opener.—These machines vary as to the amount of grid surface surrounding the beater. Many machines in use have grids for a quarter of the circle only, whilst others obtain a much greater surface up to one-half the circle. The modern tendency is to obtain a large grid surface around the beater in order to improve the cleaning effect. A swan neck bend is more or less necessary as a passage from the beater to the cages.

Double openers are made.

Settings are similar to other openers using porcupine cylinders and grids.

Speed and Production.—For a single machine the cylinder runs at 450 revs. per min. Double cylinder at 500 revs. per min. The production, of course, can be varied, but up to 30,000 lbs. per week can be passed through.

Notes.—The remarks made in respect to the up-stroke machines are applicable to this type.

SCUTCHERS

All openers can have lap parts attached to them. These lap parts or lap ends may be coupled to the cylinder part of the opener, a pair of cages intervening. This arrangement is common for very clean long-stapled cotton. More often an additional beater treats the cotton before it passes to the lap end. This additional beater and lap end is also built as a separate machine, and as such is known as a scutcher.

Functions.—The opening and cleaning of the cotton is never sufficiently satisfactorily performed on the preceding openers, and moreover the fleece of cotton in the lap from the opener, is not regular or of uniform thickness. This further opening and cleaning, and also regularising of the fleece, is done on the scutcher.

Two or more laps are unwound and their fleeces superimposed, and in this condition fed to the beater. This doubling of irregular fleeces tends to neutralise irregularities, and further improvement is effected by the pedal regulating motion. The opening and cleaning of this doubled feed thoroughly mixes the cotton. The resulting lap may be considered ready to take to the card. For some kinds of cotton, usually dirty short cotton, the laps are passed through a second or intermediate scutcher, and even through a third machine, such as a breaker, intermediate and finisher scutcher, before it is judged open and clean enough for the card. In all cases, however, the scutcher is practically the same machine whether attached to an opener, or worked as an independent machine.

Two or three blades are used on the beater.

Speeds and Production.—Usual diameter of beater is 18 inches.

Speed of beater ranges from 900 to 1250 revs. per min. as follows:

Beater.	Cotton.		
	Indian.	American.	Egyptian.
2 blades .	1250 revs.	1150 revs.	1000 revs.
3 blades .	1000 ,,	950 ,,	900 ,,

As a rule a two-bladed beater is used for American and Indian, and a three-bladed beater for Egyptian and other long-stapled cottons.

The production of the machine can be varied over a wide range. The usual range is from 12,000 to 20,000 lbs. per week.

Feeding.—Sometimes fed direct from a hopper feeder. Generally fed by laps made at the opener. Four laps fed together are usual. Arrange to feed the four laps so that they are in different sizes on the lattice. Avoid bad piecings, and renew lap before a run-off lap has passed beneath the next lap. See that the lattice runs freely between the framing. Adjust lattice brackets to effect this. Flanged bowls on feed end of the lattice will maintain it.

See that the lap ends do not rub against the lattice framing. Adjust the cone drum strap in the centre for feeding, and lock the adjustment so that no one can tamper with it.

Remember that the pedal regulating motion does not regulate in the width of the lap, but only in length or weight.

Settings.—Much depends upon judgment and state of the cotton, so only a general idea can be given.

Pedal nose to beater $\frac{3}{16}''$ to $\frac{1}{4}''$ for Indian cottons.
Pedal nose to beater $\frac{5}{16}''$ to $\frac{3}{8}''$ for American cottons.
Pedal nose to beater up to $\frac{7}{16}''$ for Egyptian, etc., cottons.

Beater bars are set as follows from beater :

Cotton.	Distance of first Bar.	Distance of last Bar.
Indian, American . .	$\frac{5}{16}''$ to $\frac{3}{8}''$	$\frac{3}{8}''$ to $\frac{7}{16}''$
Egyptian . .	$\frac{3}{8}''$ to $\frac{7}{16}''$	$\frac{1}{2}''$ to $\frac{9}{16}''$

Stripping rail a full $\frac{1}{16}$ in. from beater. This rail, as a rule, is not adjustable.

Avoid stringing the cotton or forming tails. Plucking is a necessary evil in both the two- and three-bladed beater, so the previous opening must be well done to minimise the passing of lumps or large tufts.

Note that the cotton from the feed roller or pedal nose receives as high as 60 blows per inch from the beater.

$$\frac{\text{Revs. of beater} \times \text{No. of blades}}{\text{length}'' \text{ del. by feed roller per. min.}} = \text{blows per inch del.}$$

Adjust the pressure of pedal on roller by the weight on lever; too much pressure is better than too light a grip.

Grid Bars.—As many as possible consistent with a free falling space between them. The first few to be at an angle of 45° and one side of the angle set tangent to the beater path. The rest are not of importance, but a great advantage will accrue if the top edge is undercut so as to give a wider space between the bars at their lower ends. The recess thus formed in the bars will break up the currents of air and prevent a great part of the dust, etc., re-entering. An electric light placed under the bars of any scutcher or opener will show streams of dust passing in and out of the dust grids. If bars have some form of projection, or are recessed out, this movement of the dust will be minimised. One or two deep bars in the series will add to their effectiveness. Dust bars ought not to be considered as opening organs, but as cleaning organs, by allowing the dust, etc., from the already open and shaken cotton to fall away and remain away.

The first bars only receive the effect of the blow given to the cotton, and it is through these bars, mainly, that the heavier impurities are driven.

The grid leading to the cages ought, on all reasonable grounds, to be transverse and not longitudinal. The passage is simply a dust trunk, and longitudinal bars are only adopted, because it is the easiest way to prevent the evil of rolling cotton. If cotton is opened properly, cages designed correctly for position and the air currents regulated, there would be no rolling of the cotton on the cross bars.

A deep bar every seven bars is a great improvement.

Delivery.—Maintain a regular distribution of cotton on the cages. Expose only a small portion of the bottom cage, so as to get the cotton well up in the space, and prevent rolling along the dust bars.

Keep the fan and air passages clear of fluff and dirt. Run the fan at the minimum speed that will cause the cotton to be deposited gently on the surface of the cages, and not dash on to them. Completely seal the lap end from admission of air. Keep the air excluders round the cages a perfect fit. Examine the leather flaps or strips on dividing plates, and replace if not effective in preventing air currents.

Dampers are a great source of trouble in causing accumulations of fly and dirt in the cages. They are unnecessary if air is carefully excluded around the backs and ends of the cages.

See that the lap racks work freely. Apply a light breaking action at first, and gradually move the weight on lever away from the fulcrum, until a suitably sized lap is obtained. Too soft a lap is likely to be easily damaged, whilst too hard a lap may stick badly in unrolling; the reverse of this may happen, so judgment is necessary.

See that both racks are correctly geared to the rack wheels, and that the pressure on each end of the lap is equal, otherwise conical laps will be formed.

See that the calender rollers are equally weighted on each side, and that the weight is screwed on the lever to prevent its displacement. Prevention of conical laps may be effected by adjustments of the calender weighting, but such a method is more or less of a dodge, to save the trouble of finding out the real cause.

Weight and Hank of Laps.—The table on following page gives the usual range of laps for different purposes. It may be pointed out, however, that it is purely tradition to think a certain hank lap from the scutcher is necessary for any given counts. One can use, say, a 12 oz. lap for 16's to 120's. It simply means adapting subsequent machines to suit hank slivers and rovings.

Altering Weight of Lap.—To obtain a heavier lap, *i.e.* heavier weight per yard:

(*a*) Feed a heavier opener lap.

(*b*) Increase the speed of the feed roller by changing the speed of the side shaft.

(*c*) Increase the speed of the feed roller by changing the speed of the bottom cone drum by the bottom cone drum gear.

To obtain a lighter lap :

(*a*) Feed lighter laps to the scutcher.

(*b*) Decrease the speed of the side shaft.

(*c*) Decrease the speed of bottom cone drum by the bottom cone drum gear.

Ounces per yard.	Grains per yard.	Hank of Lap.	Suitable for Spinning.
10	4375	·00190	80's upwards
$10\frac{1}{2}$	4594	·00180	
11	4813	·00173	60's to 70's
$11\frac{1}{2}$	5031	·00165	
12	5250	·00158	36's to 50's
$12\frac{1}{2}$	5469	·00152	
13	5687	·00146	24's to 32's
$13\frac{1}{2}$	5906	·00140	
14	6125	·00136	16's to 20's
$14\frac{1}{2}$	6344	·00131	
15	6562	·00127	8's to 14's
$15\frac{1}{2}$	6781	·00123	
16	7000	·00119	below 8's

Rule for hank of lap:

$$\frac{16 \text{ oz.}}{840 \text{ yds.} \times \text{ozs. per yd. of lap}} = \text{hank of lap.}$$

EXAMPLE :

$$\frac{16 \text{ oz.}}{840 \times 10 \text{ oz.}} = \cdot 0019 \text{ hank,}$$

or

$$\frac{7000 \text{ grains}}{840 \text{ yds.} \times \text{grains per yd.}} = \text{hank of lap.}$$

EXAMPLE :

$$\frac{7000}{840 \times 4375 \text{ grs.}} = \cdot 0019 \text{ hank.}$$

To alter Length of Lap.—Change the wheel on the measuring motion or stop motion at lap end. Hunter cog wheel, worm wheel, or a ratchet motion are the usual form of measuring for the full lap stop motions.

Variations in Total Weight of the Laps.—It is as well to exercise strict supervision on this point and the weight of every lap recorded. A limit of variation is frequently fixed, and laps under or over this limit are placed aside. This limit extends to $\frac{1}{4}$ lb over or under a fixed total weight, say 30 lbs., but it is advisable to fix this limit as low as possible to prevent carelessness of the tenter.

It must always be remembered that the total weight of a lap has nothing whatever to do with the opening and clearing action of the machine. It is simply a convenient method of noting if the regulating mechanism is acting correctly. Laps can be taken off at any stage of their formation. If laps are too heavy, they are likely to be easily damaged in carrying them to the cards.

Laps should be closely examined frequently to see if thick and thin places are prominent. Yard or two-yard lengths should be frequently weighed to see if the machine or its feed is correct for hank or weight.

Faulty Laps.—Keep speed of fan as low as possible; a gentle flowing of the cotton and no dwelling on the grate bars will indicate the correct speed. This adjustment of fan speed will give good selvedges and frequently stops licking. Use very little of the lower cage to prevent licking. A very strong draught and the two cages well covered with cotton, always tends to cause licking or split laps, which form a species of double fleece. Uniform pressure and freedom of movement of the lap racks and brake gear, will prevent conical or tapered laps. Conical laps may be caused by parts of the cages being choked with dirt. The pedals may be sticking at one side of the machine, or air currents are entering on one side of the dust-box door. Irregularly bent blades in the opener may result in conical laps.

Since the finished lap is the feature usually judged as to the working of the machine, it happens that most authorities wait for faulty laps to turn up before attending to various factors in the machine. This is the wrong method to adopt. Faulty laps are, in a sense, always with us. They have bad selvedges, thick and thin places, lumpy and well-opened cotton combined, dirty laps, unequal weights per yard and per lap, stringy cotton in the lap, sticky laps, split laps, etc. Every fault in a lap may be due to various causes in the openers and scutchers, but they are all more or less due to inattention to the requirements of the machine. For instance, the following factors ought to be frequently supervised or remedied at once. Blunt blades; worn bearings; cone-drum bearings wearing; pedals choking; pedals not pressing enough on roller; badly set pedal knife rail; slippage of belts on fan, cone drums, lap end pulleys, etc.; lattice sticking or slipping over its bowls; badly pieced belts; backlash in movement of the cone belt through having the strap guide too wide; back pressure in flues; accumulation of fluff and dirt in fan-box and flues; too small a capacity of dust chamber for the number of fans; dirty pedal bowls or links; insufficient lubrication; too slow or too fast a fan speed; sharp bends in flues; sometimes a fan will be designed so as to work one way only, and it may be revolving the wrong way; dirty or partially blocked up cages; accumulations of fluff on cage ends; accumulations of fluff inside of cages; broken teeth on wheels; very often bad opener laps; accumulations of impurities on grate bars, especially near the frame sides; sometimes the stripping rail will accumulate bunches of cotton; making up blocks for width of lap being wrongly set or not of the correct thickness; rough places in the machine over which the cotton passes; badly mixed cotton of different degrees of openness; soft waste not thoroughly mixed with the cotton; oil getting on inside of framing, etc.; irregularity of the air currents to the cages; bad settings; excessive speed of beater; beater too slow if a heavy feed is going through; too heavy a feed. No good purpose is served in trying to obtain a maximum production by changing the beater end pulley through which the whole machine can be speeded up for increased production.

Cleaning.—Empty the dust-boxes at least four times per day. All droppings to be cleared away at least twice per day. The whole machine to be cleaned out once per week. Remove pedals, rollers, and cages, and clean out all bearings, oil-holes, and interior of the machine every month. If accumulations of fluff, etc., are noted on any part of the machine, clear off at once. Have all gears, revolving shafts, straps, covers, and any dangerous parts protected and made fool-proof.

No covers to be opened whilst machine is running.

Use some form of tucker-in for starting a lap.

Use a smooth board (heavy wood) to smooth surface of lap as it forms, and don't pat down the surface of the lap by hand. Don't produce too heavy a lap, it is apt to be damaged in lifting and carrying it to the cards.

Flues.—All fans used on openers and scutchers are suction fans. They draw air through their centres and send it out on their periphery. They draw air from a wide area, and send it out through trunks or channels (flues), to some common centre chamber. If these flues are inadequate to deal with the volume of air from the fans, eddies and back pressures are set up which interfere with the fans' efficiency. Flues should be isolated from each other as far as possible, and frequently inspected and cleared of accumulations; they are apt to become blocked with fluff. Sharp bends in flues should be avoided, also sharp or rough corners or surfaces. An area of at least ten square feet in the dust chamber should be allotted to fan, a minimum of 10 feet high.

A dust tower rising to the top of the mill will create a strong draught to carry off the dust, but a fan at the foot of it is an advantage.

In old mills, with badly arranged flues, considerable difficulty is experienced in the fan action. Changes of temperature or of the direction of the wind, or opening doors or windows or stopping or starting up other machines, will make notable differences in the strength of the currents of air, and produce irregularities in the clearing process and in the laps. These give rise to problems that can only be solved on the spot, if solvable at all. The real remedy is to lay trunks or new flues, a separate one to each machine or each fan, and all to open out into a large enough chamber.

In most modern mills there is a room below the blowing-room and perfect freedom in moving about is provided.

Draft in Openers and Scutchers.—The total draft is made up of several small drafts distributed from the feed roller to the lap roller. The only method of changing the draft is by altering the speed of the feed roller. All the other drafts remain unaltered. The lap rollers are usually run at a fixed speed, but can be changed in speed by changing the pulleys through which the lap end is driven. This is very seldom done.

By noting the gearing from beater to lap rollers, and from lap end to feed rollers, we obtain the surface speed of feed roller and of lap rollers, so that by dividing the surface speed of lap roller by the surface speed of feed roller we get the draft of the machine. Slippage of belts and ropes must be allowed for in the calculation. New belts will have less slip than old and slack belts. Also allow for waste made in the machine. The rollers move slowly and their revolutions can be counted, so it is much easier to obtain the draft as follows:

$$\frac{\text{r.p.m. of lap roller} \times \text{dia.}}{\text{r.p.m. of feed roller} \times \text{dia.}} = \text{draft of scutcher.}$$

Percentage of Waste.—Frequently found by simply gathering up the waste and weighing it, and so obtaining the percentage by noting the amount fed.

For exactness it is much better to mark out, say, two yards on the lattice framing, and whilst the machine is running normally, make a mark on the unrolling doubled fleece on the lattice. Do the same on the finished lap, and when two yards have covered the marks on the lattice framing, cut off the delivered length from the calender rollers and weigh. The difference between the two yards of the, say, four opener laps, and the, say, 16 yards of delivered fleece at the lap end, will give at once the loss. It will not be all waste that can be gathered up. Some of the waste has gone in dust and fly, through the cages, and some of the loss will be moisture that has evaporated in passing through the machine. These two losses are often spoken of as the invisible loss.

Porcupine Cylinder in Scutcher.—There is a growing appreciation of this type of beater as a substitute for the two- or three-bladed beater. Its success depends largely upon the number of blades and their disposition. Terrific blows are not necessary, and as every particle of cotton, the full width of the machine, should be acted upon, one or more times in a revolution of the beater, a maximum number of blades is advisable. If the blades are also very short, so much the better. High speed is also not essential. A combing action is really what is desirable, with just sufficient force to gently knock the larger impurities through the first bars.

Cone Drums.—After ascertaining the average of the opener lap by unrolling one, and cutting out yard or two-yard lengths at intervals, and doing the same with the scutcher lap, arrange that the strap of cone drums occupies the dead centre of the cones. If four laps are used on the scutcher, and the regulator motion is working all right, the scutcher will give the same lap if only three opener laps are put up.

Trouble through wear of the cone drums bearing, especially the one driving the feed roller, is sometimes experienced. This indicates a new bearing at once or the heat developed may become dangerous. The worn drive produces a great pressure on the bearings, and if a cone drum drops through wear, the lower end of the cone drum will rub on the bracket.

Reasonably tight belts should be used to avoid slipping. Slippage of this belt will destroy all attempts to get a regular lap.

General Remarks on Blowing-room Machinery.—Wet cotton or cotton with a general high percentage of moisture is difficult to open and clean. It will not separate easily and the impurities adhere to the fibres. This leads many mill authorities to the erroneous conclusions that cotton requires a lot of beating to open and clean it, and to do this they pass it through several beating machines, to the detriment of the cotton. This repeated beating is not really necessary, for the efficacy of the beating lies in the fact that the cotton is drying all the time it is passing through the various machines. In other words, some machines in blowing-rooms are practically drying machines, and it is no cause for surprise that frequently the finishing scutcher is considered to be an opener and cleaner "par excellence."

Dry cotton, on the other hand, is much more easily opened and cleaned, but if too dry it cannot be calendered so well, and consequently sticky laps are the result, not to mention that static electricity aids this effect in very dry cotton.

A due medium must be observed between the two extremes and it is as well to keep within the standard of moisture permitted.

When cotton has excessive moisture, it is advisable to have it made up in thin mixings in a dry room before using, so that it can part with some of the water, whilst very dry cotton may be treated the same way but in a damp room. "Not worth the trouble," many will say, but nevertheless it is an indication of good management to do so, and it has great economical advantages in several directions which are obvious.

Another method of conditioning the raw cotton, is to open it thoroughly before it is subjected to any beating process, and to keep the blowing-room at a constant humidity. The cotton can then become, as it were, standardised in moisture, and be passed direct from bale to opener or scutcher without forming a mixing.

When a mixing is being made for a stack or direct feeding to openers, a definite instruction should be given that all wet blocks of cotton should be put aside, and not passed through the bale breaker until they have dried out.

A careful and frequent examination of the droppings from openers and scutchers should be made. Only the very shortest of fibres ought to be tolerated in the droppings.

If flocky droppings are found, it is a sure indication that the flocks have been made by the machine, for they do not exist in that form in the raw cotton. Such flocky droppings invariably contain a quantity of good fibres, as may be readily seen on opening them out. If droppings contain these peculiar flocks, it is evidence that many more have been made, which have not been ejected through the grids, and so pass on to the card, and neps then become a common complaint in the card room. Don't blame cotton until previous processes or machines have been investigated.

It is quite common when yarn, rovings, slivers, etc., are not quite satisfactory, to mix a higher-priced cotton to bring the result up to a satisfactory standard. If it is known that a given cotton or mixing will produce a given yarn, and it does not do so, then some machine or process is at fault, and this fault should be found out and remedied. It is a luxurious method to shove in some better cotton to improve matters, and to do so, undoubtedly indicates bad management.

Exact records of all speeds, beaters, and fans should be kept, as well as the cotton and the weight of feed and delivery per yard associated with the speeds. A waste record is also recommended for each cotton used.

Keep all blades in a smooth state, and the two- or three-bladed beater reversed when the blades become worn, dull, or dented. Have the blades re-planed when both edges require it.

Carelessness in cleanliness must be checked at once.

Get the very best results out of each machine, and do not permit carelessness in the attention given to any machine, simply because the next machine may improve matters.

Above all, forget that a card will clean cotton, and so try and send a perfectly clean lap into the card room. A dirty card room means a bad blowing-room and bad supervision.

Note.—A complete series of drawings to illustrate the remarks in above chapter is given in the author's book, *Cotton Machinery Sketches.*

CHAPTER VII

CARDING

Functions.—To open and (unfortunately) clean the cotton. To reduce a thick fleece of cotton to a filmy fleece, and to gather this film or web of cotton into a rope form called a sliver. Incidentally also to mix and double the cotton.

Opening.—Performed (*a*) by a saw-covered roller combing the cotton from the nip of a roller and dish plate; (*b*) by passing the cotton between two layers or sets of teeth, one lot of teeth moving faster than the other. This action practically separates the mass of fibres into their individual fibres.

Cleaning of the Cotton.—Mainly by the effectiveness of the opening action allowing the impurities to fall out, or become embedded in the wire or adhere to the points. Stripping clears the flats, whilst the embedded impurities on the cylinder and doffer are sucked out by a vacuum process or brushed out by wire brushes.

The Web is formed by depositing the individual fibres on a slowly revolving wire-covered doffer as a film, from which it is stripped by a comb.

The Sliver is formed by gathering the thin filmy web together, and passing it through a trumpet from which it emerges as a rope or sliver.

The web is an excellent feature for examination, as to the efficiency of the opening and cleaning action of the card.

Mixing.—The web, stripped from the doffer, in passing to the trumpet does not move uniformly, so that the sides of the web are mixed with the intermediate parts, and a very thorough mixing of the fibres takes place.

Doubling.—Up to the point where the comb strips off the doffer web no doubling can occur in the card, so the web is a replica, more or less, of the scutcher lap unevenness, but owing to the folding over of the web, and the different positions that the fibres take up in passing to the funnel, an exceedingly good doubling effect is produced. Even without taking into account the different movements of the parts of the web, the mere fact of rolling the web up into a sliver is a doubling action, as well as a mixing one.

Speeds and Productions.—The production of a card is usually calculated from the hank sliver produced, and the revolutions or the surface speed of the doffer. A standard size of the doffer is $24\frac{3}{4}$ inches measured over the wire. Doffers 26 inches diameter are very common.

The table of productions on following page for various hank slivers and revolutions of doffer covers a wide range of counts.

The usual limits of productions are sometimes stated as follows:

Indian and short-stapled cotton .	150 to 200 lbs. per 10 hours.
American and similar cotton . .	100 ,, 180 ,, ,,
Egyptian cotton	40 ,, 110 ,, ,,
Sea Islands cotton	25 ,, 55 ,, ,,

Production of Card per Continuous Working Ten Hours, Waste allowed but no Allowance for Stoppages

Grains per yard.	Grains per 5 yards.	Hank Sliver.	Revolution of 24¾" Doffer per minute.												
			8.	9.	10.	11.	12.	13.	14.	15.	16.	16½.	17.	17½.	18.
			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
69·4	347	.120	103	115	128	142	154	167	180	193	206	215	218	225	233
66·6	333	·125	99	111	124	136	148	160	173	185	198	206	210	218	224
64·1	320	·130	95	106	119	131	142	154	166	178	190	198	201	208	215
61·7	308	·135	91	103	114	126	137	148	160	171	182	191	192	200	207
59·5	297	·140	88	99	110	121	132	143	154	165	176	184	187	193	200
57·4	287	·145	85	96	106	117	127	138	149	159	170	178	181	186	193
55·5	278	·150	82	93	103	113	123	134	144	154	165	172	175	180	187
53·7	268	·155	80	89	100	109	119	129	139	149	159	164	169	174	181
52·8	260	·160	77	86	96	106	116	125	135	144	154	161	164	169	175
49	245	·170	72	82	91	100	109	118	127	136	145	152	154	159	164
46·2	231	·180	68	77	86	94	103	112	120	128	137	143	145	150	155
41·5	207·5	·200	62	69	77	85	93	100	108	116	124	127	131	137	139
37·9	189·5	·220	56	63	70	77	84	91	98	101	112	115	120	122	126
33·2	166	·250	50	56	62	68	74	81	87	93	99	102	105	108	111
Production in hanks.			12·34	13·88	15·4	16 96	18·5	20·05	21·6	23·13	24·67	25·8	26·21	26·98	27·96

Waste and stoppages in a 48-hour week are uncertain factors, and each mill must find out its own average percentage to allow for these factors. If a calculation is made from cylinder shaft through the gearing to, say, coiler, slippage of belts must also be taken into account.

The following method of obtaining production may be used:

Find speed of doffer per min. Find the circumference in inches, multiply circumference by revs. and divide by 36 for yards. Multiply this result by grains per yd. of sliver and divide the product by 7000 grains for lbs. per min. actual working time. Deduct percentage of time for stoppages only.

$$\frac{\text{Revs. of doffer per min.} \times \text{dia.}'' \times 22 \times \text{grains of sliver per yd.}}{7000 \times 7 \times 36''} = \text{prod. per min. in lbs.}$$

Or weigh an empty sliver can. Run in sliver for two or three minutes and again weigh. Subtract the two weights and thus obtain the weight of the sliver. Production per min., hour, etc., will be given at once. Deduct stoppages.

If the production of any card is once obtained, and speed of doffer and hank of sliver noted, it is easy to find the production for any speed of doffer and hank sliver.

Suppose 206 lbs. is the production of a card in 10 hours producing a ·120 hank sliver, and having 16 revs. of doffer per min., then

$$\frac{206 \text{ lbs.} \times \text{new speed of doffer} \times \text{old hank}}{\text{old speed of doffer} \times \text{new hank}} = \text{production per min. of new speed and hank.}$$

EXAMPLE:

$$\frac{206 \text{ lbs.} \times 10 \text{ revs.} \times \cdot 120 \text{ old hank}}{16 \text{ revs.} \times \cdot 140 \text{ new hank}} = 111 \text{ lbs. in 10 hours.}$$

Any one with an elementary knowledge of algebra can substitute, in the above rule, and find the revs. of doffer, or the hank sliver required to give a certain production. For partially combed cotton, the card can be run to give a maximum production and less waste taken out.

Suitable Hank Sliver for Counts.—It is usual to state and probably useful to know what hank sliver to produce from the card for certain counts.

India cotton . . .	up to 20's	counts 70	grains per yard.
American cotton . .	,, 40's	,, 60	,, ,,
American cotton . .	,, 80	,, 55	,, ,,
Egyptian cotton . .	,, 120	,, 50	,, ,,
Sea Islands cotton .	above 100	,, 35	,, ,,

It must be pointed out that these are arbitrary figures, and though fixed, in some modification, in the minds of mill authorities, they must not be looked upon as settled factors in cotton spinning in any mill. Machinists, in designing or planning machinery, must of necessity fix on some definite figures of hank produced in order to balance the output; but productions, speeds, drafts, doubling, etc., are all in the hands of the mill authorities, and it is obvious that one can manipulate these factors in a variety of ways for economy in labour, machines, room occupied, and general supervision, without detriment to the yarn or full production. Some mills doing a wide range of counts from 20's to 120's will have the cards producing a 36-grain sliver for the whole range.

Production is usually changed by altering the barrow wheel through which the whole machine is driven from the cylinder. Of course the same thing will occur if the cylinder is run faster or slower, but this important change place is generally overlooked, but it is as well to consider it, and find out whether the machinists have given you the best speed of cylinder. Greatly improved results and great economics can be produced, if this factor is intelligently considered, and especially with reduced working hours.

The side shaft bevel driving the feed roller, if changed, will alter the draft and of course the production.

Speeds.—Cylinder 50-in. diameter.

Indian cotton . . .	180 revs. per min.
American cotton . .	170 „ „
Egyptian cotton . .	160 „ „
Sea Islands cotton . .	150 „ „

There is no cast-iron rule about these speeds and they vary widely; tradition has had a lot to do with fixing them.

Taker-in.—$9\frac{1}{2}$-in. diameter over teeth.

Indian and American cotton .	420 revs. per min.
Egyptian cotton . . .	360 „ „
Sea Islands cotton . . .	300 „ „

Wire Clothing.—The wire is designated by counts and indicates the number of wire points in a given area. The following table states the usual practice in counts.

Organ.	Counts of Wire.						
	Indian Cotton.		Brazilian.	American.	Egyptian.		Sea Islands.
	Low.	Good.			Ord.	Super.	
Cylinder .	80's	90's	90's	100's	110's	120's	130's
Doffer .	90's	100's	100's	110's	120's	130's	140's
Flats .	90's	100's	100's	110's	120's	130's	130's

If the "counts" of the wire is multiplied by five we obtain the number of points of wire per sq. inch. The piece of wire is bent and inserted from the back of the clothing, and such a wire will have two points, which is known as a "crown."

Character of the Wire.—A wide variation exists in this feature of the card. Some wire will wear away quickly, whilst other wire will last as long as fifteen years in a reasonable working condition. Some wire will grind up the tips into very exaggerated hooks, and even heat up sufficiently to practically flow into large hooked ends. Others will have the necessary fine hook, and maintain this condition for long periods before requiring regrinding. Again, some wire will be so tempered as to snap easily, and other will be so soft as to have very little elasticity. A good strong foundation is necessary that will not lose its holding power on the wire. The wire and the foundation must be in perfect harmony. As wire is a manufactured article, requiring the highest skill and judgment in its preparation and choice of the steel, it is not possible to indicate, in terms, what wire to choose, or even the angular shape the wire must have. Samples ought to be closely examined, and only firms with a high repute ought to be trusted with the supply.

Flats.—The usual number of flats is 106 to 110. 40 to 42 of these are working flats. Width of flat usually $1\frac{3}{8}$ inches. Keep flat ends perfectly clean and don't allow any bits of waste to harden on their sliding surfaces or on the flexible. Have the flats running off the flexible on to the bowls without any tipping. Take up any slackness in the flat chain immediately any signs are noticed of the flats coming off or on the flexible in a tipped manner. See that flat studs are secure. Set flat stripping comb perfectly parallel to flat, so that clean flats go round to the back. See that no fluff and dirt from overhead pipes, shafts, or projections on ceiling, fall on to the flats. See that every flat bears equally on the flexible. Tipped-up flats on the flexible may be due to fluff or dirt wedged beween flat and chain.

Carding takes place between the flats owing to the opposite inclination of the wires. The direction in which the flats are travelling has little to do with the effectiveness of this carding action, and it is a convenience to mould the flats as we do.

Speed of Flats.—Various. Usually $2\frac{1}{2}$ inches per min. on a 50-in. cyl. running at 160 revs. per min. Modern practice is 5 inches per min. and flat waste, or strips regulated by changing speed of flats through the pulley.

Flats will work badly if every flat is not ground true; all flat wire should be of equal length.

Clothing Cylinder, etc.—This is a job done by the card clothing people, who send men especially trained for the work and who use appliances suitable for the purpose. In some mills the cards are clothed or re-clothed by the carder and under carders.

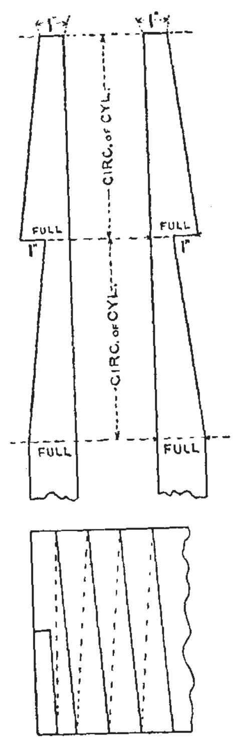


Fig. 4.

Let the filleting stand exposed to the atmospheric conditions of the card room for several days before using it. The fillet is shorter when damp than when dry. If put on the cylinder when damp it will dry out and become longer, and so probably buckle or develop blisters. Cover the metal surface of the cylinder with coats of white paint evenly put on. See that all wooden plugs are perfectly level with surface of cylinder and all plugs firmly fixed in. Use suitably hard wood and perfectly dry replaced plugs.

To cut out the starting and finishing ends of the fillet requires experience, and there are a variety of ways of doing this. One method is shown in Fig. 4. It is good practice to use, say, a 6-in. cylinder of wood and cut out strips of paper for trying the different methods.

Some men can use a bar of iron effectively in obtaining the necessary tension, but it is not advisable. A machine is much better in uniformity of tension (300 lbs. tension is usual) and in laying the spirals regularly and in close contact, without overlapping.

When to re-cloth a Card.—Variable periods are adopted. Some mills wait until clothing is useless, many have to do so, but long before wire is ground down to a practically useless length, the carding action has been deteriorating. Nine to eleven years is sufficient time to allow a card to work without re-clothing it. In a completely new mill this would mean a new set of card clothing in 10 years, so to avoid this it is usual to do it gradually by doing, say, two cards a week in a mill with 100 cards, or the operation could be spread over two years. In older mills the method works out in such a way that a card is being re-clothed at the rate of one or two a week or month as a matter of routine. One or two firms are now making wire clothing, which is claimed to last four to five years longer than normal. Careful notes should be kept of every card in the mill, when re-clothed, character of wire, etc.

Settings.—There is no fixed rule for the degree of settings in any part of the card and everybody has his own ideas on the subject. Conditions are various: Make of card; speeds; amount fed; state of the wire; state of the bearings; condition of the cotton; idiosyncrasy of the carder or manager; condition of the gauges used, etc.

Gauges are usually numbered as No. 7, etc., and these numbers mean that the gauge is 7 thousandths of an inch thick $= \frac{7}{1000}$. A standard set of gauges should be kept in the office, for occasional use only, in testing the everyday working gauges. The ordinary gauges, of necessity, wear through constant use, and whilst a carder will have a fixed idea that a 7's gauge is absolutely necessary for setting flats, it is no uncommon thing to find he is using a worn gauge that is only a No. 3 or 4. On the other hand, gauges become bent, slightly distorted, and in such cases the No. 7 gauge will be setting really to a No. 10 or even more. Discard all imperfect and worn gauges immediately they vary from the standard gauges. The following settings are only given as a guide.

Dish plate to taker-in .	No. 10	gauge	$= \frac{10}{1000}''$
Mote knife to taker-in .	No. 10	,,	$= \frac{10}{1000}''$
Taker-in to cylinder .	No. 7	,,	$= \frac{7}{1000}''$
Flats to cylinder .	No. 8	,,	$= \frac{8}{1000}''$
Doffer to cylinder .	No. 9	,,	$= \frac{9}{1000}''$
Doffer comb to doffer .	No. 20	,,	$= \frac{20}{1000}''$
Stripping comb to flats .	No 15	,,	$= \frac{15}{1000}''$
Taker-in grid to taker-in .	No. 10	,,	$= \frac{10}{1000}''$

NOTE.—Owing to the thinness of the doffer comb and the high speed at which it works, the comb invariably bends, and this vibrating buckling renders a close setting impossible.

These settings cover much of the American and Egyptian cotton. In some mills the flats are set a little farther away at the taker-in end than at the doffer end. The under-casings to taker-in are also sometimes set nearer at the mote knives than near the cylinder. Cylinder covers are usually fixed at about No. 30, but both back and front plates are adjustable. These plates are used for fixing the amount of flat strips, especially the front plate, and in most mills it is only at this point that the waste is varied. Of course, it is the wrong place to do it, but it is easy and requires no particular thought. Altering the speed of flats is a better method.

Setting by ear was, and in some cases is, yet the method adopted, just as grinding is done by ear. It is unreliable, inasmuch as it depends on human faculties that are very unreliable, and no two people are equal in respect to them.

Settings are usually done whilst the machine is stopped; most of them can only be done then. This, combined with the fact that all the settings are very fine in dimensions, will cause one to recognise that the slightest irregularity of movement in the organs set will destroy the exactness of the settings. For instance, a worn bearing, or the slightest eccentricity, will destroy some of the settings. Wide cards, unless flats and other parts are strengthened, are difficult to set accurately owing to deflection. Many people prefer, say, a 36-in. to a 45-in. for this reason.

Re-setting is often neglected; it ought to be done every month or so, in some organised manner, without waiting until the web shows that something ought to be done.

Front Plate.—As noted above, the front plate is the usual adjusting place for the increase or decrease of the flat strips. It is an adjustment that requires some degree of judgment, and in any case it is never a satisfactory one. In the first place it must be noted that, practically, carding has been completed by the time the cotton has reached the front plate, so that it is a serious question as to where the increase of strips comes from, or where the decrease of strips goes to. The matter is one deserving of a few words.

A wide divergence of settings is adopted, and scarcely two mills set alike. This is partly accounted for by the adjustment of the front flat bracket, which carries the driving of the flats. In most cards this bracket is so fixed that the last flat or two are slightly raised from, or tipped up on, the flexible as the flats pass on to the bowl. It is whilst the flats are working in this manner, that the bulk of settings of the front plates are made. As the last two flats may be raised from the flexible to varying degrees, it follows that the setting of the front plate can be varied as regards its distance from the flats, and this can be done without touching the front plate. A difference of setting often occurs, if the gauge is used when the strap is off the flat-driving pulley. In most cards, the mere fact of putting on the belt will alter the setting, and it may be taken for granted that in very few cases is the setting what it is considered to be. If the flats are set to a 5's gauge to the cylinder, and so that they come off the flexible perfectly true, and the front plate is set to a 22's gauge to the flat wire, the plate will be about a 12's gauge from the cylinder wire. Under these conditions there will be no strips at all on the flats. This happens with a 12-oz. lap and a 37-grain sliver, Egyptian cotton, 160 revs. of cylinder and flats $2\frac{1}{4}$ inches per minute. Moreover, it is highly probable that if a flat is taken off, say, over the middle of the cylinder (or at any other place) of any card, it will be found to be quite free from cotton or waste. This leads to the conclusion that the flats do not extract waste, they simply assist in opening and disentangling the cotton. Owing to this very effective disentangling process, the dust, fine particles of impurities, and very short fibres become free and fall between the wires of the cylinder, and to a very small extent may be driven between the wires on the flats. The flat strips represent a purely accidental occurrence, and, strictly speaking, ought not to be there at all.

Two reasons for the flat strips and their usual dirty appearance may be noted. The general unevenness of the lap from the scutcher, provides a surplus of fibres on the cylinder wire, and in their criss-cross condition many of them are not held by the wire points. The pressure of air set up by the revolving cylinder, will cause these free fibres to fly off, on to the outlet at the front plate, and are caught by the wire on the flats nearest to the plate. The dust, etc., is also plentiful, and this escapes at the same time, and is partly deposited on the escaped fibres, and gives them their dirty appearance. With perfectly regular laps and an opening process in the blowing-room, that frees the cotton from dust, etc., flat strips ought to become non-existent.

With the last two flats raised off the flexible, which is more or less usual, thick or thin strips can be made at will, by simply moving the front plate farther away or nearer to the cylinder wire. It must, however, be clearly understood that there is not the slightest reason to conclude that *waste* is being extracted or reduced by this setting.

Feeding.—See that all laps are carefully conveyed to the cards. Crushed, distorted, or torn laps mean irregular carding. See that ends of lap are not binding on the lap creel, and that the lap unrolls evenly. Make or see that good piecings are made, and if the finishing ends of the laps are bundled up, or slovenly started on the scutcher, have this altered in the blowing-room at once. To prevent a number of laps running out at the same time, arrange for different-sized laps to be put on the cards.

Instruct tenters as to the evil effects of bad piecings, bad lap cores, and give an example by showing the effect on the web. Have the feed roller weighted equally at each end. See that the nip of the roller on the dish plates is equal along the full width of the card. See that the making-up pieces, that narrow-in the lap width to the carding width, are not catching the selvedges of the lap, and letting them go through in bunches. Clean the clearer of the feed roller frequently to prevent the sheets of fluff going through. Droppings from the mote knives under taker-in should have no fibres in them except the very shortest. As a matter of fact, droppings of any kind under the taker-in are an indication of inferior opening in the blowing-room.

Uneven Laps from the Scutcher.—At this point it will be advisable to examine closely what effect the card has on the uneven character of the fed lap. The thick and thin places in a lap are spread about the fleece indiscriminately, and at the nip of the roller and dish plate there will be thick and thin places in the lap. A thick place will be held tightly by the pressure of the feed roller, whilst the thin place adjacent to it, will be held with much less pressure, and if very thin, will not be held at all. The tightly held part will be combed out carefully by the taker-in, but the lightly held thin part will come away easily in a greater amount than the thicker portion, for it is not gripped as much. It is thus obvious that the card at the very beginning of its operations has a tendency to equalise an uneven scutcher lap, and that inequalities of lap do not go through a card unaltered, or that they exist in the web (thinned out of course) exactly as they are in the lap. As a matter of fact, it is the thick places of a lap that are the best carded parts, and it is the thin places, that are snatched or plucked away in tufts from the nip, that are badly carded and cause cloudiness. From this it is seen that thick and thin places in the web are due to thin and thick places in the lap, and not the reverse of this as is generally supposed. Any one with a card at his disposal for a few minutes can test this for himself, by artificially making thick and thin places in the lap. Using some red or other coloured loose cotton and making a thick or thin place of it on a lap, one can readily see the effect in the web.

A further useful feature to note is that if a yard, say, is cut off a lap, and rolled up the opposite way to the way it was rolled on the lap, there would be doubling effect. It would be equal to cutting strips lengthwise of the lap, and placing them one on top of the other precisely as the four laps are doubled in a scutcher. If this yard length were drawn out to 100 yards there has been drawing and doubling to this extent. Now the card does not double the lap up at the feed, but it draws out 100-fold, and then we gather it into a roll or sliver, and if there are thick and thin places in the web, these varying thicknesses tend to neutralise each other, and we have an important doubling effect. Now all this is apart from a further doubling effect that takes place, as the web passes from the doffer to the trumpet. Some people cannot free themselves from the idea that the whole web is travelling, so that the part stripped from the doffer reaches the trumpet at the same moment. Even the most practical man can see that the distance from the ends of the doffer is greater than from the middle of the doffer, and as the whole web is travelling at the same rate, the part of the web from the middle of the doffer will get to the trumpet first, and the other parts follow in after. At the trumpet entrance, therefore, there is a very prominent doubling effect. A test for this can easily be made by lightly sticking some wafers along the web just by the doffer, and noting whether they reach the trumpet at the same time. Carding is bad enough in its irregularities, but it would be a hopeless machine if it did not tend to correct the irregularities of the scutcher lap.

Delivery.—A perfectly unclouded even film of cotton from the doffer is the ideal state. It is so thin that its unevenness cannot be detected, unless its thick and thin places are prominent enough to be called cloudy, and when this cloudy appearance can be seen, then it must be extremely irregular. The most perfectly looking web is astonishingly irregular, and one has only to weigh the sliver in short lengths to find this out.

Heavier feeding will give a denser web than a light feed, but cloudiness in this denser web is traceable to similar causes, as when it appears in a thinner web. The stripping of the web from the doffer may not be perfect, and faults are traceable to various causes. Badly ground wire; projecting wires; rusty wire; changes in humidity or temperature in the room, this being noticeable on starting up in the morning or after the week end; doffer comb defective or vibrating too much; comb set too high or too low; comb not set at correct distance from the doffer; trumpet not kept clean and in perfect smoothness; calender rollers too slow, or if the top calender roller is not driven it may be sticking, through not being kept clean at the necks; doffer comb too slow or its driving band slipping; draughts from open doors, windows, or air currents from the machine itself or from straps may cause the web to be disturbed.

Irregular Slivers are inherent in the machine, but much can be done by producing well-opened and even laps; perfectly parallel settings across the width of the machine; good piecings of laps; perfectly parallel grinding of cylinder and doffer; exclusion of air currents from cylinder ends; free unrolling of the lap and careful settings to suit the cotton and amount fed.

Cloudiness may occur in the web from a variety of causes, and of course is tangible evidence of irregular slivers, so that the following causes may be added as a supplement to the previous paragraph:

Worn bearings disturbing the whole of the settings; one bearing of cylinder worn more than the other due to the pull of the belt on one side of the machine, this not only alters the settings generally, but also makes them unequal on each side of the machine; vibration of the whole machine causes a constantly disturbing effect on the settings; dirty rollers, taker-in, cylinder, and doffer; settings not parallel; card left unstripped too long; badly stripped cylinder; jerky flats due to worn carrier bowls or slack chain; feed roller clearer waste being taken through; flat strips getting on to the doffer; front plate set incorrectly and taking waste from the flats which the cylinder carries forward, this is one way of reducing waste, done carefully it will not show as cloudiness, but carelessly done a cloudiness will be apparent; faulty wire on cylinder or flats; bare patches on the filleting, this may or may not cause cloudiness, cards are working well with bare patches; patches of irregularly tempered wire; irregularity of the grinding due to differences in the character of the wire.

Flat Strips.—The bulk of these strips is good cotton in spite of its very often dirty-looking condition. The flats get charged with them in the last part of the flats' career over the cylinder, and they exist as bent fibres, so consequently have the appearance of being short, until one opens them out to the full length. They are invariably re-used in the mill, by mixing them at the mixing or hopper with ordinary cotton, and can be used for carded or combed yarns. For a quantity of flat strips the hopper must be run quickly, twice as fast as for ordinary purposes.

Flat strips are good indicators of the regularity in working or the setting of the cylinder, by their uniformity of appearance as they are stripped from the flats. Irregularities in the appearance of the strips, such as wide and narrow, thick and thin, may mean a lot to the observant carder or manager, and their condition may be a measure of a man's qualifications in managing a card.

Grinding.—If the cylinder, doffer, and flats are not ground perfectly level throughout their length, it will be impossible to "set" these again to an exact gauge. If the grinding roller is not set perfectly parallel to the cylinder, etc., a level surface of wire cannot be obtained.

If the grinding roller is not perfectly cylindrical, level grinding will be impossible.

Trying a gauge at each side of the card will not be reliable, the middle points must be tested also.

If the grinding roller on cylinder is not absolutely parallel to the grinding roller on the doffer, the two ground surfaces will not be parallel. Absolute exactness is therefore necessary in grinding, otherwise all the trouble and skill in using fine gauges are wasted.

Any carelessness in grinding which results in a very slight conical shape of cylinder and doffer or both, through grinding a little more off one end than the other, will not interfere much with the working of the card provided the surfaces are straight. Such conical surfaces can be easily set to each other and will work together all right. In such a case, however, opportunity should be taken, during further grindings, to correct the fault.

See that all bearings and shafts of grinding rollers are quite clean.

The "hiss" of the grinding roller, when grinding, should be a uniform tone over the whole length; in fact, uniformly continuous. If the hiss is jerky the grinding roller is at fault, or jumpy bearings, jerky straps or bands, blisters or loose filleting, etc., must be looked for as a cause. A slight dust on a grinding roller shaft will upset the accuracy of grinding, so the greatest care should be exercised in carrying the rollers from card to card; this requires constant supervision.

Object of Grinding.—To sharpen the tips or points of the fine wire covering. Smooth rounded tips of wire would allow the fibres to slip off, and consequently useless for disentangling purposes. A perfectly clean sharp edge on the points of the wire would, however, be also of little use, for the fibres would slip off the same. It must be remembered that it is the points of the wire that perform the carding action. To enable the points to act, there must be some holding feature on the tip. This is provided by grinding. A very delicate turned-over edge is given to the wire; under the microscope it looks like a distinct hook at the front, and tapering to nothing at the sides. These hooks hold the cotton, and the opposing hooks on flats and cylinder enable the entangled fibres to be pulled asunder, and carried forward by the more quickly moving cylinder. Heavy grinding will produce larger hooked ends, and the friction may be such, as to develop heat enough to cause a partial fusion or softening sufficient to give the points of wire very prominent hooks. Grinding ought to be considered, therefore, as a delicate operation, otherwise the large roughened hooks will play havoc with the delicate fibres upon which they act.

When to Grind.—Methods of organisation have much to do with this matter. In general, light grinding and often ought to be the policy. The very fine roughened edges of the tips are soon broken off and require renewing, and the lightest touch of a grinding roller will reproduce them. Speeds, production, and character of the wire will regulate the frequency of grinding. Periodic grinding varies in different mills. Half an hour twice a week is one extreme and a day per month is the other extreme. Quality carding is indicated by the first, and quantity, of poor stuff, the object of the other.

Grinding Rollers.—Dead roller for new wire, afterwards finishing with Horsefall roller. Renew emery fillet when too smooth. Renewing the fillet on a grinding roller ought not to be done in the mill. Without special tools it is absolutely impossible for any one to obtain a perfectly cylindrical surface on the emery. The job ought to be done by a firm who make a specialty of it, and who can be relied upon to produce a true surface. Amateur grinding roller coverers are responsible for a lot of bad grinding and bad carding.

Speeds of Grinding.—Cylinders, of course, run at their normal speed as when carding. Doffers must be speeded up to give about the same surface speed as cylinder. Grinding roller speed from 500 to 800 revs. per min.

Faulty Grinding is not easy to detect, and consequently is often done carelessly unless strictly supervised. Records ought to be kept of every card ground, with dates and even the time of day and duration; a sheet of paper divided into squares and numbered as each carding machine is numbered. These squares filled in with date, etc., will be a permanent record and check the missing of cards, a thing that is far from uncommon. A glance at such a record by the management each day will show what has been done or left undone.

A powerful magnifying-glass will show if grinding has produced very hooked wire or distorted it out of line, and will also disclose points unequally ground, which often happens with loose wire or very hard wire, which occasionally occurs on the most carefully manufactured clothing. Mild steel, tempered and plough-ground, is probably the best wire to use on the card.

Flat Grinding.—Practically done in position on the card by specially designed apparatus to ensure the heel and toe surface. Sometimes the flats are removed and ground on a flat grinding machine and then replaced. Accuracy is assured by this latter method if studs, chains, and alignment of all studs are perfect and no backlash.

Few firms take the trouble to grind the flats on a separate grinding machine, but it is the best method. In any mill it proves a troublesome job, especially if short-handed. Suitable keys ought to be provided to unscrew and screw up the flats quickly. An experienced man with his three helpers can replace a set of flats in about an hour. When short-handed the work can be done in overtime, so that the stripper's and grinder's duties are not neglected.

A feature to note in flat grinding is the very slow-moving flat and the fast-moving grinding roller, a method which is quite different from cylinder and doffer grinding. A slow doffer grinding is often adopted, which certainly eliminates the tendency of heating up the wire points, and producing excessively hooked tips.

Taker-in Teeth.—These get worn in time, and are not the worse for it, if worn equally all over, rather better than otherwise, but if unequally worn, they can be lightly ground up level and then well burnished. Bent teeth, when noted, should be straightened. The taker-in has a saw-gin effect on badly opened cotton.

Stripping.—Vacuum process always. Usual method by stripping brush must be strictly supervised and not left as a haphazard method. Frequent stripping is necessary, say three times per day, early in the morning, near mid-day, and about middle of afternoon. Strippers, of course, cannot be doing all the cards at any given time, so organisation must decide the actual periods, and here records are invaluable just as in grinding. In most mills stripping is done badly and cards frequently left unstrippod. The depth of stripping brush in the wire must be fixed, for it is no use stripping, say, one-eighth of an inch deep, and on the other hand it is not of benefit to the wire foundations, if wire bristles are digging it up, through being set too deep into the wire.

Carelessly stripped cards leave portions unstripped or leave patches or lengths of stripped cotton and dirt on the cylinder. Carelessness in regard to the speed of stripping brush may easily cause the cylinder to sweep the whole of the strips from the brush, and spoil some sliver, or wedge the flats.

Good stripping brushes are essential, and ought to last some time if carefully treated. Renew filleting when necessary.

Cleaning.—Periodic cleaning is usual, but well-trained tenters in a satisfied state of mind will clean off waste fluff, etc., at any time they notice it. A wipe down after stripping is necessary, and once a day at least the framing is cleaned. Saturday morning is the time when the machine is cleaned over thoroughly. Droppings from taker-in to be removed once per day; from cylinder and doffer once per week; flat strips as they accumulate.

Thoroughly pick and scour the machine every two or three months, and leave no trace of fluff or dirt in chains, necks, wheels, etc. All oil holes and passage cleaned out. Lubricate the fast-running bearings twice per day, other moving parts once per day. Flat chains to be lubricated after they have been picked and cleaned. Avoid oil getting on the inside of the machine or on the wire. Make a practice of feeling pedestals to see if they are getting hot. Have grease or oil handy in case of hot bearings.

Many cards have a tin under the dish feed plate, and this accumulates a lot of dirt. Clean this frequently. Brushing down at the week-end of shafts, hangers, etc., causes lots of dust and particles to fall on web, flats, etc. See that all this is picked off on starting up on Monday morning.

Notes.—Neps—these may be in the raw cotton and are difficult to eradicate. Small but prominent neps when present in the web may be due to the action of the card. Bulky feeding and too fine setting may cause them. Waste getting on to cylinder or not cleared from the flats; any part of the machine that offers rough edges, bent or distorted edges, or surfaces past which the cotton travels, may cause a twisting up of fibres and dirt; and in due time these pass into the web and look neppy. Long pieces of wire or crooked wire, hooked wire, crossed wire, wires touching on cylinder and flats, and cylinder and doffer may produce twisted bits of cotton, all of which are generally called neps.

It would save a lot of trouble, if the raw cotton were examined carefully before using, and thus see if neps were present. If they are in the cotton, the card cannot eliminate them to any extent, but if made by the card, then carders can be put on their mettle to prevent their formation by exercising that care which a card ought always to receive, whether it makes neps or not. It is strange that some carders think more skill is displayed in curing rather than in preventing faults.

NOTE.—A complete series of drawings to illustrate the remarks in above chapter is given in the author's book, *Cotton Machinery Sketches.*

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The mixing of the fibres is taking place during the drafting process, for the position of the fibres, relative to each other, are altered, and they occupy widely separated positions in the longer length of sliver. This mixing is greatly augmented in the doubling process, by the mixing of the fibres of several slivers into one sliver.

	Front.	2nd	3rd.	Back.
Indian Cotton.				
Bottom rollers	$1\frac{1}{8}$ in.	1 in.	$1\frac{1}{8}$ in.	$1\frac{1}{8}$ in.
Top ,,	$\frac{7}{8}$,,	$\frac{7}{8}$,,	$\frac{7}{8}$,,	$\frac{7}{8}$,,
Low American.				
Bottom rollers	$1\frac{1}{4}$ in.	1 in.	$1\frac{1}{4}$ in.	$1\frac{1}{4}$ in.
Top ,,	1 ,,	1 ,,	1 ,,	1 ,,
Good American.				
Bottom rollers	$1\frac{3}{8}$ in.	$1\frac{1}{8}$ in.	$1\frac{3}{8}$ in.	$1\frac{3}{8}$ in.
Top ,,	$1\frac{1}{8}$,,	$1\frac{1}{8}$,,	$1\frac{1}{8}$,,	$1\frac{1}{8}$,,
Egyptian and Sea Island.				
Bottom rollers	$1\frac{1}{2}$ in.	$1\frac{1}{4}$ in.	$1\frac{1}{2}$ in.	$1\frac{1}{2}$ in.
Top ,,	$1\frac{1}{4}$,,	$1\frac{1}{4}$,,	$1\frac{1}{4}$,,	$1\frac{1}{4}$,,

Dia. of top rollers as uncovered.

Rollers.—Several slivers are passed through the rollers side by side; the number of slivers may be from 4 to 10, but 6 or 8 are usual. These slivers are combined together into one at the front of the machine and are called the **delivery**. A complete machine may have several of these "deliveries," four to eight, and then the whole machine is called a **head**. The cotton may be passed through several machines, in which case we speak of these being 2, 3, or 4 "heads" of drawing, which simply means that the cotton has been put through 2, 3, or 4 complete drawing frames.

Diameter of Rollers.—Usually dependent on the kind of cotton to be used; this, of course, means the length of the staple. As a consequence of this policy, the table on the opposite page represents the usual practice.

It will be noted that the diameters increase as the staple becomes longer, and that the 2nd roller is the smallest. Throughout the mills of the world these diameters will be found somewhere about the dimensions given. A critical examination of the table will arouse thought, and for this reason alone it may be worth something. Just remember one set of rollers and add $\frac{1}{8}$ for each succeeding one; they are conveniently arranged in this methodical manner. Strength of the roller is the first consideration in fixing its diameter, so that torsion will not interfere, and also so that the weight which it carries does not bend it. Indian cotton is no different in this respect than Egyptian except that a roller usually is more heavily weighted.

From the table we see that the front and 2nd roller for Indian cotton can be set a minimum distance from centre to centre of $1\frac{1}{16}$ in., the rollers just touching, $\frac{1\frac{1}{8}'' + 1''}{2} = 1\frac{1}{16}''$, so the setting is well "outside" the bulk of Indian cotton; any wider setting is easily done. The rollers are evidently strong enough and can be run at any surface speed, so the question arises: Why are the rollers for Egyptian cotton of different dimensions? Drafting of the Indian cotton is done with their smaller rollers, so another question arises: Why different-sized rollers for drafting Egyptian or other cottons? Other questions will readily suggest themselves, but they all point in the same direction, and the answers will probably be that provided rollers are strong enough and can be "set" for the cotton and draft, they can be used for any cotton from the shortest to the longest. To copy the diameters, settings, and drafting of some mill because it turns out good yarn is extremely unreliable; good yarn is more probably due to the use of a Crighton opener in the blowing-room, or some other factors far removed from the drawing frame.

Production and Speeds.—Production is based on surface speed of the front roller and the weight of the delivered sliver. When the slivers pass through two, three, or four heads of drawing, the finishing delivery is usually taken as the production of a passage of drawing frames.

PRODUCTION OF A SINGLE DELIVERY AT THE DRAW FRAME.

48 hours' continuous running. No allowance made for stoppage. Deduct lost time.

Hank Sliver.	Grains per yard.	Grains per 6 yards.	Revolutions of Front Roller per min. $1\frac{3}{8}''$ dia.						
			200	250	280	300	320	350	400
			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
·100	83·33	500·00	823	1029	1153	1234	1317	1440	1646
·115	72·40	434·40	707	883	991	1072	1131	1252	1431
·120	69·44	416·64	678	847	949	1028	1083	1200	1370
·125	66·66	400·00	658	822	921	987	1053	1152	1316
·130	64·1	384·60	627	783	878	950	1003	1107	1266
·135	61·77	370·62	609	760	852	914	974	1076	1220
·140	59·52	357·12	587	732	822	881	939	1026	1175
·145	57·47	344·82	567	708	794	851	907	993	1140
·150	55·55	333·33	548	685	767	823	873	960	1096
·155	53·76	322·56	532	665	745	796	851	930	1060
·160	52·08	312·48	514	642	720	771	822	900	1028
·165	50·45	302·72	498	622	697	747	797	871	996
·170	49·01	294·06	484	605	677	726	774	847	968
·180	46·29	277·74	457	570	640	686	731	800	913
·200	41·66	250·00	411	513	575	617	658	720	822
·220	37·9	227·40	374	467	524	561	598	644	748
·250	33·3	200·00	330	412	462	495	528	577	660

It is a simple matter to construct the above table of productions.

$$\frac{\text{Circ. of F.R.} \times \text{revs. of F.R.} \times \text{hours worked} \times \text{grs. per yd.}}{36'' \times 7000 \text{ grs.}} = \text{prod. in lbs.}$$

EXAMPLE :

$$\frac{1\tfrac{3}{8}'' \times \tfrac{22}{7} \times 200 \times 48 \text{ hrs.} \times 60 \text{ min.} \times 83 \cdot 33}{36'' \times 7000} = \text{lbs.}$$

$$\frac{11 \times 22 \times 200 \times 2880 \times 83 \cdot 33}{8 \times 7 \times 36 \times 7000} = 823 \text{ lbs. in 48 hrs.}$$

When a single calculation has been made for a certain speed, diameter of roller, and grains per yard of sliver, it is unnecessary to repeat the whole calculation. The whole of the table can be filled in by simple proportion for any other speeds, roller diameters, and weight of slivers. The production for other diameters of rollers can be found by dividing any of the above productions by 41, and multiplying by the following constants :

$1\frac{1}{8}$ in. dia.	divide	by	41	and	multiply by	34.
$1\frac{1}{4}$,,	,,		41	,,	,,	37.
$1\frac{3}{8}$,,	,,		41	,,	,,	41.
$1\frac{1}{2}$,,	,,		41	,,	,,	45.

No allowance has been made for stoppages, so deduct, say, 20 per cent from the table.

It is advisable to find out what the actual running time is. Some mills lose much less time than others. The loss may be 15 per cent or as high as 25 per cent.

Various cottons may require different hank slivers and speeds of front roller. As a general rule for guidance, the productions per 10 hours will be :

Indian cotton	160 to 170 lbs.
American cotton	120 to 150 ,,
Egyptian cotton	60 to 120 ,,
Sea Islands cotton . . .	40 to 60 ,,

A further guide to hank sliver to be used is given :

Indian and Low American . .	·120 to ·140 hank sliver
American	·140 to ·170 ,,
Egyptian	·170 to ·230 ,,
Sea Island	·230 to ·280 ,,

A great deal depends upon the character of the cotton used and the individual judgment. Mass or bulk production will rush up the speed of front roller, whilst high-quality yarn will keep speeds low. Settings and drafting may enable one mill to do better than another mill in quality and production.

Draft.—The total draft between the four pairs of rollers may be anything that is desired; there is no Act of Parliament about it. As a rule, the total draft is equal to the number of ends put up. This total draft is divided up into three parts of an increasing series: a little between the back and 3rd roller, a bit more between the 3rd and 2nd, and a still further increase between the 2nd and front roller.

A usual rule for the draft is as follows:

Draft between front and 2nd roller = square root of total draft.
" " 2nd and 3rd roller = cube " "
" " 3rd and back roller = the rest.

Multiply the first draft by the second and divide the product into the total draft. The result will be what is termed the "rest," *i.e.* the draft between the back and 3rd rollers.

EXAMPLE: **Total draft of 6.**

Square root of 6 = 2·45 the draft between 1st and 2nd.
Cube root of 6 = 1·82 " " 2nd and 3rd.
$\frac{6}{2{\cdot}45 \times 1{\cdot}82} = 1{\cdot}34$ " " 3rd and 4th.
$\therefore 2{\cdot}45 \times 1{\cdot}82 \times 1{\cdot}34 = 6$ total draft.

EXAMPLE : **Total draft of 8.**

Square root of 8 = 2·828 draft between front and 2nd.
Cube root of 8 = 2 „ „ 2nd and 3rd.

$\frac{8}{2{\cdot}828 \times 2} = 1{\cdot}4$ „ „ 3rd and back.

$\therefore$ 2·828 × 2 × 1·4 = 8 total draft.

NOTE.—It will be seen that the "rest," or the draft between the 3rd and back roller, is the square root of the draft between the 2nd and 3rd roller.

EXAMPLE : **Total draft of 8.**

Square root cf 8 = 2·828 draft between-front and 2nd.
Cube root of 8 = 2 „ „ 2nd and 3rd.
Square root of 2 = 1·4 „ „ 3rd and back.

SQUARE AND CUBE ROOTS

Number.	Square Root.	Cube Root.	Number.	Square Root	Cube Root.
4	2·0	1·587	6·25	2·5	1·841
4·25	2·06	1·62	6·5	2·55	1·865
4·5	2·121	1·66	6·75	2·6	1·889
4·75	2·18	1·685	7	2·645	1·913
5	2·236	1·71	7·25	2·692	1·934
5·25	2·291	1·736	7·5	2·73	1·956
5·5	2·345	1·763	7·75	2·783	1·978
5·75	2·4	1·79	8	2·828	2·0
6	2·45	1·817	8·25	2·872	2·218

This cube and square root rule appeals to many authorities, probably because it appears scientific.

It will be noted that in the above rule the back and middle drafts multiplied together will always give the front draft.

Machine firms do not adopt the rule, and most machines are left pretty much as they are delivered. The drafts in such machines are somewhat as follows:

Between front and 2nd roller = 2·75.
,, 2nd and 3rd roller = 1·75.
,, 3rd and back roller = 1·25.
$2·75 \times 1·75 \times 1·25 = 6·015$ total draft.

Settings of Rollers.—The common practice is to set the rollers so that the distance between the centres of the front and 2nd roller is outside the length of the staple.

EXAMPLE:
From front to 2nd roller = $\frac{1}{8}$ in. more than length of staple.
,, 2nd to 3rd roller = $\frac{1}{4}$,, ,, ,, ,,
,, 3rd to back roller = $\frac{3}{8}$,, ,, ,, ,,

Weighting of Rollers.—The weighting of the rollers is a matter that is usually left to the machine maker. They vary somewhat in different makes of machines, but the following weights are usual:

Cotton.	Weight hung from Top Rollers.			
	Front.	2nd.	3rd.	Back.
	lbs.	lbs.	lbs.	lbs.
Indian and Low American .	20	20	20	20
American and Low Egyptian .	18	18	18	18
Egyptian and Sea Island .	16	16	16	16

In some machines the 2nd roller is weighted with a 2-lb. heavier weight, but this is bad practice.

This weighting of the rollers is a subject that ought to be seriously considered, and not accepted passively as it usually is. A spring balance connected to any part of a top roller by putting a piece of fine string round the roller and hooking the spring balance to it, and then lifting the roller up, will show how the pressure varies if a sliver going through is irregular. Except under ideal conditions in the slivers, the pressure is not uniform along the length of the top roller.

If quality and preservation of leather covers are factors, the weights on the rollers should be kept low, but there is nothing to prevent double the above weights being used if the main purpose is to get the stuff through, and there is a market for it. Heavy weighting is unnecessary and unreasonable, and too many mills are saddled with these heavy weights.

Roller Bearings.—The top rollers are friction driven from the bottom rollers, and owing to the spread of the 6 or 8 slivers they may be said to be driven through the film of the slivers. Friction must be reduced to a minimum, for which purpose they have various types of bearings: viz. loose boss rollers; loose bushes on the ends; single boss and double boss rollers with either loose or fast bosses. These may be arranged according to fancy. For instance, some will have single or one length roller to each delivery with loose brass bushes. Others prefer the roller divided into two parts or double boss with loose brass bushes. Others consider loose boss or a shell roller for front or front and 2nd rollers, or the same in the form of a double boss shell roller. Careful handling is necessary with loose boss or shell rollers, and of course they are expensive, but the weighting is better distributed, and friction is reduced.

Varnishing.—Varnish all the rollers, but see that it is well done. It will save time, perhaps, if first and second only are varnished. Use a good varnish. Buy it or make it. Varnish is usually made in the roller-covering department, and all kinds of so-called secret mixings are employed.

Glue, gum, or gelatine forms the main feature of a varnish. These substances are rendered damp-proof by some body substance such as a chromate or acetic acid. Green, black, or red colouring matters are added, and some liquid of a drying nature. Various touches of some preservative are also added; this is generally oil of marjoram.

One method of making is given.

Take 8 oz. of glue and 4 oz. of gum arabic, and soak them for twenty-four hours in 5 gills of cold water. Well grind the following substances into a fine powder, and mix with sufficient water to make a thick paste:

4 oz. of yellow chrome (chromate of lead).
4 „ common sub-chromate of lead.
3 „ green paint dry powder.
2 „ blacklead powder.

Make up the glue and gum into 2 quarts and melt on the stove. Add the paste and a little methylated spirits, about two table-spoonfuls. When thoroughly mixed a jelly is formed when cold. Cut out a piece of this jelly, sufficient for the number of rollers to be varnished, and warm it up. Apply to the rollers with a good camel-hair brush.

Varnish must be put on perfectly level and must dry smooth. The slightest signs of cracking are an indication for revarnishing, otherwise good fibres will be detached from the slivers and be taken up by the clearer. Cut surface of the varnish and leather must be attended to at once. Periodic replacement of rollers is advisable, the operative being supplied with a spare roller or two each week. A better plan is to inspect rollers constantly, and replace on the slightest signs of rough or unlevel surfaces or cracked varnish. Too much glue or glue of a poor quality will become sticky in a very moist atmosphere. A hot, dry atmosphere will cause cracking of the varnish.

Notes.—Cleanliness is all-important. All fluff should be gathered up by a brush, and the brush frequently cleaned by wiping, or picking the fluff off the bristles, and placing the waste in a can or box. Knocking or flipping the fluff away ought not to be allowed. When brushing down, the machine should be stopped and all loose waste removed before starting again. Clearers, top and bottom, should be cleaned often.

Bad ends are frequent through bad piecing, such as too much overlapping; bits of waste from clearers getting loose and going forward with the slivers; careless brushing of the roller beam and top flats; accumulations of fluff on the sliver guides; the spoons sticking and not acting promptly; slivers being torn by rough edges of coiler cans; continuing to use clearers the flannel of which has become too smooth or worn; careless oiling. A hot, dry atmosphere will tend to produce an electric state in the cotton and cause the fibres to stand out and fly about to such an extent, that they become a frequent cause of bad ends. Bad selvedges are frequent from the same cause. Slight electric shocks are sometimes given to the operative, when the electric current is discharged by contact and earthing. Sparking may occur on such occasions, so it is a source of danger. Earth the machine to a rod driven into the ground if possible.

Stop Motions.—Straighten any bent or distorted spoons. See that all spoons are well balanced. Spoons must act promptly, so require careful adjustment. Keep the spoon surfaces smooth. See that the hooked ends of spoons do not slip either off the spider or over the end of vibrating lever, whichever type is used. Keep trumpets clean and the aperture small enough to take the finished sliver, but not too large to permit lumps of waste to pass through.

Trumpet levers must act promptly and be kept in good condition. Stop motions acting through waste or extra thick places in the sliver should have the irregularities removed before piecing up.

Test finishing sliver for weight and calculate what the weight should be. Do this carefully, and if any difference is found, it will be due to stretching either before or after passing through the rollers. This must be corrected so that the merest fraction of a carrying draft exists. Holes in guide plate and plates to be kept smooth. Dents or roughened surfaces, made accidentally through knocks or careless use of screw keys, etc., to be smoothed off at once.

Doubling.—This is the main function of a draw frame. Drafting is not a particularly successful feature of its action, but doubling gives it the important place it occupies in the mill processes. It is the amount of doubling, or equalising of irregularities to some desired average result, that ought to dictate the number of draw frames through which to pass the material.

8 ends up through 3 machines $= 8 \times 8 \times 8 = 512$ doublings.
6 ,, ,, 4 ,, $= 6 \times 6 \times 6 \times 6 = 1296$ doublings.
6 ,, ,, 2 ,, $= 6 \times 6 = 36$ doublings.

It must be recognised that these numbers of doubling are fallacious; they mean so little, and are certainly not represented, in any sense, by any corresponding reduction of irregularities in the sliver. It would be much better to simply add the doublings together, and so get figures that are much nearer to the result. It is not implied by this that doublings are not to be multiplied together, but simply that the enormous amount of doubling in a mill, suggests that irregularities ought to be practically eliminated. They are far from being so, and hence the sooner we find out why the better. In the meantime, drop the talk about them as much as possible.

Number of Draw-frame Processes.—This clearly depends upon the condition of the card sliver. If very irregular, the slivers must be doubled as often as possible. The drafting effect, due to the lengthening, supposedly draws the fibres out straight, and as all card slivers are made up of fibres in a very criss-cross condition, from Indian to the finest Sea Islands cotton, they all require to be laid parallel to each other by drafting. If American cotton requires three drawing frames to get it into a right condition for the slubber, by doubling and drafting, which is the usual practice, it is reasonable to suppose that all cottons would require the same for carded yarns. If the draw frame parallelises the fibres to the extent assumed, the fibres ought to be unusually parallel after passing through three draw frames, but four frames are not unusual. For combed yarns, one draw frame, derby doubler, a ribbon lapper, comber, and then two or more draw frames are used. The comber sliver alone represents, on the usual method of reckoning, an unusually large number of doublings. It also represents probably the best parallelisation of fibres that can be made, and yet it is passed through two more drawing frames in addition to the drawing head on its own machine, so it has been subjected to the equivalent of five draw frames and an enormous amount of doubling. All this happens before the sliver gets to the slubber. This will convey an idea of what cotton is subjected to in order to obtain some slight degree of regularity and parallelisation of the fibres before a roving is formed.

In some cases the drawing frame is left out before combing. This makes a slight increase in the comber waste, but not sufficient to neutralise the gain in machinery, labour, expense and accessories connected with the drawing frames. Tests can readily be made, and ought to be made to see whether the use of any machine is necessary, and, if the results warrant it, machines should be shut down. There is no reason for using a third line of drawing if the third line does not improve the sliver to an appreciable extent.

This latter note is intended to suggest that a little probing into the result of a machine's action may eliminate certain machines. A further instance may be cited, in which it was found that taking the comber sliver straight to the slubber, produced better yarn than when it was passed through the usual passages of drawing, previous to going to the slubber. If combers were equipped with stop motions and careful labour employed, much machinery could be saved and great economies effected in this way.

Cleaning and Oiling.—Wipe down often, at least three times a day. Clean through once or twice a week. Interest in her work will induce an operative to keep parts polished, and some suitable polishing powder or paste will be a well-spent item on the part of the mill. Oil daily, except loose boss top rollers, which can be oiled slightly every fortnight. Oil that dries and leaves a film of brown varnish anywhere on the machine, should be avoided. Any machine with this brown appearance is an indication of the use of very poor lubricant. A touch of good grease or vaseline is better than oil for top roller pivots.

Scour the machine every six months, and clean up flutes, etc. Examine bearings, brushes, necks, etc., for wear, and replace necessary parts. Examine teeth of wheels and clean. Re-set wheels to avoid backlash. Level up machine if the floor has sunk or packings been displaced. Attend to belts, tighten, and make neat piecings, preferably without overlap, but if laced see that the overlap is tapered off at the end on inside of strap. Good leather is essential to avoid frequent breakages, piecings, and renewals.

Attend to damaged cans at once; they may be a cause of injury to the operatives, and interfere with the laying-in or drawing-out of the sliver.

When scouring the rollers, care should be taken not to bend them. Rest them on wood blocks at the ends and middle in V recesses.

The weight-relieving motion should always be used when the machine is standing idle for week-ends, etc.

NOTE.—A complete series of drawings to illustrate the remarks in above chapter is given in the author's book, *Cotton Machinery Sketches.*

CHAPTER IX

COMBER AND PREPARING MACHINES

Preparing Machines.—A perfectly formed lap of uniform thickness in width and regularity in length is required if the best results are to be obtained from the comber.

A lap is formed by laying side by side a number of slivers. The number of slivers will vary according to the hank of the sliver, and the width of the lap, 14 to 22 being the usual range. Two types of machines are used to effect this, one called a sliver lap machine, and the other a derby doubler.

Sliver Lap Machine.—This is a compact machine. Cans of sliver are placed at the back, pass through a guide plate and over spoons. Drawing rollers receive the slivers, and pass them on to the lap roller, which rolls them up into a lap. Start the machine with cans filled to various amounts so that one can at a time is emptied; piecings will then come at irregular intervals, and not all or several together or near to each other. Have the spoons working freely and acting promptly. Arrange the sliver cans so that the slivers are not crossed, and with a minimum of bend in them from can to guide plate. A direct line of sliver through the guide plate will prevent friction and stretching. If the lap is taken from this machine to the comber, four lines of rollers are used, but if the lap is passed to the ribbon lap machine, three lines of rollers only are usual.

Production and Speeds.—400 to 500 lbs. per day. Big productions are inadvisable. Owing to trying to keep pace with the comber, this is sometimes done, and sticky laps result and careless attention given. The speed of lap roller is about 40 revs. per min., but may be varied from 25 to 50 revs. per min.

Rollers and Draft.—These follow the usual lines of draw-frame rollers, but the settings are a little wider apart between each pair, say $\frac{1}{4}$ to $\frac{3}{8}$ in. over the average length of staple between the front and second roller, and the spacing of the rest a corresponding increase on this. The draft is always low and is generally somewhere between 2 to $2\frac{1}{2}$, the bulk of which is in the rollers. A very slight carrying draft only is necessary in other parts of the machine.

Notes.—The lap is made in widths to suit the comber, $7\frac{1}{2}$ to $10\frac{1}{2}$ in., but if the lap is taken to the ribbon lapper it is made narrower by 1 to $1\frac{1}{2}$ in. in order to allow for the spreading out of the slivers, which occurs when passing through this latter machine.

See that the slivers pass to the rollers in a straight condition; any buckling or crossing will be fatal. Knotting of the slivers is a fruitful cause of broken ends.

Smoothness is essential where the sliver touches. End plates or discs, to which the wooden core is fastened, must be absolutely smooth and free from contact with the ends of the fluted lap rollers. As the lap is driven by the friction of the lap rollers, the brake motion must be carefully adjusted to work perfectly, no stuck bowls or weight levers touching the floor. The brake block must be periodically examined, to see that the leather or other covering is in good condition, and not worn too smooth or down to the metal or wood pegs which hold it in position. Weighting should be equal on both sides or ends. Racks quite free but not jerky in movement. Rack wheel adjusted to rack teeth exactly alike on each side, so that one side is not slightly higher than the other side, by the amount of back-lash in the wheels.

Full lap stop motions can be applied, but laps can be taken off at any time, and in all sizes, so that they do not run off together in the comber or ribbon lapper.

Derby Doubler or Sliver Lap Machine with V table. This machine is gradually displacing the sliver lap machine. The cans are placed in lines on each side of the V table instead of being bunched together; the crossing and knotting of ends are avoided, and much less attention is required in piecing up and arranging cans as they become empty. Stop motions must be carefully attended to, and the table kept clean and free from roughness or anything that will impede the passage of the sliver. Three lines of rollers are used if the lap is to pass to the ribbon lapper, but four lines of rollers if the lap goes direct to the comber. The foundation of the lap is the same as in the sliver lap machines, and the remarks on that machine are applicable.

Production.—450 to 500 lbs. per day.

Width of Laps.—$7\frac{1}{2}$ to $10\frac{1}{2}$ in. wide. When the lap passes to the ribbon lap machine the laps are made 1 to $1\frac{1}{2}$ in. narrower to allow for the spreading that occurs on the ribbon lapper.

Ribbon Lap Machine.—The placing of a series of slivers side by side cannot be done so effectively as to prevent thinner places existing, where the two slivers are in contact. By closing in the slivers, the thin places may almost be eliminated. To overcome this difficulty the lap from the sliver lap machine is drawn out to, say, a sixth of its thickness by passing it through four lines of rollers as in a draw frame. The ribbon lap machine is designed to act thus on, say, six laps. The thin film from each set of drawing rollers is passed forward superimposed on each other, so we have now a thickness equal to the original thickness of one lap. The thick and thin places have a tendency to neutralise each other. It must not be overlooked, however, that if these superimposed laps are exactly imposed one on the other, the whole of the thin places will be superimposed also, and the denser part of the slivers will occupy similar positions over each other. This can sometimes be seen by passing a lap from the ribbon lap machine again through one head of the rollers. Held up to the light, the streaks of thick and thin places are visible. To minimise the possibility of this happening, the guides from each curved plate can be set a little zigzag, and narrowing the space at each plate, so that the finished width of the lap is 1 to $1\frac{1}{2}$ in. narrower than the lap from the sliver lap machine.

Production and Speeds.—400 to 550 lbs. per day.

Rollers and Settings.—The diameters of rollers are generally on the large size as in the drawing frame for long staple, say $1\frac{1}{2}$ in., $1\frac{1}{4}$ in., $1\frac{1}{2}$ in., and $1\frac{1}{2}$ in., but these sizes possess no particular virtue. The top rollers are weighted by similar weights as in the draw frame, say 20 lbs. It is usual to set the distance between front and second roller about $\frac{5}{16}$ in. more than length of staple, and about $\frac{1}{8}$ in. more added successively to the other two pairs.

Stop Motions.—The motions applied are for stopping the machine when a lap at the back runs out and when a full lap is made. See that these are acting promptly and no fluff accumulates to interfere with their action. Avoid having all one-sized lap in the creel; use various sizes so that piecings do not come near together.

Notes.—The web of cotton from the drawing rollers is rather delicate and easily broken. Avoid placing the machine where draughts can blow the web about. Keep the curved plates and table in a perfectly polished condition. Even under the very best conditions of polish and shape, the resulting hank is different from the calculated hank because of the friction causing a stretching; this must always be taken into account. On some machines this stretching is a prominent feature. Nickel-plating the plates and table is frequent, but the plating has an awkward way of peeling off, and such plates become great offenders in stretching and catching fibres. A wipe down with whiting in the morning, on starting up, will ensure a good start, but start up gently.

At least three pairs of small guide rollers should be set along the table, and both rollers driven positively. The large calender rollers at the end should also be both driven positively by gear, so that the bottom roller has not to drive the top roller frictionally. See that the weighting of the large calender rollers is equal at both ends, and adjust weight along the lever for correct pressure. Use ball bearings on the calender rollers.

Ball bearings on the lap spindle are a great advantage.

The brake motion must have close attention. The leather shoe, or the band-brake type, must not be interfered with by oil, fluff, or wear of parts. Pressure is more important in the early stages as the lap is being made. If this pressure continues throughout the formation of the lap there would be rucking up in folds, and a distorted lap would be made. To obviate this a reduction of the pressure of the brake is made automatically as the lap enlarges.

With careful attention, broken ends are scarce. If an end breaks and a gap is made, a piecing must be made with a bit from a spare lap. If, through any cause, a single goes through, it is better to cut out the faulty portion. See that the locking motion on the spindle is kept in order. A hot, dry atmosphere in the room is bad for this machine, and electrical effects disturb the fibres of the webs, and also produce sticky laps. In a hot, dry atmosphere it is difficult to obtain satisfactory results.

Lifting motions for the roller weights ought to be applied.

When five heads are used for the ribbon lapper instead of six heads, there will be saving in several directions, and it simply means a little less draft in the rollers to obtain an equivalent weight of lap.

Comber.—Two forms of this machine are in use, viz. the Heilmann, and a modification of it known as the Nasmith. Comparisons between the two are no longer necessary, but in the early days of the Nasmith there occurred a constant series of conflicts as to the relative merits of the two systems. These differences of opinion, or rather prejudices, arose for the same reason that many improvements in cotton spinning are not given a fair start in our mills. The mastery of cotton machinery involves a long experience, and an intimate knowledge of all the fine details of mechanism, and the effect of such mechanism on the cottons of various staples and hanks, etc. An improvement is introduced which almost wipes out this experience and knowledge of facts, and requires a readjustment of the memorised facts, or those of them that can be adapted to the new conditions. Such a revolution of mind sets up a passive, and often an active, opposition to the introduction of new methods, and as a consequence it is often only after long periods that an improvement forces its way into general use. Our younger men, with their wider outlook and technical education, study the reasons for the results attained, and are becoming conversant with the underlying principles of the operations and processes. This enables them to appreciate the advantages and disadvantages in the mechanism and processes in the mill, and to welcome improvements and changes of procedure that are brought forward.

Productions and Speeds:

HEILMANN COMBER

No. of Nips per min.	Weight of Lap per yd.	Width of Lap.	Waste per cent.	Lbs. per Head del. in 10 hrs.	Kind of Cotton.
	grains.	in inches.			
80	192	$7\frac{1}{2}$	20	6·37	Sea Islands
80	216	$8\frac{1}{2}$	20	7·22	,, ,,
80	264	$10\frac{1}{2}$	20	8·92	,, ,,
80	216	$7\frac{1}{2}$	18	7·5	Egyptian
80	252	$8\frac{1}{2}$	18	9·0	,,
80	312	$10\frac{1}{2}$	18	11·15	,,
80	216	$7\frac{1}{2}$	18	7·5	American
80	252	$8\frac{1}{2}$	18	9·0	,,
80	312	$10\frac{1}{2}$	18	11·15	,,

The three items, number of nips, weight of lap fed, and width of lap, regulate the production. The waste extracted can be adjusted to whatever amount is desired, and the above table extended indefinitely down to a very low waste percentage, or to 100 nips per minute.

Comber laps are frequently weighed in pennyweights and grains, but modern methods are adopting grains only for weights of lap, sliver, roving, etc. 1 dwt. = 24 grains.

Cylinders.—The cylinder is divided into four sections. 110° are occupied by needles; 70° flutes; a bare section following the last row of needles of 110°; and a bare section between the first row of needles and the flutes of 70°.

Seventeen rows of needles are almost invariable. The number of needles varies, and also their fineness, from the first row to the back, whilst they vary for different cottons. The diameter of the needles is indicated by the Birmingham wire gauge. The diameters vary usually from 20's to 80's gauge. The number of needles in a row is indicated by the number per inch. The needles are placed close together along the brass strip and soldered, so the diameter of any wire can be readily calculated and the gauge number found. Almost every mill has its own ideas about the arrangements of the needles on the half lap, so a single example is sufficient—$10\frac{1}{2}$ in. lap.

Rows.	Needles per inch.	Total Needles.
1, 2, 3	56	1,764
4, 5, 6	58	1,827
7, 8, 9	62	1,953
10, 11, 12	70	2,205
13, 14, 15	72	2,265
16, 17	77	1,616
	Total	11,630

All these needles go through the lap from 70 to 95 times per minute. Each nip will feed from $\frac{3}{16}$ in. to $\frac{1}{4}$ in. of cotton, and this length of cotton will have passed through it the combing effect of over 11,000 needles. Even with this apparently large amount of combing, only about every four fibres are touched by a needle. The needles ought to penetrate the full depth of the thickness of the lap fed, otherwise the combing is inefficient and the top comb will extract a quantity of good fibres. Examine carefully, with a good magnifying glass, the new needled strips or cylinder before using. Many half laps come from the repairers with dulled, flat points on the needles, due to rubbing the row of needles level on the oil stone. Note if all needles are clear pointed, that is, are not slightly hooked. Straighten bent needles when found. Have spare strips on hand, and a few complete half laps for replacements, whilst others are in the repairers' hands. Keep the fluted segment clean and flutes perfect. Cylinder must on no account have any play, so the bearings must be maintained in perfect condition.

Settings and Gauges.—A book could be filled with the various settings of the comber, and scarcely two men set alike for the same conditions; nevertheless each one considers his settings the best. The numbers on the index wheel can be juggled with, and the timings and gauges are wonderful combinations. There are, however, several factors common to all. Nipper and cushion plate should be perfectly parallel to the cylinder needles. Nipper and cushion plate should meet throughout their length simultaneously, and grip the web uniformly the whole length. The cushioning will allow for some slight irregularites in the web, but it is obvious that irregularities will prevent all fibres being held equally by the nippers, and in such cases good fibres can be easily plucked out by the cylinder needles. Poorly prepared laps and high speeds are responsible for excessive waste and bad combing results.

Feed rollers and detaching rollers, steel and leather ones, must be perfectly parallel to cylinder in all positions. The leather detaching roller must come in contact with fluted segment along its whole length at the same instant. The condition of the leather covering will very soon indicate if this roller is not set correctly; a mere glance in passing a comber will be sufficient to supply this information. All rollers must be free in their bearings, and fluff and oily waste removed at once. All flutes kept clean; and sticky, cracked, or worn leather rollers replaced; but do not wait until these faults occur, but prevent them happening by organised replacements at periods found by experience. If, through accidents or other unforeseen circumstances, damage is done to leather covers or anything else, replace at once. Making a fetish of periodic replacements or renewals sometimes leads to faults continuing until some specified time arrives for replacements or renewals. Avoid this, but find out exactly why renewals are necessary before their time.

A few notes on setting may not be out of place, but it is obvious that they can only serve as a guide.

The cylinder occupies a fixed position. This position is fixed by setting the index wheel at 5 and then turning the cylinders each on its shaft until a gauge of $1\frac{1}{8}$ in. fits between the bottom steel detaching roller and the front edge of the fluted segment. The gauge has a circular piece cut out at one end to fit on the roller, whilst the other end may be pointed or slightly flat. See that the edge of the fluted segment is not chipped away, otherwise all the cylinders will not be exactly alike. Screw up the cylinders to this $1\frac{1}{8}$ in. gauge.

The distance between the surfaces of the feed rollers and the bottom steel detaching roller is $1\frac{13}{16}$ in. for Egyptian cotton, and $2\frac{1}{16}$ in. for Sea Islands cotton. It will be seen that this setting will vary according to length of staple, and is less for American cotton.

The space between the bottom steel detaching roller and the front edge of the cushion plate is also a variable one, to suit length of staple. For Egyptian cotton $1\frac{3}{16}$ in.; for long Sea Islands cotton $1\frac{7}{16}$ in.

Nippers should be set together to the thickness of a piece of ordinary writing-paper at each end, the paper being equally held. Paper is used simply because one can test if the grip is equal, and it bends to the plate edge. The cushion plate, when nippers are open, must be set as above, say $1\frac{3}{16}$ in. from steel detaching roller; the stop screws of cushion plate will be about $\frac{1}{4}$ in. through, and set the edge of the cushion plate to 19's or 21's wire gauge from the cylinder needles after putting a $\frac{3}{8}$-in. gauge between one of the stop screws and the nipper stand. Remove the gauge and set the other screw just to touch the stand. See that the distance between the bottom steel detaching roller and edge of cushion plate has not altered. Put on the springs. Now move the nipper cam round until the bowl is on the circular part of the cam; put a $\frac{3}{8}$-in. gauge under the nipper stop screw and then adjust the connecting rod by the nuts until the $\frac{3}{8}$-in. gauge is just eased. Turn the nipper cam until the nipper stop screw points are eased from the stands; now turn the nipper cam back again as it was, and test if the space between cushion plate and needles is to gauge.

A mere statement of this would be:

Set nippers to 19's wire gauge from cylinder needles for Egyptian.

Set nippers to 21's wire gauge from cylinder needles for Sea Islands.

As the **top comb** comes down to its lowest position whilst the fluted segment is passing, it may be added:

Set top comb to 19's wire gauge from cylinder segment for Egyptian.

Set top comb to 21's wire gauge from cylinder segment for Sea Islands.

The angle of the comb is about 28°. It will, of course, be noted that the row of teeth is inclined to the plate on which they are soldered, so that angle cannot be altered; the plate is therefore used as a guide to the angle, and can be set to the angle required. An angle gauge is frequently used which clamps to the top comb plate, and a plumb bob indicates an angle on scale. With such an angle gauge, the degree for setting the comb will be 14° on the scale of the gauge for Egyptian. The angle has some effect in altering waste, etc., and will vary a little for different lengths of staple; for instance, the more it is inclined the greater the waste will be.

The top comb must just miss the leather detaching roller.

Feed Rollers.—For Egyptian cotton, the distance between surface of feed roller and bottom detaching roller is $1\frac{13}{16}$ in., and for Sea Islands cotton $2\frac{1}{16}$ in.

Set the brush so that the bristles touch the brass of the needles of the cylinder. In a new machine with all new brushes, a gauge could be made after setting one brush and used on all the others, but brushes wear unevenly and require re-setting, in which case each must be set separately according to wear.

The brush tin ought to have a clearance of only $\frac{1}{8}$ in.

The Lap Guides.—These must be set centrally with the feed roller and $\frac{1}{4}$ in. wider than the lap.

To set the leather detaching roller, the 80's toothed wheel on the cam shaft is moved out of gear. This enables the cam shaft to be turned round. Do this until the quadrant moves forward, and set the index wheel to 6. The roller must touch the segment at $6\frac{1}{2}$. Adjust all the lifters equally; a piece of paper is a good gauge to use.

The fluted top detaching roller must be set perfectly parallel to the bottom one, and must be quite clear of the leather detaching roller when this latter roller is touching the segment of cylinder.

Timings.—Various timings are in use, but the following will serve as a guide for Egyptian cotton:

Clutch wheel in gear at .	$\frac{3}{4}$ = 3	teeth of index wheel.		
Feed at	5 = 20	„	„	„
Top comb down at . .	$5\frac{1}{2}$ = 22	„	„	„
Detaching roller forward at	6 = 24	„	„	„
Detach at . . .	$6\frac{1}{2}$ = 26	„	„	„
Nip at	9 = 36	„	„	„

Such matters as length of fibre, weight of laps, amount of waste to be taken out, and the general cleanliness of the cotton will require different timings. Different makes of machines will also necessitate variations in the timings. No two machines will work precisely alike, though great care in setting and timing will get them very nearly equal.

Waste.—Too many people harp too much on the waste question, and conclude that the more waste taken out the better the yarn. This accounts for the big waste percentages taken out in some mills. If the comber was considered also as a drawing frame, and an almost perfect paralleliser of the fibres, and work on that foundation much more than is done, the cotton would be better prepared for it and better yarn would be produced. It is easy to find out if the resulting yarn warrants the amount of waste extracted. Any mill taking out more than 15 per cent must be working under peculiar conditions, and a thorough overhauling would appear necessary.

A good average of, say, 12 to 14 per cent of waste is an amount that could be used as a standard for any fully combed yarn, and only under special conditions should it be exceeded.

Waste is easy to make, or rather what is called waste. An examination of the waste will show that most waste consists of good fibres. A casual examination will, of course, suggest a mass of curly fibres that are bent and twisted in all directions, spotted with neps and other matter, but the action of the brush and doffer would turn the whole of the combed fibres into that condition, if it were allowed to go through to the brush, so the appearance is not much to go by. Brushes are also so badly attended to, and wear irregularly, and their speed often remains unaltered as they wear down, that the waste is imperfectly cleared from the needles of the cylinder or stripped from the brush. The good fibres in such cases that are combed out are actually turned into very disagreeable-looking stuff, and the tendency is to conclude that it is better for the yarn that such poor material should be extracted. Examine all waste carefully and not casually, and do not rely on a mere hand-pulling test for the length of the fibres; it is a most deceptive method.

The greater the angle of the comb the more waste will be taken out. The later the nippers are set to close there will be an increase of waste. If you feed later there will be more waste.

When setting is too close there will be more waste.

It is obvious why more waste should be made in the above cases, but what kind of waste is it? There are only two organs that extract fibres, viz. the cylinder needles and the top comb. The cylinder extracts waste independently of the top comb, so the top comb takes out the waste that the cylinder has left behind or has not touched. If cotton has been well prepared for the comber, and with the fibres parallel, which ought to be the case, seeing what drafting has been done to the cotton, then the top comb would simply clean up the back end of the combed bit and a few short fibres drawn out when the web is broken or pulled asunder. Very frequently the top comb extracts a large part of the waste. An easy test can be made to see what proportion of waste is taken out by the top comb.

EXAMPLE: Heilmann Comber, 90 nips per min.

Ribbon lap 405 grains per yard.

Top comb down. Average waste 16·7 per cent sliver, $129\frac{3}{4}$ grains per yard.

Top comb up. Average waste ·180 per cent sliver, $160\frac{1}{2}$ grains per yard.

EXAMPLE: Heilmann Comber, 95 nips per min.

Top comb down.

Average weight of lap, 1 yard = 15 dwt. 3 grains.
" " of sliver, 3 yards = 116·8 grains.
Percentage of waste = 14·5 per cent.

Top comb up.

Average weight of lap, 1 yard = 15 dwt. 3 grains.
" " of sliver, 3 yards = 134 grains.
Percentage of waste = 1·19.

EXAMPLE: Nasmith Comber, 97 nips per min.

Top comb down.

Average weight of lap, 1 yard = 19 dwt. 23 grains.
" " of sliver, 3 yards = 120 grains.
Percentage of waste = 12·39 per cent.

Top comb up.

Average weight of lap, 1 yard = 19 dwt. 23 grains.
" " of sliver, 3 yards = 120 grains.
Percentage of waste = 13·17.

A second test on this machine gave a percentage of 8·4 per cent with top comb up.

EXAMPLE:

WASTE PERCENTAGES

Type of Comber.	Total Percentage.	Half Lap. Per cent.	Top Comb. Per cent.
Nasmith	14·83	6·47	8·36
Nasmith	14·92	6·84	8·08
Average	14·875	6·655	8·220
Heilmann	11·3	2·53	8·77
Heilmann	11·1	2·67	8·43
Average	11·2	2·60	8·60

The foregoing examples were taken in mills turning out good yarn and well managed. The normal working of the combers was not interfered with in making the tests, and settings, etc., remained the same. Seventeen rows of needles in one cleaning organ and one row in the other. Which cleans the best, and what is the difference between the character of the waste extracted by each of these organs? The relative differences in waste and the relative differences in the needles of each, and both the method of taking out fibres and the kind of fibres taken out by each, are matters that ought to be seriously considered. It is recognised that the above tests are not strictly accurate methods of testing the respective combing effects of top comb and cylinders, but they are suggestive of what frequently happens in the comber.

Percentage of Waste:

$$\frac{100 \times \text{Waste}}{\text{Waste} + \text{cotton}} = \text{per cent of waste.}$$

EXAMPLE:

$$\frac{100 \times 12}{12 + 70} = \frac{1200}{82} = 14{\cdot}6 \text{ per cent of waste.}$$

Notes.—Every delivery of a comber should be set alike. Every part made secure so that no disturbance of settings can take place. Freedom of movement in revolving parts, but no play. Wrap frequently the finished sliver, twice a day at least. Test occasionally the sliver from each lap, and do not rely simply on the combined sliver from the draw box; quite notable differences will be found, and the wastes from the six separate laps are never alike; test this occasionally. See that the needles penetrate the fed cotton; if they do not penetrate fully, the upper part of the web is not combed. This has given rise to the statement that, by altering the distance between the cushion plate and the needles, one will alter the amount of waste; of course one will, simply because the lower part of the web only has been combed; if the cushion plate is moved far enough away, the cylinder will not comb at all. **Curling** of the web may be caused by rough or damaged detaching roller cover, or the roller not touching the cylinder uniformly or at the right time, or not being set perfectly parallel to the bottom roller.

Uniform springs are necessary for uniform pressure, so test all springs by a strong spring balance. See that all weight hooks are in correct position, and the weights free from contact with any part of the machine. If the needles of cylinder get clogged, the brush is wrongly set or loose. Broken teeth must be repaired at once. Clutch wheels, if worn, must be renewed. Form of teeth in clutch wheels to be formed so that they always move into and out of gear promptly. See that all parts of the machine along which cotton travels are well polished, and free from protuberances. Tins perfectly smooth; trumpet clear; stop motions acting promptly; piecings nicely made; absolute cleanliness. Examine springs to see that none have snapped. As in the ribbon lap machine and draw frames, so in the comber, a dry, hot atmosphere will cause laps to stick, the web in the tin to curl and play havoc with waste percentages; the machine is subject to electrical charges in such atmospheric conditions, and sparks and shocks are to be expected.

If laps are badly prepared for the comber, all kinds of faults may appear. Thick and thin places, bad selvedges, etc., must be remedied at the previous machines; the comber will not correct them.

As the lap is driven by friction, its weight resting on the lap rollers, see that no slippage occurs, or that the jerky feed given by the star wheel does not jerk the wooden rollers round without carrying the lap with them. Weak lines in the web will point to some irregularity of feed.

Nasmith Comber.—This has become a general term, although all machine makers now make the machine more or less identical except in small details. The machine will deal with any length of staple that can be held by the nippers, and all percentages of waste can be taken out. It is rapidly displacing the Heilmann comber even for the best Sea Islands cotton.

Productions and Speeds.—80 to 100 nips per minute, but a lot of time is saved in the intermittent actions. Heavier laps can be used, and the production is high. A 700-grain lap can be used for coarse work, down to a 300-grain lap for the finest cotton. The production will vary according to the weight of lap fed, waste, speed, and number of heads, say from 230 to 600 lbs. per week for a comber of 6 heads.

Timings, Settings, etc.—On setting the front edge of the plain segment of the cylinder to $2\frac{1}{2}$ in. from the detaching roller and the index at $2\frac{1}{2}$, see that the steel detaching roller is fixed at the mark on the stand. If it has been disturbed through any cause from this mark, replace it before setting the cylinder. The brush, too, ought to come within $\frac{1}{16}$ in. from the under side of the back steel detaching roller.

Nipper Crank Stud.—The stud on the index wheel should be on a line drawn from the index mark 37 to the centre of the shaft. The position fixes the time when the nipper reaches its nearest point to the detaching roller, and so determines the piecing. If the nipper arrives too early before the detaching roller commences to move forward, the projecting fibres will touch the roller and curl up. A further disadvantage of being too early will be that the detaching roller will carry the fibres too far forward, and so spoil the piecing. If the nipper arrives too late at the detaching roller, a very irregular detaching will occur in the form of a straggling break, and of course the loose ends will be taken out as waste.

Nipper.—When setting this, see that the set screw is loose on the nipper arm. Move the cushion plate or bottom jaw to its forward position to index 19. Adjust the plate parallel by the nuts on the nipper connecting rod. Use the stepped gauge in setting the end of cushion plate to the correct distance from the detaching roller. This distance varies from $\frac{8}{32}$ in. to $\frac{15}{32}$ in., each step advancing by $\frac{1}{32}$ in. The gauge number used will depend on the length of fibre; for $1\frac{3}{4}$ fibre the gauge number would be $13 = \frac{13}{32}$.

All in charge of Nasmith combers must give this setting very serious consideration, for it is the chief setting (really the only one) for the amount of waste to be extracted. For low waste from short cottons use the $\frac{1}{4}$ in. (No. 8) and increase the gauge as the cottons increase in length up to $\frac{15}{32}$ for Sea Islands cotton. High percentages will be taken out if $\frac{1}{2}$ in. (No. 16) is used. A setting of $\frac{11}{32}$ in. to $\frac{1}{32}$ in. for good Egyptian cotton will give about 16 per cent of waste.

At index 33 adjust the cushion plate to a $\frac{25}{1000}$ in. from the needles; no cotton or springs must be on when this is done. Just loosen the screws which fasten the plate brackets to the nipper arm, and turn the adjusting screws gently. Both ends of the plate must be done carefully. After screwing up firmly test with the gauge to see if correct.

Opening the Nipper.—Open as late as possible, but be careful that, in closing, it does not press the web out of the top comb before separation is completed. If this happens the opening must be adjusted a little earlier.

At index 27 set the incline leg down until the incline just comes into contact with the bowl on top nipper lever. See that the incline is well screwed up. The amount of the opening is regulated by turning the index to 19; rest the stepped gauge on the detaching roller and place the No. 12 gauge ($\frac{3}{8}$ in.) between the jaws of the nippers. Now set the incline so that its end touches the nipper lever bowl.

There will be trouble with the piecing if the nipper does not open enough, so some judgment is needed in setting. Short cotton generally requires a wider opening, say No. 14 gauge ($\frac{7}{16}$ in.).

Top Comb.—The distance from the detaching roller must always be $\frac{1}{16}$ in. when the index is at 19. This is easily effected. The angle of the comb is adjustable, and can be tipped to a certain amount. For general purposes it is usually tipped so that about $\frac{5}{8}$ in. of the arm projects beyond the top comb bridge.

Depth of Comb.—This is a delicate setting and requires care. The comb ought not to be lowered more than that given by the following setting. A doctor gauge No. 6 ($\frac{6}{1000}$ in.) rests on the two steel rollers; the comb is now lowered by the adjusting screws until the needle points press the gauge down, and raise the other end of the gauge $\frac{1}{16}$ in. above the front detaching roller. Even this may be too low, in which case the doctor gauge need not be raised by the teeth. To alter the waste by lowering the top comb or altering its angle is not a reasonable method, as the waste is simply a tearing away of good cotton. The better way is to set the nipper back and so put the comb into the web a little more forward. When long-stapled cotton is being used, and a light lap, the longer space between the nipper and detaching roller will allow of some slight adjustments of the angle of the comb, and the depth or penetration of the needles. If the nipper is altered to a nearer position to the detaching roller for the purpose of reducing the waste, care must be taken to prevent the top comb being forced into the detaching roller. When the alteration is made, the top comb must be re-set.

Top Comb Lifters.—The top comb ought not to be lifted out of the web before separation is completed. It sometimes is lifted too soon in order to reduce the waste, and it is obvious why waste is reduced in this manner, but it is a most undesirable way to adopt and ought not to be tolerated. Timing is done by setting index to 11 and fixing the lifters to touch the bowls. See that the lifters are well screwed up when set.

Feed Rollers.—Set far back for long cotton, and $\frac{1}{4}$ in. more forward for short cottons. A $\frac{1}{4}$-in. feed is usual, and this is obtained with a 5-teeth feed; a little less or a little more can be given if required. If the lap puckers up at the feed roller, change the ratchet wheel to feed less, and if tight, feed a little more. Wheels are provided for this purpose.

Don't put too much pressure on the feed roller by tightening up the springs too much; a very light tension is sufficient.

Detaching Roller.—This roller must begin to turn backwards when the index is at 1, so loosen the cam and turn it forwards until the roller begins to move backwards. Test the action by hand after screwing cam up.

Leather Detaching Roller.—The revolution of this roller will, of course, be moved exactly as the bottom detaching roller, but its forward and backward bodily motion is controlled by the eccentric. Set the eccentric so that the lever just starts to move inwards when the index is at 20. At index 19 the top roller should be as near the top comb as it will work. If set too far away from top comb, a lot of waste will be made. Lubricate the pivots of the leather rollers with a touch of vaseline, and not oil.

Degrees of Combing.—The unusual degree of control over the combing enables a very wide range of staple to be combed. This control allows waste to be extracted in any percentage desired. It must be remembered, however, that this control of the waste taken out means less combing effect. Quite a variety of combinations can be made up which improve the yarn, and yet in some of these very little waste has been extracted. Some of these may be stated.

Combed Yarns.—This is the ordinary produce with a reasonable carding, and say 12 to 15 per cent of waste taken out at the comber.

Super-combed Yarns.—Usually from better carded cotton, the result of taking out 7 to 8 per cent waste at the card. As much as 17 per cent waste is taken out at the comber.

Double-combed Yarns.—Put through comber twice and a double dose of waste taken out. The amounts vary, but 17 and 5 per cent are an average.

Triple-combed Yarns.—A refinement of very doubtful usefulness, but in such cases there will be about 16, 6, and 4 per cent at each comber respectively.

Coarse-combed Yarns.—These are substitutes for fine carded yarns, and to be effective to deal with the inferior carded cotton and heavy laps, the comber requires coarser and stronger half laps and top combs. The card needs to take out only about 4 per cent, and the comber from 5 to 8 per cent of waste.

These coarse-combed yarns are sometimes designated **Semi-combed** and **Half-combed.**

Any cotton can be combed in this partial manner, and even then further refinements in this direction are possible, for one or more ends of ordinary combed sliver, or of the various degrees of coarse-combed sliver, can be mixed with carded slivers at the draw frame.

It may be remarked that sometimes yarns sold as double-combed are simply single-combed, and it is seldom that coarse-combed yarns are sold by any distinctive name, but just combed yarns.

Weight of Laps.—Laps are usually $10\frac{1}{2}$ in. wide, but may be as narrow as $7\frac{1}{2}$ in. Waste 15 per cent, and stoppages allowed for in the following table:

Cotton.	Width of Lap.	Weight per yard.	Weight per yard.	Production per week of 48 hours. 6 heads.	Nips per min.
	inches.	dwts.	grains.	lbs.	
Sea Islands, Fine . .	$10\frac{1}{2}$	12	288	280	85
,, ,, ,, . .	,,	13	312	303	85
,, ,, ,, . .	,,	14	336	327	85
,, ,, ,, . .	,,	15	360	350	85
,, ,, ,, . .	,,	16	384	375	85
,, ,, ,, . .	,,	17	408	400	85
Florida Cotton . .	,,	18	432	440	90
,, ,, . .	,,	19	456	464	90
,, ,, . .	,,	20	480	488	90
,, ,, . .	,,	21	504	513	90
Egyptian and American .	,,	22	528	598	100
,, ,, .	,,	23	552	625	100
,, ,, .	,,	24	576	652	100
,, ,, .	,,	25	600	680	100
,, ,, .	,,	26	624	707	100
,, ,, .	,,	27	648	734	100
,, ,, .	,,	28	672	751	100
,, ,, .	,,	29	696	788	100
,, ,, .	,,	30	720	815	100
,, ,, .	,,	31	744	842	100
,, ,, .	,,	32	768	870	100

If one set of conditions, such as percentage of waste, width of lap, weight per yard, and nips per min., give a certain production per hour or week, a simple proportion sum will enable one to work out the production for any changes in these conditions.

Notes.—Many of the notes on the Heilmann comber are applicable, which see. Keep the leather-covered rollers in good condition. The detaching leather roller is the earliest to show wear; the two leather rollers may be reversed in place, if economy is a necessity and the front one is in a good state.

Attention should be given to the needles both on cylinder and comb, and repairs made at once on finding bent needles. A few needles more or less are not of much importance, so if broken out needles are found or are broken out when straightening, there is no immediate cause for fresh top combs or new strips, but see that no rough edges of solder, etc., are left to catch the fibres.

See that the doffer and comb are working correctly and stripping the brush clean. Avoid high speeds in brush, doffer, and comb. Do not reverse brush if bristles become bent; this simply means that the waste is flipped about instead of adhering to the bristles.

Get an aspirator installed for collecting waste, fluff, and dust.

See that the ratchet and pawl for roller feeding act properly and that there is no missing of teeth.

Loose screws anywhere in the machine will introduce faults, and the first examination for the cause of a fault will be for looseness in some part, and a changed setting. See that piecings are correctly made.

All springs ought to be carefully adjusted in tension. Any haphazard way of tightening the springs will result in lumpy feeding, irregular pressure on each end of rollers, etc.

See that the lap revolves uniformly with the feed roller, so that a tight or slack fleece does not occur.

Feed four teeth of feed roller; this gives $\frac{1}{4}$ in. feed. Five or three teeth feed must depend upon circumstances.

Be careful that roller laps do not occur on bottom back detaching roller. This roller is set to about $\frac{1}{40}$ in. from the needle, and a roller lap coming into range of the needles plays havoc with them. A roller lap on the front detaching roller may force the back detaching roller, by bending it, into the path of the needles, and seriously damage them.

Needles.—These are very much the same as in the Heilmann, and a variety of combinations of coarse and fine are made between the first and last row of the seventeen rows. In this connection it may be remarked that the early coarse rows of needles practically do no combing except the slightest touches on the under side of the fleece. These needles never get damaged except by pure accident, certainly not by any combing; they are also practically free from any waste. The last few rows of the fine needles do the bulk of the combing, and these become charged with the waste, and are also the ones that get damaged the most through having to do the real part of the combing. If the earlier rows of needles were finer, even the little combing they did would be of some use in preparing for the later finer needles.

When timing the backward motion of the detaching roller, see that no cotton comes back into the path of the cylinder needles, otherwise a quantity of good fibres will be carried away, as the needles pass the fibres that hang down. Let the last needles pass before the detaching roller turns backward.

The stop motion on the front of the condensing tin frequently fails to act and requires constant attention. If single of any kind goes through, cut it out at the coiler whether one foot or several; it only means future trouble.

Give a careful look at all the slivers on the table, to see if the lap has any single on it. A good tenter should draw attention to this fault, so that it can be guarded against at the ribbon lapper.

Electric effects on the comber can sometimes be earthed by a copper wire connecting the machine to a pillar, gas-pipe, water-pipe, etc., but the best way is to drive an iron rod into the floor some distance, and connect the copper wire to this.

No driving belts ought to run over the machine.

An interesting feature to observe in combing is the appearance of the sliver before and after passing through the draw box of the machine. Owing to the combed web being gathered together and passed through a small funnel, a certain amount of fuzziness appears on the surface of the combed slivers on the table. We know that this is merely a surface appearance, for the interior of the sliver is composed of parallel fibres. On passing, say, the six-combed slivers through the draw box, the surface fibres become incorporated in the general mass of the fibres, and a single sliver is delivered that has a much improved appearance. By still further doubling and drawing these finished comber slivers, it is possible that the good appearance is maintained and possibly improved, and the doubling will tend to equalise irregularities, but it is extremely doubtful whether the doubling effect is not over-neutralised by the drafting in the draw frames. It is therefore quite possible that an improved yarn could be produced if the comber sliver were taken direct to the slubber instead of first passing it through any draw frames. It has been and is being done commercially with greatly improved results, but if it gave only the same results there would be a great saving in machinery, labour, etc.

Cleaning and Oiling.—Clean away all fluff when it becomes noticeable. Don't let it be flipped away. Use a brush and remove the fluff from the brush by hand, so that it does not touch the slivers and be carried off. Stopping the machine for cleaning down is advisable. No matter how carefully cleaning is done, there are sure to be bits of fluff and dirt lying about, so run the machine for two or three yards of sliver to be cut out at coiler to avoid the possibility of dirt being in it. Use a little vaseline to lubricate the detaching roller; this may be put on with the finger, or, better still, with a small paint-brush.

An examination of the aspirator, if one is attached, will show an accumulation of sand, leaf and seed husks lying in the lower part of the sheet metal box. This stuff amounts to a considerable amount in the course of a year, from a complete comber system, and it indicates clearly the failure of the card to extract this form of impurity to the extent that is frequently assumed.

Timings and Settings.—It frequently happens that the inexperienced ask for information in regard to timings and settings of the comber. It cannot be too strongly pointed out that no one ought to be asked these questions, unless he has had the opportunity of examining carefully the cotton to be used, its condition, and the comber itself. So many factors have to be taken into consideration that what is suitable for one batch of cotton is not suitable for another. The comber presents opportunities for judgment, and cast-iron rules are to be avoided.

NOTE.—A complete series of drawings to illustrate the remarks in above chapter is given in the author's book, *Cotton Machinery Sketches.*

CHAPTER X

BOBBIN AND FLYER FRAMES: SPEED FRAMES

THESE are essentially draw frames, but as the sliver is drawn down too fine for placing in a coiler, it is wound on a bobbin, and in order that this may be effected, the thin roving is strengthened by putting a slight twist into it by means of a flyer. The reduction of the roving occurs in steps from one to four flyer frames. These are known respectively as Slubber, Intermediate, Rover, or Roving Frame, Jack Frame, or Fine Roving Frame. Speeder is also a common name for the Flyer Frame.

Productions and Speeds.—Productions depend on a number of factors which vary according to cotton and yarn to be spun. These factors even vary considerably in various mills using the same cotton. Management and organisation may produce differences in time lost in doffing, cleaning, etc. A table of productions is given (pp. 126, 127) which covers a very wide range of hanks for the various cottons and the different fly-frames used. Such a table, however, would be useless unless the full details are given of how it is built up. In the first place, a long time was spent in good mills and exact times recorded of all stoppages for piecing, cleaning, etc., for a large number of full bobbins. Weights were carefully taken and the full particulars of speeds, bobbins, etc. After a number of representative hanks on each type of machine and with various cottons, the rest of the table was filled in by calculation. The following are the particulars on which the production table is based :

Machine.	Cotton.	Revs. of Spindle per min.	Dia. of F.R. inches.	Lift. inches.	Time lost in Doffing, etc. mins.	Dia. of full Bobbin. inches.	Weight of full Bobbin.
Slubber	Indian and Low American	500	$1\frac{1}{8}$	10	per set. 14	$5\frac{3}{4}$	30
,,	American . .	500	$1\frac{1}{4}$	10	14	$5\frac{1}{2}$	28
,,	Egyptian and Sea Islands	400	$1\frac{3}{8}$	10	14	$5\frac{1}{2}$	26
Intermediate	Indian and Low American	750	$1\frac{1}{8}$	10	14	$4\frac{3}{4}$	24
,,	American . .	700	$1\frac{1}{4}$	9	14	$4\frac{3}{4}$	22
,,	Egyptian and Sea Islands	650	$1\frac{3}{8}$	9	14	$4\frac{1}{2}$	20
Roving	Low American .	1100	$1\frac{1}{8}$	7	13	$3\frac{3}{4}$	11
,,	American . .	1100	$1\frac{1}{4}$	7	13	$3\frac{5}{8}$	$10\frac{1}{2}$
,,	Egyptian and Sea Islands	900	$1\frac{1}{4}$	8	13	$3\frac{1}{2}$	$10\frac{1}{2}$
Jack	Egyptian. . .	1120	$1\frac{1}{4}$	7	13	$2\frac{7}{8}$	8
,,	Sea Islands . .	1050	$1\frac{1}{4}$	6	13	$2\frac{5}{8}$	6

Speed of Spindles.—The speed of spindle is limited to a large extent by mechanical considerations. In the first place, it is an unbalanced piece of mechanism, and in the second place, the long arms have a tendency to fly apart when revolving. Try this by gradually increasing the speed of a spindle and flyer, and as the speed increases the arms spread out until eventually they stand out in a straight line from the spindle. A further point to note is the pressure of the paddle on the bobbin. This pressure is obtained by the flying out of the wire up the side of the flyer leg. This wire, in moving outwards, causes the paddle to move inwards, the centrifugal effect on the wire being greater than the centrifugal effect of the paddle. As the bobbin builds up in diameter, the wire occupies a nearer position to the centre of spindle, whilst the paddle has moved away from this centre. A consequence of this action is that the paddle presses on the bobbin harder at the commencement of a set than at the finish of a set, and the higher the speed of spindle the greater this difference of pressure will be. A bobbin becomes softer as it builds from this cause, in addition to becoming softer owing to the softer foundation on which each successive layer is put. Now a cone drum is designed under a certain set of conditions which interfere with the accurate theoretical form, or more correctly the calculated shape, of the curves, and if these conditions are changed, then the cone drums will show signs of not operating correctly. With these facts in mind, one can see what will happen if speeds of spindles are increased. One can run spindles much higher and chance the results. Get a bigger production and sacrifice other things. Wear out spindles and collars and shake the frame out of some years of its life. There is nothing to prevent big speeds if one desires a reputation of that kind, and some do, so they run slubbing spindles up to 800 revolutions, and roving spindles up to 1400 revolutions per minute. Yarn is made and, as any kind of yarn has a use, the yarn can be sold. Speed of spindle, therefore, becomes a question of judgment or business policy.

Twists per Inch.—Every revolution of the spindle puts a twist in the roving. The number of twists put in the roving will regulate the surface speed of the front roller. It follows, therefore, that by increasing the speed of spindles and keeping the same twist per inch, we must increase the speed of the front roller, and so get greater production.

PRODUCTION IN LBS. PER 10 HOURS. ALLOWANCE MADE FOR DOFFING, CLEANING, ETC.

	SLUBBER.			INTERMEDIATE.			ROVING.			JACK OR FINE ROVING.	
Hank Roving.	Indian and Low American.	American.	Egyptian and Sea Island.	Indian and Low American.	American.	Egyptian and Sea Island.	Indian and Low American.	American.	Egyptian and Sea Island.	Egyptian.	Sea Island.
0·4	23·51										
0·5	18·33										
0·6	14·83										
0·625	14·06	17·06									
0·7	12·17	...	15·14								
0·75	11·18	13·72	13·96								
0·8	10·25	12·72	...	13·71							
0·875	...	11·32	11·56	...							
0·9	...	10·94	11·14	11·85							
1·0	...	9·52	9·75	10·38							
1·1	...	8·4	8·6	9·2							
1·125	...	8·1	8·32	...							
1·2	...	7·48	7·67	8·22	7·80						
1·25	...	7·07	7·27	7·80	...						
1·3	...	6·7	6·87	7·4	...						
1·4	...	6·07	6·22	6·7	6·44						
1·5	...	5·51	5·65	6·1	...	7·41					
1·6	...	5·04	5·18	6·58	5·37	...					
1·7	...	4·62	4·76	5·15	...	...					
1·75	...	4·44	4·58	4·95	...	6·31					
1·8	...	4·25	4·4	...	4·57	...					
1·9	...	3·94	4·07	...	...	...					
2·0	...	3·67	3·8	...	3·98	5·2	4·42	5·12			
2·2	...	...	...	...	3·45	...	...	...			
2·25	...	...	...	...	...	4·48	...	...			
2·4	...	...	...	...	3·05	...	...	...			
2·5	...	...	...	...	2·87	3·87	3·3	3·85			

2·6	...	...	...	...	2·72						
2·8	...	...	...	...	2·45						
3·0	...	...	...	...	2·21	3·00	2·57	3·02			
3·5	...	...	...	...	...	2·42	2·07	2·58			
4·0	...	...	...	...	...	1·99	1·7	2·14	1·90		
4·5	...	...	...	...	...	1·68	...	1·80	1·62		
5·0	...	...	...	...	...	1·44	...	1·47	1·38		
5·5	...	...	...	...	...	1·25	...	1·30	1·21		
6·0	...	...	...	...	...	1·10	...	1·14	1·06		
6·5	...	...	...	...	...	0·978	...	1·03	0·94		
7·0	...	...	...	...	...	0·878	...	0·92	0·84	1·26	
7·5	...	...	...	...	...	...	...	...	0·767	1·14	
8·0	...	...	...	...	...	...	...	...	0·695	1·04	
8·5	...	...	...	...	...	...	...	...	0·64	0·95	
9·0	...	...	...	...	...	...	...	...	0·588	0·879	
9·5	...	...	...	...	...	...	...	...	0·546	0·814	
10·0	...	...	...	...	...	...	...	...	0·505	0·754	
10·5	...	...	...	...	...	...	...	...	...	0·704	
11·0	...	...	...	...	...	...	...	...	...	0·658	
12·0	...	...	...	...	...	...	...	...	...	0·579	
13·0	...	...	...	...	...	...	...	...	...	0·515	
14·0	...	...	...	...	...	...	...	...	...	0·462	
15·0	...	...	...	...	...	...	...	...	...	0·417	0·369
16·0	...	...	...	...	...	...	...	...	...	0·379	0·335
17·0	...	...	...	..	...	...	...	...	...	0·346	0·307
18·0	...	...	...	...	...	...	...	...	...	0·318	0·282
19·0	...	...	...	...	...	...	...	...	...	0·298	0·261
20·0	...	...	...	...	...	...	...	...	...	0·27	0·24
21·0	...	...	...	...	...	...	...	...	...	...	0·225
22·0	...	...	...	...	...	...	...	...	...	...	0·21
23·0	...	...	...	...	...	...	...	...	...	...	0·197
24·0	...	...	...	...	...	...	...	...	...	...	0·184
25·0	...	...	...	...	...	...	...	...	...	...	0·174
26·0	...	...	...	...	...	...	...	...	...	...	0·165
27·0	...	...	...	...	...	...	...	...	...	...	0·155
28·0	...	...	...	...	...	...	...	...	...	...	0·146
29·0	...	...	...	...	...	...	...	...	...	...	0·139
30·0	...	...	...	...	...	...	...	...	...	...	0·132

By keeping the same spindle speed, but with a lower twist per inch, we must increase the speed of the front roller and so increase production. By keeping the same spindle speed, but with more twists per inch, we must decrease the revolutions of front roller and so decrease production.

The twist per inch in all stages of the roving is a variable factor. It is put in to enable the roving to be drawn from the bobbins and to be wound on the bobbins. It must stand the strains to which it is subjected in these operations. The conditions of the fibres in the roving are the deciding factors, whether long or short, well opened, clean, well carded, or well drawn, etc., whether rollers are correctly set or drafting done properly. There is not enough consideration given to these factors, and, speaking generally, there is too much twist put in the rovings and a consequent diminution of production. A trial ought to be made to find the reasonable twist per inch that the roving will stand without causing trouble in the creels or when building.

Twist Constants or Multipliers.—The twist constant can readily be found on any fly-frame, by calculating the length in inches delivered by the front roller per minute. Divide this length by the revolutions of spindle, and we obtain the twist per inch. Now extract the square root of the hank roving delivered, and divide it into the twists per inch. This gives us a number or constant. This constant, when multiplied by the square roots of any other hank roving, will give the twists per inch for that hank.

$$\sqrt{\text{Hank roving}} \times \text{constant} = \text{twists per inch.}$$

The various cottons, long or short, carded or combed, require a different constant for each as well as for the different fly-frames. These are a matter of judgment, so the following constants are given as a guide :

Machine.	Indian and Low American.	American and Low Egyptian.	Good Egyptian and Sea Islands.
Slubber .	1·3	1·0	0·7
Intermediate	1·2	1·16	0·78
Rover . .	1·5	1·25	0·9
Jack . .	...	0·9	0·95

From the above table it will be seen that more twists per inch are put in short than in long cottons, and also less proportionate twists per inch in the succeeding frames. Each carder, however, must decide this for himself according to his cotton and method of preparing it. Excess or insufficiency of twist is economically bad.

Doubling at the Fly-frames.—This is effected by passing two ends together and twisting them into one. At the slubber only one end is passed through, but at the succeeding frames two ends may be passed through.

The result of passing two ends through is to decrease the hank of the roving by one-half, since both ends are of the same hank.

If two different hanks are put through, then

$$\frac{\text{One hank} \times \text{other hank}}{\text{one hank} + \text{other hank}} = \text{resulting hank.}$$

EXAMPLES:

Two hanks, each ·5, will give ·25 hank
" " 4 " 2·0 "
" " 20 " 10·0 "

Two hanks, one ·5 and the other ·6, will give

$$\frac{\cdot 5 \times \cdot 6}{\cdot 5 + \cdot 6} = \frac{\cdot 30}{1 \cdot 1} = \cdot 272 \text{ hank.}$$

Two hanks, one 11 and the other 12, will give

$$\frac{11 \times 12}{11 + 12} = \frac{132}{23} = 5 \cdot 74 \text{ hank.}$$

Suitable Hank Rovings.—The draft will regulate this to a large extent, and no two mills are alike unless copying is done. As in other things, in mill work, copying from other mills is not much use unless **everything** done previously is copied, and even then a personal element may count. An example will perhaps illustrate the passage of the cotton through the machines. We will commence with a 200-grain sliver per 6 yards at the draw frame. This is

$$\frac{6 \times 7000}{200 \times 840} = \frac{1}{4} = \cdot 25 \text{ hank drawing.}$$

This ·25 hank drawing is put up at the slubber, which has a draft of 5·1; the slubber will therefore deliver a

$$\cdot 25 \text{ hank drawing} \times \text{slubber draft } 5\cdot 1 = 1\cdot 275 \text{ hank,}$$

$$\text{or} = \frac{30 \times 7000}{1\cdot 275 \times 840} = 196 \text{ grains per 30 yards.}$$

The slubber bobbin is put up at the intermediate and two ends doubled, which makes the hank = ·6375. The draft in the intermediate frames is 6·6, so the hank delivered will be

$$\frac{1\cdot 275}{2} \times 6\cdot 6 = 4\cdot 21 \text{ hank } (4\cdot 2075),$$

$$\text{or} = \frac{60 \times 7000}{4\cdot 21 \times 840} = 118 \text{ grains per 60 yards.}$$

The intermediate bobbin is put up at the jack frame and doubled, which makes the hank 2·104. The draft in the jack is 6·1, so the hank delivered will be

$$2\cdot 104 \times 6\cdot 1 = 12\cdot 83 \text{ hank,}$$

$$\text{or} = \frac{120 \times 7000}{12\cdot 83 \times 840} = 77 \text{ grains per 120 yards.}$$

This 12·83 hank is put up at the mule, two ends up

= 6·42 hank, and spun, say, into 90's counts with a total mule draft of 14.

Note to the above.—It will be seen that if the hank slubbing is multiplied by all the drafts and divided by the doublings, the counts spun will be obtained.

EXAMPLE:

$$\frac{1 \cdot 275 \times 6 \cdot 6 \times 6 \cdot 1 \times 14}{2 \times 2 \times 2} = 89 \cdot 83 \text{ counts spun.}$$

It is thus seen that we can vary any of the drafts or hank slubbing, and obtain any given counts. But if the calculation is made and the result is **less** than the counts spun (theoretically it ought to be always the same), one may conclude at once that there is considerable irregularity in the yarn and in the rovings of all the fly-frames; stretching is occurring. The result of the calculation ought to come out **slightly more** than the counts spun, in order to prevent the thin places being stretched thinner, especially in the fly-frames. About 5 per cent more is a good figure to adopt for this compensation. The more perfectly the cotton is prepared a less amount may be allowed. The long lengths we use for averaging the hanks and weights are responsible for the variation. Such long lengths never give correct information as to the degree of irregularity in slivers, rovings, or yarn.

Suppose we lay out the hanks for spinning 50's counts as follows:

	Drafts.
Slubber, 1·2 hank	...
Intermediate, 3·5 hank	5·83
Rover, 12 hank	6·28
Mule, 50 counts	8·33

$$\frac{1 \cdot 2 \times 5 \cdot 83 \times 6 \cdot 28 \times 8 \cdot 33}{2 \times 2 \times 2} = 50 \cdot 73 \text{ counts.}$$

This figure, 50·73, indicates some stretching, and the drafts should be eased off a little to bring the figure down to, say, 48.

Drafting in the fly-frames is limited. Very seldom is it carried slightly above 6, and then only in the roving and jack frames. To put in bigger drafts in these frames, in order to dispense with another passage of fly-frames, is a distinct sign of bad management, or a compulsory emergency method, and requires an unusual degree of care in setting the rollers and drafting. On the other hand, the draft cannot be very small, unless the whole machine is slowered and production lost, otherwise the back roller will pull the roving from the creels at too fast a rate, and stretching will occur and the bobbins will overrun themselves.

In laying out fly-frames for any given counts to be spun, decide on the drafts, and then deduce the hanks from them for each machine.

Cotton.	Counts.	Suitable Hank Roving.		
		Slubber.	Interm.	Rover or Jack.
Indian .	10 to 12	·625	1·0 to	
,, .	12 to 18	·5	1·125	1·75 to 2·75
,, .	20 to 26	·625	1·25	3 to 3·25
,, .	25 to 30	·75	1·5	3·25 to 3·75
American .	16 to 24	·5	1 to 1·125	2·5 to 3·25
,, .	26 to 30	·625	1·25	3·375 to 4·25
,, .	32 to 38	·75	1·5	4 to 4·75
,, .	40	·812	1·7	4·5 to 5
,, .	44	·875	1·75	4 to 5·25
,, .	50 W.	·875	1·875	5
,, .	60 W.	·875	2	5½
Egyptian .	40 to 50	·875 to 1	2·75 to 3	9 to 9·5
,, .	60	1 to 1·125	3·25 to 3·5	11 to 11·5
,, .	70	1·125 to 1·25	3·75	12 to 13
,, .	80	1·25 to 1·375	4	14
,, .	90	1·375 to 1·5	4·25	15 to 16
,, .	100	1·5	4·5	16 to 17

See note for further remarks on draft at the end of this chapter.

Draft.—It is advisable to commence at the slubber with an easy draft, but do not exceed five of a draft at this machine. The succeeding machines should be a little more at each step. By adopting the method of using a hank of card sliver for a fairly wide range of counts, the drafting in the fly-frames becomes an easy matter, especially if the rule of

$$\frac{\text{Weight of slubbing} \times \text{inter. draft} \times \text{roving draft} \times \text{spring draft}}{\text{doublings of } 2 \times 2 \times 2}$$

= 5 per cent higher than the counts.

EXAMPLE: $$\frac{1 \cdot 5 \times 6 \times 6 \cdot 7 \times 14}{2 \times 2 \times 2} = 105.$$

The result shows that the above drafts would be suitable for 100 counts. The wheels in use may give a little more on one frame, but this can be compensated for by getting a little less on another frame, but excessive drafts in the rollers of fly-frames are to be avoided. Lay out, as above, somewhere near what you desire in the drafts, and then humour them a little on either side to obtain the desired result. No two mills work alike to the same drafts. The draft between the back and middle rollers of fly-frames is small, and varies very little from 1·2 to 1·3. When the total draft is changed by altering the speed of back roller, the "break" draft remains unaltered.

Weighting.—The weights in table on following page are a guide only. They vary in different makers' machines, and are sometimes changed by the mill authorities to suit conditions of hank, settings, draft, etc. It may be remarked that they are generally too heavy, especially the weight on the middle roller. It will be noted that all three passages of frames have dead weights for Indian and American cottons, but self-weighted rollers on middle and back for Egyptian and Sea Islands cottons. These arrangements are also variable, so that no hard and fast line can be drawn.

WEIGHTING : LBS.

Machine.	Indian.			American.			Egyptian.		
	Front.	Middle.	Back.	Front.	Middle.	Back.	Front.	Middle.	Back.
SLUBBER.									
One end to a boss .	20	14	10	...	...	...	16	self	self
Saddle to 2nd and 3rd	20	24		18	24		16	20	
INTERMEDIATE.									
One end to a boss .	16	12	8	14	16		14	16	
Two ends to a boss .	16	20		24	28				
One end to a boss .	...	...	...	...	...	...	16	self	self
ROVING.									
One end to a boss .	...	...	...	10	12		9	self	self
Two ends to a boss .	20	14	10	18	24				
Saddle to 2nd and 3rd	20	24							

Spindles.—These must be strong enough to withstand the unbalanced character of the flyer, especially if speeds are put up to a limit. Vibrating spindles are caused by weakness, or bent spindles, or wear in the collars, or very unbalanced flyers that have been knocked about and distorted. Short or long collars are a question of judgment; either are good if well made and adjusted. A number of practical factors enter into the question that can only be decided on the spot and by a full knowledge of the conditions in a mill. Some makers recommend long collars for all frames, others short collars for exactly the same machines. Long collars are always an extra, so they are a luxury. When re-setting, always see that a spindle revolves equally freely at the bottom and top of the bobbin rail traverse or lift.

Distance of spindles from centre to centre in inches	10¼	10	9¾	9½	9¼	9	8¾	8½	8	7	6¾	6½	6¼	6	5¾	5½	5¼	5	4¾	4½	4¼	4	3¾	3½
Gauge of 4 spindles in a box	20½	20	19½	19	18½	18	17½	17	16															
Gauge of 6 spindles in a box	..	..	..	..	..	..	..	..	..	21	19⅞	19½	18¾	18	17¼	16½								
Gauge of 8 spindles in a box	..	..	..	..	..	..	..	..	..	..	..	..	..	..	23	22	21	20	19	18	17	16	15	21
Gauge of 10 spindles in a box	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	22½	21¼	20	18¾	21
Diameter of full bobbin in inches . . .	6	6	5¾	5¾	5¾	5¾	5¾	5¾	5½	5	4⅞	4¾	4½	4¼	4	4	3¾	3½	3¼	3⅛	2⅞	2⅝	2¼	2
	Slubbing Frame.									Intermediate Frame.										Jack Frame.				
															Roving Frame.									

DIAMETERS OF SPINDLE

Machine.	Dias. of Spindle. Inches.	Lift. Inches.
Slubber . .	$\frac{3}{4}$, $\frac{13}{16}$, or $\frac{7}{8}$	10, 11, or 12
Intermediate .	$\frac{3}{4}$ or $\frac{13}{16}$	9, 10, or 11
Roving . .	$\frac{5}{8}$ or $\frac{11}{16}$	7 or 8
Jack . . .	$\frac{9}{16}$, $\frac{5}{8}$, or $\frac{11}{16}$	5, 6, or 7

Diameters of Rollers (in inches):

Machine.	Indian.			American.			Egyptian.		
	Front.	Mid.	Back.	Front.	Mid.	Back.	Front.	Mid.	Back.
Slubber .	$1\frac{1}{16}$	$\frac{15}{16}$	$1\frac{1}{16}$	$1\frac{1}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{8}$	$1\frac{1}{4}$
,, . .	...	...	...	$1\frac{1}{8}$	1	$1\frac{1}{8}$	...	...	...
,, top .	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{15}{16}$	$\frac{15}{16}$	$\frac{15}{16}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$
Intermediate .	$1\frac{1}{16}$	$\frac{15}{16}$	$1\frac{1}{16}$	$1\frac{1}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{8}$	$1\frac{1}{4}$
,, .	...	...	...	$1\frac{1}{8}$	1	$1\frac{1}{8}$	...	...	...
,, top . .	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	1	1	1	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$
,, self weight	...	...	...	...	...	...	$1\frac{1}{8}$	$1\frac{1}{8}$	$2\frac{1}{4}$
Roving . .	1	$\frac{7}{8}$	1	$1\frac{1}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	1	$1\frac{1}{4}$
,, top .	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{13}{16}$	$\frac{13}{16}$	$1\frac{1}{8}$	1	$2\frac{1}{4}$

Top rollers are for uncovered diameters.

Circumference of Rollers:

$\frac{7}{8}$ in. dia. = 2·7489 circ.	$1\frac{1}{8}$ in. dia. = 3·5343
$\frac{15}{16}$,, ,, = 2·9452 ,,	$1\frac{1}{4}$,, ,, = 3·9270
1 ,, ,, = 3·1416 ,,	$1\frac{3}{8}$,, ,, = 4·3197
$1\frac{1}{16}$,, ,, = 3·3379 ,,	$1\frac{1}{2}$,, ,, = 4·7124

Proportions of Machinery:

16's T. INDIAN OR AMERICAN COTTON.

Scutcher lap, 13½ ounces.

Mule Spindles.	Machine.	Hank Roving.	Draft.
465 to	1 Card	·138	93
476 to	1 Draw frame dely.	·126	5·45
47·6 to	1 Slubber spindle	·5	3·96
26·4 to	1 Interm. ,,	1·0	4
8·7 to	1 Roving ,,	2·5	5
1 to	1 Mule ,,	16	6·4

18's T. INDIAN OR AMERICAN COTTON.

Scutcher lap, 13½ ounces.

Mule Spindles.	Machine.	Hank Roving.	Draft.
493·8 to	1 Card	·138	93
476 to	1 Finishing dely.	·138	6
52·9 to	1 Slubber spindle	·5	3·6
30·7 to	1 Interm. ,,	1·0	4·0
8·7 to	1 Roving ,,	2·75	5·5
1 to	1 Mule ,,	18	6·54

20's T. INDIAN OR AMERICAN COTTON.

Scutcher lap, 13½ ounces.

Mule Spindles.	Machine.	Hank Roving.	Draft.
519·4 to	1 Card	·138	93
519·4 to	1 Finishing dely.	·138	6
59·5 to	1 Slubbing spindle	·5	3·6
30·3 to	1 Interm. ,,	1·125	4·5
8·5 to	1 Roving ,,	3·0	5·32
1 to	1 Mule ,,	20's	6·66

30's T. AMERICAN COTTON.

Scutcher lap, 13 ounces per yard.

Mule Spindles.	Machine.	Hank Roving.	Draft.
714 to	1 Card	·154	100
714 to	1 Finishing dely.	·154	6
77 to	1 Slubber spindle	·625	4
29·8 to	1 Interm. ,,	1·5	4·8
9·9 to	1 Roving ,,	4·0	5·2
1 to	1 Mule ,,	30·0	7·5

40's T. AMERICAN COTTON.

Scutcher lap, 12 ounces per yard.

Mule Spindles.	Machine.	Hank Roving.	Draft.
952 to	1 Card	·173	104
952 to	1 Finishing dely.	·173	6
101 to	1 Slubber spindle	·25	4·3
38·4 to	1 Interm. ,,	1·75	4·6
11·9 to	1 Roving ,,	4·75	5·4
1 to	1 Mule ,,	40's	8·4

40's T. EGYPTIAN COTTON.

Scutcher lap, 12 ounces per yard.

Mule Spindles.	Machine.	Hank Roving.	Draft.
645 to	1 Card	·189	113
833·3 to	1 Finishing dely.	·189	6
92·6 to	1 Slubber spindle	·875	4·6
26·8 to	1 Interm. ,,	2·75	6·2
7·09 to	1 Jack ,,	9·0	6·5
1 to	1 Mule ,,	40's	8·8

50's T. EGYPTIAN COTTON.

Scutcher lap, 11½ ounces per yard.

Mule Spindles.	Machine.	Hank Roving.	Draft.
762·9 to	1 Card	·208	119
1111 to	1 Finishing dely.	·208	6
106·38 to	1 Slubber spindle	1·0	4·8
32·25 to	1 Interm. ,,	3·0	6
8·18 to	1 Jack ,,	10·0	6·6
1 to	1 Mule ,,	50's	10

60's T. EGYPTIAN COTTON.

Scutcher lap, 11 ounces per yard.

Mule Spindles.	Machine.	Hank Roving.	Draft.
569·5 to	1 Card	·208	114
1333 to	1 Finishing dely.	·208	6 or 8
119 to	1 Slubber spindle	1·125	5·4
38·4 to	1 Interm. ,,	3·25	5·76
9·18 to	1 Jack ,,	11·0	6·76
1 to	1 Mule ,,	60's	10·9

70's T. EGYPTIAN COTTON.
Scutcher lap, 11 ounces per yard.

Mule Spindles.	Machines.	Hank Roving.	Draft.
1025·6 to	1 Card	·231	127
1428·5 to	1 Finishing dely.	·231	6 or 8
121·4 to	1 Slubber spindle	1·25	5·4
38·4 to	1 Interm. ,,	3·75	6
9·09 to	1 Jack ,,	13·0	6·92
1 to	1 Mule ,,	70's	10·76

80's T. EGYPTIAN COTTON, CARDED.
Scutcher lap, 11 ounces per yard.

1110 to	1 Card	·231	127
1428·5 to	1 Finishing dely.	·231	6 or 8
156·25 to	1 Slubber spindle	1·25	5·4
38·46 to	1 Interm. ,,	4·0	6·4
10·0 to	1 Jack ,,	14·0	7·0
1 to	1 Mule ,,	80's	11·4

80's T. EGYPTIAN COTTON, COMBED.
Scutcher lap, 11 ounces per yard.

1000 to	1 Card	·231	127
10,000 to	1 Sliver lap	...	2
10,000 to	1 Ribbon lapper	...	5
1425 to	1 Comber 8 hds.	·231	5
1428·5 to	1 Finishing dely.	·231	6 or 8
156·25 to	1 Slubber spindle	1·25	5·4
38·46 to	1 Interm. ,,	4·0	6·4
10·0 to	1 Jack ,,	14·0	7·0
1 to	1 Mule ,,	80's	11·4

90's T. EGYPTIAN COTTON, COMBED.
Scutcher lap, 10 ounces per yard.

1176 to	1 Card	·277	138
10,000 to	1 Sliver lap	...	2
10,000 to	1 Ribbon lapper	...	5
1818 to	1 Comber 8 hds.	·208	5·8
1616 to	1 Finishing dely.	·208	6 or 8
294 to	1 Slubber spindle	·875	4·2
135 to	1 Interm. ,,	2·0	4·4
41·6 to	1 Roving ,,	4·5	4·5
10·4 to	1 Jack ,,	15·5	6·8
1 to	1 Mule ,,	90's	11·6

100's T. EGYPTIAN COTTON, COMBED.

Scutcher lap, 10 ounces per yard.

Mule Spindles.	Machines.	Hank Roving.	Draft.
1333 to	1 Card	·277	138
10,000 to	1 Sliver lap	...	2
10,000 to	1 Ribbon lapper	...	5
2000 to	1 Comber	·231	5·8
2000 to	1 Finishing dely.	·231	6 or 8
311·9 to	1 Slubber spindle	1·0	4·3
138·8 to	1 Interm. ,,	2·25	4·5
40·16 to	1 Roving ,,	5·5	4·8
11·45 to	1 Jack ,,	16·5	6
1 to	1 Mule ,,	100's	12

16's T. INDIAN OR AMERICAN COTTON.

Scutcher lap, 13½ ounces per yard.

Ring Spindles.	Machine.	Hank Roving.	Draft.
285·6 to	1 Card	·138	93
292·4 to	1 Finishing dely.	·126	5·45
29·12 to	1 Slubber spindle	·5	3·96
16·24 to	1 Interm. ,,	1·10	4·0
4·68 to	1 Roving ,,	12·75	5·5
1 to	1 Ring ,,	16's	5·8

20's T. INDIAN OR AMERICAN COTTON.

Scutcher lap, 13½ ounces per yard.

312·9 to	1 Card	·138	93
312·9 to	1 Finishing dely.	·138	6
35·8 to	1 Slubber spindle	·5	3·6
18·25 to	1 Interm. ,,	1·125	4·5
4·62 to	1 Roving ,,	3·25	5·76
1 to	1 Ring ,,	20's	6·15

30's T. American Cotton.
Scutcher lap, 13 ounces per yard.

Ring Spindles.		Machine.	Hank Roving.	Draft.
485·8	to	1 Card	·154	100
485·8	to	1 Finishing dely.	·154	6
52·2	to	1 Slubber spindle	·625	4
20·3	to	1 Interm. ,,	1·5	4·5
5·65	to	1 Roving ,,	4·5	6
1	to	1 Ring ,,	30's	6·6

40's T. American Cotton.
Scutcher lap, 12 ounces per yard.

Ring Spindles.		Machine.	Hank Roving.	Draft.
631	to	1 Card	·173	104
631	to	1 Finishing dely.	·173	6
66·9	to	1 Slubber spindle	·75	4·3
20·7	to	1 Interm. ,,	2·0	5·32
6·57	to	1 Roving ,,	5·5	5·5
1	to	1 Ring ,,	40's	7·27

The foregoing are given as guides, but there is nothing cast-iron about them. They can be varied, and it is advisable to practise drawing up tables of a similar kind for various counts of yarn on Mule or Ring. The tables, or similar ones, enable one to see how many roving spindles, for instance, are required for one slubber spindle. The whole of the card-room machinery can be tested to see if too many spindles are in use. By a little adjustment of hanks and drafts, one may dispense with a machine or two or utilise spare machines. It is no use running machines for the mere sake of using them.

A revision in many mills would do much to improve the economical working of the mill.

Cone Drums.—The cone belt requires constant attention. Atmospheric conditions will alter its tension. No cone drums have ever been made that will work with mathematical precision, but all cone drums will produce a good bobbin if properly worked. Good judgment is required in having the belt at the right tension so that there is a minimum of slippage. Any extra power thrown on the belt through wheels not gearing properly, increase of friction in bearings from fluff, want of oil, etc., will cause slippage or a jerky action of the cone belt. Perfectly smooth piecings are necessary on the belt, and few piecings in any case. Don't use up old belts to piece up comparatively new ones.

Cone drums are designed to work with open belts, and these adapt themselves automatically to the correct diameters of the cone drum by reason of their tension. Cone drums are also designed without any reference to the diameters of the empty bobbin. A convenient length of cone drum has been chosen, and a practical range in diameters for variation of speed as the bobbin builds. The belt can be started at any point in the cone drums for any diameter of bobbin, but the speed of the cone drums must be right for the diameter of bobbin to commence winding. Afterwards the cone drum speed will be correct for the increasing size of bobbin up to the limits of the cone drum. It is a practical convenience, however, always to start with the strap near the end of the cone drum for any size of bobbin, and simply change the speed to suit.

See that the locking motion or lifting motion for the bottom cone drum is in order so that this drum is kept from jumping. See that the bottom cone drum is lowered carefully after winding back the belt.

Notes.—Note very carefully that the weights for balancing the bobbin rail are not too heavy. The rail ought to be the heaviest side, so that the pressure is in one direction up and down throughout the lift; any change of balance during the building of the bobbin will result in back-lash of all the gearing connected with the lift being taken up and producing an irregularity on the bobbin where it occurs. See that the projections on the bobbin rail and the slides on the spring pieces are quite clean and that no binding is occurring. Keep the creels clean and wipe down frequently, also have the tops of the bobbin wiped. See that all skewers are well ended with a smooth rounded end, and the porcelain cups in good condition.

Have all lines of rollers running true, no wobbling or lifting. Use cut wheels wherever possible. Note if wheels that are carried on studs are geared well, and that the studs are perfectly rigid and secure. Have every spindle working, otherwise there is a loss in production and no saving in wages. See that piecings are made correctly with clean fingers. Don't permit a tenter to interfere with the cone drum belt whilst a bobbin is being built. If ends go slack or tight, the machine must be stopped and reported immediately. Test all bobbins for diameter, and reject irregular sizes. Don't use oily bobbins. Cracked and oily bobbins are a cause of spoiled rovings and yarn. Prevent bobbins coming in contact with oil. If a slack end is noticed, there has been too long an interval before piecing. Stop any fooling with such bobbins, and point out the seriousness of the faults that will arise in the yarn. It pays to explain fully to a tenter the result of carelessness. If, in general, there is a fair average of stoppages, piecings and attention required in the frames, and one or two old hands work their machines and never have trouble, it will pay to watch them carefully; they may be unusually careful, or they may have all the little dodges off for keeping their frames running and letting bad work go through.

If $\frac{1}{4}$ or $\frac{3}{4}$ of a turn is put on the top of flyer, or two or three turns on the pressers, see that every spindle is the same and no carelessness allowed in this respect.

Don't use broken or blunt-ended skewers; send them to be re-ended, or, if the saving will warrant it, get a machine and repair the skewers at the mill; it is a simple job. Don't use bobbins that do not hold on the bobbin wheel; worn slots in the bobbin or worn snugs on the bobbin bevel cause a lot of bad work. Rattling bobbins and spindles must not be tolerated. The middle or any top roller ought not to be lifted whilst the machine is running. On double boss rollers, if a roller lap occurs on one boss, the roving from the other boss is seriously impaired and should also be looked to.

Remember that the winding and building on front and back rows of spindles are exactly alike; the difference in the tension of the rovings between the roller and the spindle top is partly due to the longer lengths of what is a very weak roving, and also due to a slight stretch, due to the jerk that occurs at every revolution of the flyer as the roving slips round the opening in the flyer top; the smaller this opening is, the less the slackness will show.

Owing to the invariable difference between the front and back bobbins, it is a good plan to use different coloured bobbins on each row, especially on the jack frame. Each colour can then be put up on different mules or rings, or one of each colour put up and passed together. Do not mix the bobbins indiscriminately, as this will simply increase the fault.

If bobbins show signs of running over at the change of traverse, the taper ought to be altered. Too little taper will cause the ends to slip over and break the roving. If the bobbins get easily damaged when handling them, or in the spinning machine through the shoulder being easily spoiled by slipping, this must be altered at the building motion by shortening the rack poker. See that the poker is quite horizontal when the rail is half-way up the bobbin, otherwise there will be a difference of taper at each end of the bobbin. As the bobbins are used in the mill this is not of any great importance, provided neither taper is excessive one way or the other. The point in this inequality lies in the fact that it indicates carelessness, and suggests that carelessness will be shown in other, and perhaps more important, directions in managing the machines. If the taper is too steep, there will be a slight difference in the amount that can be put on the bobbin, and a few minutes will be lost in extra doffing during a week, but it is better to be on the safe side rather than lose yarn and time in piecing.

An extensive variety of troubles or faults may arise in flyer frames, due to the mechanism, the adjustments, and the condition of the fed rovings. The irregular shape of the bobbin will suggest that wheels are not secure, that a tooth of a wheel is broken, excessive back-lash in the gearing, cone belt slipping or jerky, pieces of fluff in teeth of wheels, worn bearings, worn ratchet pawls, worn pigeon catches, balance weights of bobbin rail too heavy or too light, bobbin rail binding in the slides or spring pieces, etc.

Hard or soft bobbins may be looked upon as faults, or they may be produced purposely, according to the judgment of the management. A medium hard bobbin is generally to be considered desirable, as less likely to suffer damage and as exhibiting a nice degree of care in adjusting the frame. There must of necessity be a pull on the roving in being dragged through the eye of the flyer, along the hollow leg, and then being bent at right angles and wrapped round a presser. The twist in the roving, small as it is, will sustain this pulling up to a point, beyond which stretching begins. Testing of short lengths, say foot or at most yard lengths, will give results which will show if stretching occurs in obtaining a harder bobbin by putting another turn on the presser. Hard bobbins must always suggest stretching, but they need not be due to that cause. The condition of the cotton may permit a tighter winding; the judicious twisting and drafting in previous machines may assist in a harder bobbin, and of course *vice versa.* It is not advisable to put in extra twist to obtain a compact bobbin; this simply means a reduction of production and an extra risk of stretching. The friction in the flyer and the pressure of the paddle on the bobbin are permanent factors, so one cannot make any change in them, beyond the extra friction at the eye, and by putting more friction on the paddle by extra turns of the roving; but one can prevent soft or hard layers being put on, by seeing that perfect cleanliness is observed in the flyer, no accumulations of fluff on the top, or blocking or partial blocking of the leg by fluff carried down, or cotton catching or fluff resting on the paddle end where it is pivoted on the flyer leg. Where pressers are below the end of the flyer leg, they have a tendency to collect the fine fluff which continually falls down the leg, and if constant care is not exercised this fluff soon disappears on to the bobbin.

Wooden flats, clearers, etc., must be of perfectly seasoned wood, otherwise they will twist in all directions when used in the mill. Several bad faults arise through supplies of clearers, skewers, bobbins, etc., being obtained from firms or local dealers who have not the requisite conditioned timber.

Coils and Layers per Inch.—The number of these depends upon the thickness of the roving. The thickness of the roving depends upon the amount of twist in the roving, for obviously more twists per inch will make a roving thinner, and less twists will cause it to remain fuller or larger in diameter. For correct winding and building, it is necessary to have the coils on each layer touching each other, so that a good level surface is formed on which the next layer is to be wound. There ought to be no gaps between the coils as we find in a cop; they should be more like a sewing cotton spool. Carelessness in this respect is more or less responsible for the remarks frequently made that one maker's cone drums are better than others. This of course is not so, but any cone drum will be unsatisfactory if coils and layers are put on anyhow.

It is an easy matter to count the number of coils on the first layer of a bobbin after getting the coils near to each other, and also to take note of the number of layers put on per inch increase in diameter. This will give a good foundation upon which to work out the change wheels for the star wheel and the lifter wheel. Owing to the many changes in cotton and range of counts that occur in many mills to-day, it is as well to test the coils occasionally to see if the diameters of the roving have varied. If this is not done, the calculations based on some wheel in use, or some number of coils, may lead to errors.

If a 3-hank roving nicely covered the surface of the bobbin, and 109 coils are counted in 6 inches, this would give us $\frac{109}{6} = 18{\cdot}16$ coils per inch. If this number of coils per inch is divided by the square root of the counts, $\sqrt{3} = 1{\cdot}732$, we obtain $\frac{18{\cdot}16}{\sqrt{3}} = \frac{18{\cdot}16}{1{\cdot}732} =$ say $10{\cdot}5$, which is a constant number by means of which we can find the number of coils for other hanks. The rule would be: Multiply the square root of the hank by 10·5 = number of coils of roving per inch. From this we can deduce the lifter wheel.

Note that the roving spreads out on the bobbin so that it is not round but flattish, so that it is the width of the roving that we see. The depth of the roving or its thickness is less than the width, so in the number of **layers** built up on the bobbin we use a larger constant. Suppose we find that there are twenty-two layers in an inch. Proceed as before by extracting the square root of the hank and dividing it into the number of layers. So $\frac{22}{\sqrt{3}} = \frac{22}{1{\cdot}732} = 12{\cdot}7$ constant.

This constant number enables us to make a rule which reads: Multiply the square root of the hanks by 12·7 for the number of layers per inch.

EXAMPLE:

$$\sqrt{3} \times 12{\cdot}7 = 1{\cdot}732 \times 12{\cdot}7 = 22 \text{ layers per inch.}$$

This rule enables us to approximate to the wheel for the cone strap movement. Of course rules of this kind are only approximations, as carded, combed, and other conditions of the cotton vary, but if the constant is once found for the general work of the mill, it will hold good as a practical guide.

Twist Wheel.—This wheel is obtained by direct calculation. It drives the first rollers, so a larger twist wheel will increase the front roller speed and reduce the twists per inch. A smaller wheel will decrease the speed of front roller and so increase the twists per inch. The twists per inch vary inversely as the square root of the counts. That is, the thinner roving (represented by a bigger number) will have more twists than a thicker roving which is represented by a smaller number.

$$\therefore \sqrt{\frac{\text{twist wheel on}^2 \times \text{hank on}}{\text{hank required}}} = \text{required twist wheel.}$$

Ratchet Wheel, Star Wheel.—This regulates the distance moved by the cone drum strap for each layer added to the diameter of the bobbin, so it depends upon the thickness of the roving. One tooth is taken at a time for each layer, and all the wheels are the same diameter but vary in the number of the teeth. More teeth must be in the wheel for thin rovings, or finer hanks, than for thick rovings or coarser hanks. The proportion will be as the square root of the hanks.

$$\therefore \sqrt{\frac{\text{ratchet wheel on}^2 \times \text{hank required}}{\text{hank on}}} = \text{ratchet wheel required.}$$

Lifter Wheel.—This must be altered for change of hank or change of the thickness of the roving, whether the change is due to combed cotton, alteration of twist, or change of hank. The wheel will alter in proportion inversely as the square root of the hank.

$$\therefore \sqrt{\frac{\text{lifter wheel on}^2 \times \text{hank on}}{\text{hank required}}} = \text{new lifter wheel.}$$

General Remarks.—Absolute cleanliness is essential. Dirty machines and floors indicate bad organisation and very careless workers, and both reflect on the persons responsible. The maintenance of a friendly feeling with the operatives, and the same feeling among the operatives themselves, will do much to keep the machinery running smoothly. The mutual assistance of workers in doffing, etc., will save a lot of time. If all preparations are made for doffing by the fresh bobbins being laid down, the creel and top of flats wiped, and some signal to be given for the attendance of adjacent workers to come and help, the doffing is done in quick time. The causes of breakages ought to be carefully investigated, for they may occur through carelessness on the part of the operative, such as dropping flyers; denting or cutting leather rollers; scratching flutes; allowing pivots and bearings to get blocked with waste; scratching the eye of flyer; choked traverse guides; cotton wound round the skewer end; top support of skewer end choked; and many other small details on the machines. Changing the leather-covered rollers may be on some plan of allowing so many rollers per week, or a better plan is to inspect frequently and change a roller on it showing any signs of wear. At no time ought any one to be able to find a roller in other than perfect condition.

Cleaning and Oiling.—Brush out the interior of all bobbins occasionally by hand, or by fixing a brush on any revolving shaft end and passing the bobbin over the brush.

Wipe down the flyers at every doffing, and once at least between each doffing; a careful tenter will often pick off fluff and wipe down a flyer in passing along a frame.

Pick the clearers, top and under clearers every two hours.

Clean the frame end gearing and motions once per week, and oil once a day.

Oil once per day the bearings of top and bottom rollers, weight hooks and saddles; spindle shafts and other bearings twice a day.

Clean lifting chains and all gearing thoroughly, and grease about once per month. Take off casings covering the skew gearing of spindle and bobbins, and clean thoroughly every two months.

If self-oiling footsteps are used, re-oil every month, but for ordinary footsteps once a week will be necessary.

Collars and spindles must be oiled at least three times per week. This must be done carefully, otherwise surplus oil will be splashing about and the inside of the bobbins will get soaked with oil. The slightest crack in the bobbin will cause the oil to ooze out on to the surface of the bobbin and spoil the roving. Scour the fluted rollers and clean thoroughly the necks and strands every three months. Place the rollers on suitable supports when scouring so as to avoid straining them.

Become acquainted with the method of opening out the differential motion so that it can be cleaned out occasionally, say every six months.

See that the fluff, etc., is wiped or gently brushed off the machine and the waste carefully removed.

Oil that dries into a brown varnish on the metal parts of the machine must be avoided.

Hank to put up at Mule.—A very important factor in the economy of mill management is reached, when the decision is made as to the hank suitable to put up in the creel of the spinning machine for any given number to be spun. 12 to 13 hank is ample for up to 120's.

It is highly important that the lowest hank possible should be made on the last flyer frame. A tremendous amount of money is wasted in mills by producing too high or fine a hank roving for the mule. Fine hanks mean less production on the jack frame and increased cost in wages. In a modern mill, with its large number of jack frames and tenters, the loss in production and the increase in wages become a serious matter. Supervision and judgment in the preparation will give a roving that will pull off the creel of the mule, and it ought to be a matter of routine to find the correct twist to put in the roving to prevent ends breaking at the creel. If creel rods are arranged in their correct position, and the mule kept in good working condition, much coarser hanks and less twist can be used than is generally the case.

In some mills attempts are made to use a less twisted roving, but as the attempts have not been associated with a previous exercise of care in preparing the cotton, broken ends at the creel are common, and then recourse is had to the very bad practice of making a better mixing or a more twisted roving, both methods being a waste of money.

Any one who deliberately wastes money in being on "the safe side" by adopting the luxurious method of turning out too fine a hank on his jack frame, or who flies to the remedy of more expensive cotton, is not exercising his true managerial functions.

Probably the best method of arranging matters is to adopt a price list for twist wheels, that gives the tenter about ninepence over the minimum wage. This, of course, will mean a careful timing of doffing, stoppages, etc., and a thorough supervision of organised methods in doffing in order to save time. Any change of hank will then always result in the wage being just over the standard by the usual addition of so much pence for each tooth of the wheel. Many mills, unfortunately, start a price list per tooth before they have taken careful observations of lost time, or they have done it in such a way that tenters have been able to deceive them; as a consequence, tenters receive every week three and four shillings over standard, in spite of dilatoriness in all directions in attending to their frames. Responsibility for this loss must eventually rest on the management.

The list put up in the card room contains the prices to be paid, but it sometimes happens that dodges are resorted to which, while giving a fictitious appearance of adhering to the twist wheel price, enable changes to be made; altering the top cone speed is such a change. Avoid diddling the operatives by such means; if discovered, it simply means a loss of confidence in the management. A good plan to adopt is to place on the list a complete statement of the gearing and the constant, so that everything is above-board, and all wheels easily checked. Show every twist wheel to the tenter when making a change. Have every indicator correct, and don't have recourse to the use of "faulty" gearing in them; it is not cotton spinning.

SQUARE ROOT OF HANKS

Hank.	Square Root.	Hank.	Square Root.	Hank.	Square Root.	Hank.	Square Root.	Hank.	Square Root.
·1	·316	1·6	1·265	3·6	1·897	5·7	2·388	11·25	3·35
·15	·389	1·7	1·304	3·7	1·92	5·75	2·399	11·5	3·39
·2	·447	1·75	1·323	3·75	1·936	5·8	2·401	11·75	3·43
·25	·5	...	...	3·8	1·949	5·9	2·43	12	3·46
·3	·547	1·8	1·342	3·9	1·975	6	2·45	12·5	3·53
·35	·591	1·9	1·378	4	2	6·25	2·5	13	3·60
·4	·632	2	1·415	4·1	2·025	6·5	2·55	13·5	3·675
·45	·671	2·1	1·449	4·2	2·05	6·75	2·599	14	3·74
·5	·707	2·2	1·483	4·25	2·06	7	2·647	14·5	3·81
·55	·742	2·25	1·5	4·3	2·072	7·25	2·692	15	3·87
·6	·774	2·3	1·517	4·4	2·098	7·5	2·738	15·5	3·93
·65	·806	2·4	1·54	4·5	2·12	7·75	2·784	16	4
·7	·836	2·5	1·58	4·6	2·145	8	2·828	16·5	4·06
·75	·866	2·6	1·61	4·7	2·168	8·25	2·872	17	4·12
·8	·894	2·7	1·64	4·75	2·18	8·5	2·915	17·5	4·18
·85	·922	2·75	1·658	4·8	2·19	8·75	2·957	18	4·24
·9	·949	2·8	1·67	4·9	2·21	9	3	18·5	4·3
·95	·975	2·9	1·7	5	2·23	9·25	3·04	19	4·36
1·0	1·0	3	1·732	5·1	2·26	9·5	3·08	19·5	4·41
1·1	1·048	3·1	1·76	5·2	2·28	9·75	3·12	20	4·47
1·2	1·095	3·2	1·79	5·25	2·29	10	3·16	21	4·58
1·25	1·118	3·25	1·802	5·3	2·3	10·25	3·2	22	4·69
1·3	1·14	3·3	1·816	5·4	2·322	10·5	3·24	23	4·795
1·4	1·184	3·4	1·84	5·5	2·345	10·75	3·28	24	4·898
1·5	1·225	3·5	1·87	5·6	2·367	11	3·317	25	5

NOTE.—A complete series of drawings to illustrate the remarks in above chapter is given in the author's book, *Cotton Machinery Sketches*.

CHAPTER XI

SELF-ACTING MULE

Draws per Minute.—This is sometimes expressed as four draws in so many seconds, but the usual statement is to give the number of draws per minute. The following table gives the general practice:

Counts.	Length of Stretch.	Draws per minute.	Cotton.
	inches.		
16	66	5·25	American
20	66	5·25	,,
24	66	5·0	,,
30	64	4·83	,,
36	64	4·63	,,
40	64	4·5	,,
44	64	4·25	,,
50	64	4·0	,,
56	64	4·0	,,
60	64	4·0	,,
60	63 + 3 = 66	3·25	Egyptian
70	63 + 3 = 66	3·0	,,
80	63 + 3 = 66	2·75	,,
90	63 + 3 = 66	2·5	,,
100	60 + 3 = 63	2·5	,,
110	60 + 3 = 63	2·25	,,
120	60 + 3 = 63	2·15	,,

NOTE.—The addition of the 3 in. to the stretch is to allow for the roller delivery motion whilst winding. For finer counts each mill adopts its own length of stretch and speed, and is equipped with the short shaper, which enables this to be done easily.

Although a stretch is given as, say, 64 in., the changed angle of the yarn reduces this to 63 in. of yarn wound on. The stretch can be varied from 52 in. to 72 in., according to the numbers to be spun.

Productions and Speeds.—The intermittent action of the mule places a limit on the production, owing to the various changes in the mechanism requiring definite intervals of time to enable the change to be made correctly. Slight modifications can be made, but in general the following table represents a good average production and speed of spindle. Allowances have been made for stoppages and cleaning.

INDIAN AND AMERICAN COTTON

Counts.	Speed of Spindle.	Hanks per Spindle in 10 hours.	Lbs. per Spindle in 10 hours.
16	7,690	5·84	0·354
18	8,150	5·84	0·315
20	8,594	5·84	0·281
22	9,000	5·84	0·256
24	9,405	5·84	0·235
26	9,783	5·84	0·217
28	10,170	5·84	0·201
30	10,272	5·75	0·191
32	10,330	5·66	0·177
34	10,396	5·57	0·162
36	10,472	5·49	0·152
38	10,500	5·40	0·141
40	10,511	5·31	0·132
42	10,507	5·22	0·124
44	10,487	5·01	0·116
46	10,459	5·00	0·109
48	10,405	4·96	0·102
50	10,350	4·87	0·097
52	10,300	4·78	0·092
54	10,245	4·70	0·086
56	10,185	4·60	0·081
58	10,015	4·51	0·077
60	9,940	4·42	0·072

EGYPTIAN COTTON

Counts.	Speed of Spindle.	Hanks per Spindle in 10 hours.	Lbs. per Spindle in 10 hours.
30	9,900	5·663	0·188
32	9,840	5·221	0·163
34	9,780	5·115	0·150
36	9,720	4·991	0·138
38	9,660	4·867	0·127
40	9,600	4·778	0·119
42	9,540	4·708	0·112
44	9,480	4·637	0·105
46	9,420	4·566	0·099
48	9,360	4·500	0·093
50	9,300	4·424	0·088
52	9,240	4·354	0·083
54	9,180	4·283	0·079
56	9,120	4·212	0·073
58	9,060	4·141	0·071
60	9,000	4·070	0·067
62	8,940	4·017	0·064
64	8,880	3·964	0·061
66	8,820	3·911	0·059
68	8,760	3·858	0·056
70	8,700	3·805	0·054
72	8,640	3·752	0·052
74	8,580	3·700	0·049
76	8,520	3·646	0·047
78	8,460	3·592	0·046
80	8,400	3·540	0·044
82	8,340	3·486	0·042
84	8,280	3·433	0·040
86	8,220	3·380	0·039
88	8,160	3·327	0·037
90	8,100	3·274	0·036
92	8,040	3·221	0·034
94	7,980	3·168	0·033
96	7,920	3·115	0·032
98	7,860	3·062	0·031
100	7,800	3·000	0·031

SEA ISLANDS COTTON

Counts.	Speed of Spindle.	Hanks per Spindle in 10 hours.	Lbs. per Spindle in 10 hours.
70	7,139	3·500	0·049
75	7,106	3·430	0·045
80	7,073	3·362	0·041
85	7,040	3·295	0·038
90	7,007	3·228	0·035
95	6,974	3·160	0·033
100	6,937	3·092	0·030
105	6,904	3·020	0·028
110	6,893	2·957	0·026
115	6,837	2·888	0·024
120	6,811	2·823	0·023
125	6,743	2·755	0·022
130	6,690	2·688	0·020
135	6,592	2·620	0·019
140	6,490	2·552	0·018
145	6,385	2·485	0·017
150	6,280	2·416	0·016
155	6,175	2·348	0·015
160	6,070	2·281	0·014
165	5,960	2·212	0·013
170	5,866	2·145	0·012
175	5,680	2·077	0·011
180	5,525	2·000	0·011
185	5,385	1·941	0·010
190	5,260	1·874	0·009
195	5,150	1·807	0·009
200	5,050	1·738	0·008
210	4,900	1·670	0·007
220	4,760	1·603	0·007
230	4,630	1·534	0·006
240	4,510	1·467	0·006
250	4,400	1·400	0·005
260	4,303	1·332	0·005
270	4,109	1·265	0·004
280	3,925	1·196	0·004
290	3,747	1·130	0·004
300	3,575	1·062	0·003

Diameters of Rollers.—As in other machines, the diameters of the three lines of rollers vary according to the cotton.

Cotton.	Diameters of Rollers in Inches.					
	Bottom Rollers.			Top Rollers.		
	Front.	Mid.	Back.	Front.	Mid.	Back.
Indian . . .	$\frac{7}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	$\frac{11}{16}$	$\frac{11}{16}$	$\frac{11}{16}$
American . .	1	$\frac{3}{4}$	1	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$
Egyptian . . .	$1\frac{1}{16}$	$\frac{7}{8}$	$1\frac{1}{16}$	$1\frac{1}{8}$	$\frac{7}{8}$	2
,, . . .	$1\frac{1}{16}$	$\frac{7}{8}$	$1\frac{1}{16}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$

As the rollers are set within the length of the staple, this may account for the diameters, but there appears very little reason why they should vary for different cottons. The smaller the middle roller the better the drafting.

Twists per Inch.—This may be anything one pleases, but allowances have to be made to the operatives, for any variation from what has been decided upon as the standard twists per inch. The following table is based on the standard twists. Alteration of twist, of course, alters production.

TABLE OF TWIST PER INCH AND SQUARE ROOT OF COUNTS

Rules

INDIAN AND AMERICAN COTTON

Mule twist . . .	Multiply square root of counts by	3·75
Mule weft . . .	,, ,, ,, ,,	3·25
Ring frame twist .	,, ,, ,, ,,	4

EGYPTIAN COTTON

Mule twist . . .	Multiply square root of counts by	3·606
Mule weft . . .	,, ,, ,, ,,	3·183
Ring frame twist .	,, ,, ,, ,,	3·606

Counts.	Square Root of Counts.	Indian and American Cotton.			Egyptian Cotton.		
		Mule Twist.	Mule Weft.	Ring Frame Twist.	Mule Twist.	Mule Weft.	Ring Frame Twist.
1	1·000	3·75	3·25	4·00			
2	1·414	5·30	4·60	5·65			
3	1·732	6·49	5·62	6·92			
4	2·000	7·50	6·50	8·00			
5	2·236	8·38	7·26	8·94			
6	2·449	9·18	7·96	9·79			
7	2·645	9·92	8·59	10·58			
8	2·828	10·60	9·19	11·31			
9	3·000	11·25	9·75	12·00			
10	3·162	11·85	10·27	12·64	11·44	10·10	11·44
11	3·316	12·43	10·77	13·26	11·95	10·55	11·95
12	3·464	12·99	11·25	13·85	12·47	11·01	12·47
13	3·605	13·52	11·71	14·42	13·00	11·57	13·00
14	3·741	14·03	12·16	14·96	13·46	11·89	13·46
15	3·872	14·52	12·48	15·49	13·96	12·32	13·96
16	4·000	15·00	13·00	16·00	14·40	12·72	14·40
17	4·123	15·46	13·40	16·49	14·86	13·12	14·86
18	4·242	15·90	13·78	16·97	15·27	13·48	15·27
19	4·358	16·34	14·16	17·43	15·71	13·87	15·71
20	4·472	16·77	14·53	17·88	16·09	14·21	16·09
22	4·690	17·58	15·24	18·76	16·88	14·91	16·88
24	4·898	18·37	15·92	19·59	17·63	15·57	17·63
26	5·099	19·11	16·57	20·39	18·35	16·21	18·35
28	5·291	19·84	17·19	21·16	19·04	16·83	19·04
30	5·477	20·54	17·80	21·90	19·75	17·42	19·75
32	5·656	21·21	18·38	22·62	20·40	18·00	20·40
34	5·830	21·86	18·95	23·32	21·02	18·55	21·02
36	6·000	22·50	19·50	24·00	21·64	19·09	21·64
38	6·164	23·11	20·03	24·65	22·23	19·61	22·23
40	6·324	23·71	20·55	25·29	22·81	20·13	22·81
42	6·480	24·30	21·06	25·92	23·37	20·62	23·37
44	6·633	24·87	21·55	26·53	23·92	21·10	23·92
46	6·782	25·43	22·04	27·12	24·45	21·58	24·45

TABLE OF TWIST PER INCH, ETC.—*Continued*

Counts.	Square Root of Counts.	Indian and American Cotton.			Egyptian Cotton.		
		Mule Twist.	Mule Weft.	Ring Frame Twist.	Mule Twist.	Mule Weft.	Ring Frame Twist.
48	6·928	25·98	22·51	27·71	24·98	22·04	24·98
50	7·071	26·51	22·98	28·28	25·50	22·50	25·50
52	7·211	...	...	...	26·00	22·94	26·00
54	7·348	...	...	...	26·50	23·38	26·50
56	7·483	...	...	...	26·98	23·81	26·98
58	7·615	...	...	...	27·46	24·23	27·46
60	7·745	...	...	...	27·93	24·54	27·93
62	7·874	...	...	...	28·39	25·05	28·39
64	8·000	...	...	...	28·85	25·45	28·85
66	8·124	...	...	...	29·29	25·87	29·29
68	8·246	...	...	...	29·73	26·23	29·73
70	8·366	...	...	...	30·17	26·62	30·17
72	8·485	...	...	...	30·60	27·00	30·60
74	8·602	...	...	...	31·02	27·37	31·02
76	8·717	...	...	...	31·44	27·74	31·44
78	8·831	...	...	...	31·85	28·10	31·85
80	8·944	...	...	...	32·25	28·47	32·25
82	9·055	...	...	...	32·65	28·81	32·65
84	9·165	...	...	...	33·05	29·16	33·05
86	9·273	...	...	...	33·44	29·50	33·44
88	9·380	...	...	...	33·83	29·84	33·83
90	9·486	...	...	...	34·21	30·18	34·21
92	9·591	...	...	...	34·59	30·52	34·59
94	9·695	...	...	...	34·96	30·85	34·96
96	9·797	...	...	...	35·33	31·17	35·33
98	9·899	...	...	...	35·70	31·50	35·70
100	10·000	...	...	...	36·06	31·83	36·06
102	10·099	...	...	...	36·41	32·14	36·41
104	10·198	...	...	...	36·77	32·46	36·77
106	10·295	...	...	...	37·12	32·76	37·12
108	10·392	...	...	...	37·47	33·07	37·47
110	10·488	...	...	...	37·81	33·32	37·81
112	10·583	...	...	...	38·16	33·68	38·16
114	10·677	...	...	...	38·50	33·98	38·50
116	10·770	...	...	...	38·8	34·28	39·83
118	10·862	...	...	...	39·17	34·57	39·17
120	10·954	...	...	...	39·50	34·86	39·50

Space of Spindles.—The distance from centre to centre of spindles varies from 1 to $1\frac{1}{2}$ in. The usual space for twist cops is $1\frac{3}{8}$ in. and for pin cops or weft $1\frac{1}{8}$ in. It is very seldom that an inch space is used, and then only for the very finest yarns.

The usual size of a cop is $7\frac{1}{4}$ in. long by $1\frac{1}{4}$ in. diameter. Pin cops are $4\frac{7}{8}$ in. long by $\frac{7}{8}$ in. diameter. All kinds of intermediate sizes are spun, and are known as bastard sizes, whether of twist or weft. The special circumstances that dictate the size of the cop are outside the spinner's control. The manufacturers' requirements have to be met, and if sizes of shuttles or other conditions necessitate special sizes of cops in length, diameter, or both, a spinner can produce the cops, provided the space of spindles permits and it is a profitable deal. The space of spindles regulates the number of spindles that can be placed in a given length of mule, and to use any mule for spinning smaller cops is an economical problem for the business side to decide. Most mills spin twist and weft, so they are in a position to produce bastard sizes of either or both.

The weight of cops of the same size and counts may vary. This will depend on differences in shape of cop bottom, chase, kind of tubes, starching, diameter and taper of spindle, length of stretch, humidity, etc. Under exactly the same conditions it may be taken for granted that the finer the counts the heavier the cops will be, owing to the more compact nature of the yarn and less free spaces between the layers and coils.

Roller Settings:

Cotton.	Distance from centre to centre of	
	Front and Middle.	Middle and Back.
Indian	$\frac{7}{8}$ in.	$1\frac{1}{2}$ in.
American . . .	$1\frac{1}{8}$,,	$1\frac{5}{8}$,,
Egyptian . . .	$1\frac{1}{4}$,,	$1\frac{5}{8}$,,

Note.—These are given as guides. The general rule is to set the front and middle rollers inside the length of the staple. The middle and back setting is usually left to take care of itself by the fact that it is not often altered. The exact amount to allow, under the length of staple, is a matter of judgment; it may be anything from $\frac{1}{16}$ to $\frac{1}{2}$ an inch. This setting, of course, implies that the middle rollers are holding the back ends of the fibres, and the front rollers are drawing the front ends forward from the nip. In spite of the prevailing idea that the comber takes out the short fibres up to a predetermined length (quite a wrong notion), there are hosts of much shorter fibres lying free between the nips of the two rollers in both combed and carded cotton. This fact gives rise to quite a variation in the setting, but the setting is always within the length of the staple. The sizes of the rollers put a limit on the closeness of the setting. As an aid to improved drafting, near setting has been accompanied by very light self-weighted top middle rollers, which are now common enough, made of aluminium, boxwood or other substances or sizes that reduce the pressure on the middle roller. The excellent results obtained by some mills may be traceable to this judicious use of middle top rollers, and of course suitable settings combined with care in the preceding preparation. As stated in previous chapters, mere copying of such factors as the above is bad practice, unless a whole host of other details are also copied.

Driving and Power.—These are factors which exist in a mule as in all other machinery. They are pretty much taken for granted, but there is no harm in pointing out a few distinctive features of them. The intermittent action of a mule, and its variations in speeds, cause great changes in the power required to drive the machine during a complete cycle of its actions. When the carriage is at the roller beam and on the point of starting out, the carriage, spindles, and rollers have to be driven from the counter shaft through the rim shaft. This requires considerable power, and a very sudden strain is thrown on belts, bands, and bearings. The bulk of this power is necessary in overcoming the inertia of the spindles and giving them a speed of, say, 10,000 revs. per min., the mule being equipped with pulleys, etc., to obtain this speed instantaneously. The carriage takes only a small portion of the power, as can be seen when it occupies a stationary position on completing its outward run and then commences its run-in; the power required to do this is very little. This initial high power in starting the mule out varies according to new machine, length of mule, spindle speed, new belts and bands, etc., and it may be anything from 20 to 50 horse-power acting for a fraction of a second, and gradually being reduced to, say, 12 horse-power. A glance at the belt from the line shaft to the counter shaft will indicate very clearly the severe strain under which it is working. Rim bands and spindle bands exhibit the same effect. The practical side of this driving assumes an importance in the management of a mill. In the first place, bearings ought to be kept in a good condition and well lubricated. Ball bearings would be a boon if they could be adapted. Belts ought to be of the best, and of a strength capable of supporting the strain for a lengthened period. Constant breakage of belts shows that they are too weak or are of a very inferior quality. Breakages of ropes and bands will occur frequently with inferior material. Very tight belts and bands simply increase friction, but at the same time reduce slippage. Slack belts, ropes, and bands will drive, but a great loss occurs through slippage. The best method to adopt in settling these matters is to discard calculated speeds of counter shaft, rim shaft, and spindles, and to use a tachometer to obtain the speeds direct. Every overlooker ought to be provided with such a speed indicator, instead of its being used as a luxury when a mill happens to possess one. By use of the tachometer the speed of the spindle will be found to increase as the carriage runs out, and among hundreds of tests made it has not been uncommon to find the speed gradually increase up to the full stretch and then be a good bit short of the calculated speed. On some mules with tight straps, ropes, and bands the spindles will attain their full speed by the time the carriage has moved a foot to 18 inches away from its starting point. The instrument applied to the counter shaft and rim shaft will show the tremendous slippage that occurs in starting up; and if simultaneous readings are taken of rim shaft and spindles, one can obtain the revs. of spindle to one of the rim shafts exact at any part of the stretch. The results of this method will be quite different from the calculated particulars of these speeds after allowing for slippage.

Excessive breakages of ropes on one or two mules working under similar conditions to other mules must be looked on as an indication that the ropes have been excessively tightened to prevent slippage and to obtain production.

Turns of Spindle for one of Rim:

Dia. of Rim Pulley. In inches.	Dia. of Tin Roller Pulley. Inches.	Dia. of Tin Roller. Inches.	Revs. of Spindle with		
			$\frac{3}{4}$-in. warve.	$\frac{7}{8}$-in. warve.	1-in. warve
11	10	6	8·20	7·03	6·14
11	11	6	7·63	6·54	5·72
11	12	6	6·83	5·85	5·12
11	13	6	6·30	5·40	4·72
12	10	6	8·95	7·75	6·84
12	11	6	8·14	7·04	6·22
12	12	6	7·46	6·46	5·70
12	13	6	6·88	5·89	5·16
13	10	6	9·70	8·40	7·41
13	11	6	8·82	7·56	6·61
13	12	6	8·08	7·00	6·18
13	13	6	7·46	6·46	5·59
14	10	6	10·44	9·05	7·98
14	11	6	9·50	8·14	7·13
14	12	6	8·70	7·54	6·65
14	13	6	8·03	6·88	6·12
15	10	6	11·19	9·70	8·55
15	11	6	10·17	8·72	7·63
15	12	6	9·32	8·08	7·13
15	13	6	8·61	7·38	6·46
16	10	6	11·93	10·34	9·12
16	11	6	10·84	9·29	8·13
16	12	6	9·94	8·62	7·00
16	13	6	9·18	7·87	6·88
17	10	6	12·68	10·29	9·70
17	11	6	11·53	9·88	8·65
17	12	6	10·57	9·16	8·08
17	13	6	9·75	8·35	7·31
18	10	6	13·43	11·64	10·27
18	11	6	12·21	10·46	9·16
18	12	6	11·19	9·59	8·55
18	13	6	10·33	8·85	7·77
19	10	6	14·17	12·28	10·84
19	11	6	12·88	11·04	9·66
19	12	6	11·81	10·23	9·03
19	13	6	10·90	9·34	8·17
20	10	6	14·92	12·93	11·41
20	11	6	13·56	11·62	10·17
20	12	6	12·43	10·77	9·50
20	13	6	11·47	9·83	8·60

Deduct 6 per cent from above for slippage.

Rule:

$$\frac{\text{Dia. of rim pulley, in.} \times \text{dia. of tin roller, in.}}{\text{Dia. of tin roller pulley, in.} \times \text{dia. of warve, in.}} = \text{revs. of spindles.}$$

EXAMPLE:—Add $\frac{1}{16}$ in. to the dias. of tin roller and warve to allow for band.

$$\frac{15 \text{ in.} \times 6\frac{1}{16} \text{ in.}}{10 \text{ in.} \times \frac{13}{16} \text{ in.}} = \frac{15 \times \frac{97}{16}}{10 \times \frac{13}{16}} = \frac{15 \times 97 \times 16}{10 \times 16 \times 13} = 11{\cdot}19 \text{ revs.}$$

$$\text{less 6 per cent} = \frac{(100 - 6) \times 11{\cdot}19}{100} = 10{\cdot}74 \text{ revs. of spindle.}$$

A table of spindle revs. can be drawn up to suit any other particulars not given in the foregoing table.

Gain or Drag.—This is the difference between the speed of the carriage and the surface speed of the front roller. In most cases it is represented by the length of the stretch minus the length delivered by the front roller.

Counts.	Gain or Drag.	Stretch.	Cotton.
	Inches.	Inches.	
30	$\frac{1}{2}$	64	American.
40	3	64	,,
50	$3\frac{3}{4}$	64	,,
60	5	62	Egyptian.
70	$5\frac{3}{4}$	62	,,
80	7	60	,,
90	$7\frac{1}{2}$	60	,,
100	$7\frac{1}{2}$	58	,,
110	$8\frac{1}{2}$	58	,,
120	$8\frac{1}{2}$	56	,,
130	9	56	,, Sea Islands.
140	$9\frac{1}{2}$	54	,, ,,
10	2-in. loss	66	Indian and American.
20	1-in. ,,	64	,, ,, ,,

The **gain** is a drafting effect and must be taken into account.

Draft due to Grain:

Gain in inches.	1	1½	2	2½	3	3½	4	4½	5	6	7	8
Draft 64 ins. stretch.	1·016	1·024	1·032	1·041	1·049	1·058	1·066	1·075	1·085	1·103	1·122	1·143
Draft 62 ins. stretch.	1·016	1·024	1·033	1·042	1·051	1·060	1·069	1·078	1·088	1·107	1·126	1·148
Draft 60 ins. stretch.	1·017	1·025	1·034	1·043	1·053	1·062	1·071	1·081	1·091	1·111	1·130	1·153
Draft 58 ins. stretch.	1·017	1·025	1·036	1·045	1·055	1·065	1·074	1·084	1·094	1·116	1·136	1·160

Rule:

$$\frac{\text{stretch}}{\text{stretch} - \text{gain}} = \text{Draft of carriage.}$$

EXAMPLE:

$$\frac{64 \text{ in.}}{64 \text{ in.} - 4 \text{ in.}} = \frac{64}{60} = 1{\cdot}066 \text{ draft.}$$

The Carriage.—This is fixed up and started in as good a condition as modern skill can make it. The whole of the motive power to drive it is through ropes and bands, and it depends on these bands to maintain a parallel movement. The stretching, wear, and breakages of the bands necessitate constant attention, and considerable skill in judging tension and obtaining satisfactory results. All mules are fitted with rope-tightening fixtures that allow for lengthening or stretching. If ropes stretch more than can be taken up by the fixture, the end of the rope is cut and re-knotted. Indications of something wrong with the bands are the bending of the carriage, the carriage not parallel with the roller-beam, a slight springing in or out of the out ends of the carriage at the finish of a stretch. The squaring-bands under the carriage should be kept taut and frequently inspected. Owing to their great length, stretching was excessive, so wire now forms the main part, rope only being used at the ends. Broken wire squaring-bands are readily pieced, but the piecing should be neat, so that no projecting ends at the piecings will catch on the under side of the carriage.

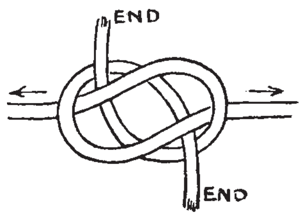
Experience only can be a guide as to the length of ropes to allow for any purpose. If any rope breaks, no matter where in its length, it means that other parts of the rope are more or less ready to break. If a rope has a habit of breaking near to its end, owing to being bent very severely over a small diameter, then a longer rope can be used, having a spare length to it, so that this extra length can be taken up; the same rope will then last two or three breakages. The fibres of the rope in the neighbourhood of a break will have been severely strained, so cut away a decent portion from the break before fixing it up again. If any of the bands show signs of breaking, by an unravelled appearance, do not wait for them to break; renew at once, otherwise more serious damage may be done than the mere breakage of a rope.

Quadrant band is the sole control of the quadrant, and it is a serious matter if the band breaks, as there is nothing to prevent the quadrant toppling forward.

Watch a new rope carefully after being put on, and have the carriage in an open position and not on the catch. Judgment alone can tell what length to put on to allow for the initial stretching.

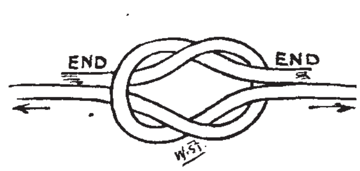
Spindle Bands.—All spindle bands should have a tendency to press the spindle down on its footsteps. The driving power of the band depends entirely on its friction with the surface of tin roller and warve, and it has no conical grip as in the rim band with its wedged grooves.

The tightness of the band is an important factor. When slack it will not drive the spindle, and when tight it means friction in the bearings. Judgment in the degree of tightness is necessary, and the lubrication must be of the best by using only the finest lubricant. The tying of the bands is considered important. The one most in use is the reef-knot; either the granny-knot or the reef-knot can be made, but in the granny-knot the ends project at right angles to the length of the band, whilst the reef-knot ends lie in



GRANNY KNOT.

FIG. 5.



REEF KNOT.

FIG. 6.

a line with the band. The two knots are shown as they look just before pulling them up tight.

The tightness of the spindle band can generally be judged by trying to stop a spindle between the finger and thumb.

Twist and Weft.—In a general sense these two terms refer to the direction in which the twist is put in the yarn. The twist yarn is also more twisted than weft yarn. Weft yarn is also softer and not so smooth as twist yarn, and is usually spun as a smaller cop on the mule. All these distinctions, however, merge into each other in the wide variety of cops made for different purposes.

On examining cops it will generally be found in a twist cop held up before you that the yarn has been wound on the cop, by revolving the spindle clockwise as you look down on the top of the spindle (see Fig. 7 at A). As the spindle reverses when backing off, it follows that a spindle when spinning twist-way revolves clockwise, as you look down on the top of the spindle or cop. This is clear, because twisting is simply the effort of the spindle to wind on the yarn; but owing to the inclination of the spindle, its taper, and the freedom of the yarn, winding is prevented by the constant slippage of the yarn over the spindle point.

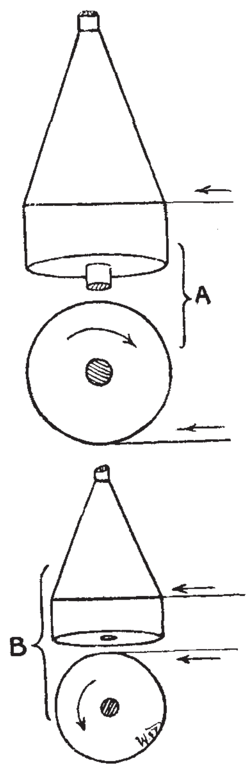


Fig. 7.

On the other hand, a weft cop is wound on in the opposite direction to a twist cop, as at B, Fig. 7, so that the winding-on direction is counter-clockwise, and the spinning direction is also counter-clockwise, as you look down on the spindle or cop point.

Twist yarn has its twists as shown in Fig. 8, and weft yarn as shown in Fig. 9.

Weft is sometimes spun twist-way, and twist weft-way, for special purposes. For some purposes both twist and weft are spun with the same twists per inch. Changing the direction of the spindle from twist to weft or *vice versa* simply means turning the spindle band, so that the driving side of the band is on the opposite side of the warve.

Note.—If the pull of the band when spinning one way has a tendency to keep the spindle down on its footstep bearing, by reversing the band the downward pull is still the same, as the tin roller always revolves one way except when backing-off.

Covering Friction Cone Clutches.—The leather covers of the cones require to be kept in good condition, and the lever must often be readjusted, as it wears down. Replacements are frequently necessary. The method of cutting out the leather is shown in the sketch (Fig. 10). Draw on some cardboard or thin wood the exact shape of the conical part of the cone as at A, B, C, D.

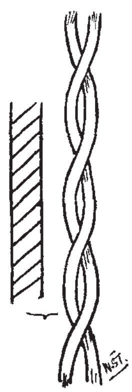


Fig. 8.

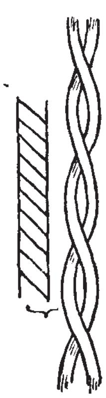


Fig. 9.

Produce the sides DC and AB to meet the centre line of the cone at E. From E as centre strike portions of circles with radius EB and EA. Find the circumference of the circle AD. If 16 in. dia. the circumference will be $16 \times 3 \cdot 1416 = 50\frac{1}{4}$ in. Now set the compasses to 5 in. and mark out on AG ten divisions each 5 in.; add a quarter of an inch. From G draw a line to E, cutting the inner circle in H. If the shape ABHG is cut out it will be found to fit the cone exactly. A wooden template can be made to this shape and used to cut out the leathers. Try the leather on the cone and cut it $\frac{1}{4}$ in. short. Stitch the ends so as to obtain a tight fit, then rivet up.

Every mill ought to have templates for leathers, and a few spare leathers on hand in case of emergency. Only the very best leather should be used, and it must be perfectly true in thickness, so as to give an equal grip all round.

As the leather wears, see that the rivets are not in contact with the interior cone. The amount of movement given to the cone in putting one into and out of gear varies according to the make of mule. Some are usually keen and prompt in action, whilst others get the grip gradually. The distance moved may be from $\frac{1}{4}$ to $\frac{1}{2}$ in.; this is a matter of regulation, and the overlooker soon discovers, from the

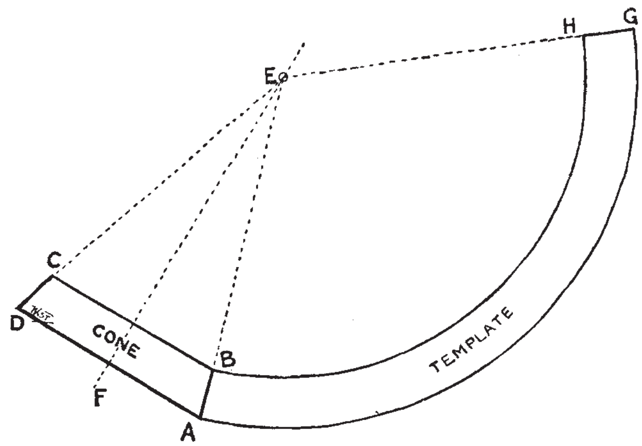


FIG. 10.

nature of the mechanism, and the inclination of the cone, as well as the condition of the leather, what amount of movement is best for the rate at which the mule is working.

Use castor oil on friction leathers.

Always rivet-on the leather. Do not peg it on.

Squeaking is due to dry and smooth leather.

Broken Ends.—The bulk of broken ends in the mule may be traced directly or indirectly to the presence of small bits of jute or hemp. These get into the cotton from the packing and sewing material used in loose baling and press baling, in sampling, patching, and general rough treatment to which bales are subjected. Some is mixed with the cotton through carelessness in the bale room of the mill. The bits are present in combed yarn almost as common as carded. If every mill had a microscope and examined some of the broken ends of yarn, and also the bits at the traverse guide, the injury these bits of jute, etc., do to yarn would be more apparent, and cause very serious complaints to be made to the suppliers of the cotton. If not causing a breakage in the spinning, these bits or specks are one of the causes of dirty yarn. Irregular roving and weak roving will break either before and after drafting. Too much "gain" will cause breakages. Bad ends are caused by fluff flying about, dropped waste on the roving, or the yarn or bits that have escaped from the clearers. The following are also responsible for bad ends:—

The clearers not being in contact with the rollers and not clearing them of adhering bits and fibres. Choked traverse guides, both back and middle, through not cleaning them. Piecing up breakage in the yarn carelessly, and also bad piecings in the roving when creeling. After picking the top rollers, putting them back with a drop instead of gently; this produces thin and thick places or cut yarn. Cut leather rollers. Dirty creels and creel pigs. Badly-set scavenger or a neglected scavenger. Excess lapping of the clearers. Putting bobbins on the creel board before the creel has been cleaned. Leaving bobbins on the creel too long, especially near the headstock. Dirty bobbin skips. Belts left in a dirty condition. Careless brushing down, batting, or beating the fluff away are bad practices. Dirty roller hooks. Carelessness in picking faller wires and sickles. Allowing bits of waste to fall down when picking top roller pivots. Dirty creel rods, wires, or tubes.

Fanning before brushing or wiping down. Pieces dropped on the floor and picked up, generally pick up fluff and dirt. Pieces of waste or spindle band lodging in footstep bearing. All kinds of dirt, neps, bits of leaf, seed scale, particles of crushed seed left in the cotton from the previous processes.

Some of the above may not cause breakages during the spinning, so if they pass on to the cop they give a dirty appearance and deteriorate the yarn, and render it useless for some purposes. They are serious faults, and must be broken out when seen.

A dry atmosphere is a prolific cause of fluff flying about and producing faulty yarn.

Clearers made of wood that is not well seasoned will become distorted and be a serious cause of bad ends. Only the best seasoned wood should be used for clearers.

A cause of bad ends is to be seen in the removal of the middle top roller and carrying it for a draw during the piecer's removal of the roller lap or on the pivot. In cases of this kind, which are not uncommon, the front roller is drafting from the back roller, the middle roller not being in action through the absence of the top roller.

The careless use of castor oil and other substances on the line shaft belt frequently causes the flutes of the rollers beneath to become completely clogged with a hard, solid dirt which is difficult to remove, and which interferes with correct drafting.

Stained and Dirty Yarn.—These are caused by some of the items just mentioned, and come under the designation of bad ends. The piecing-up at the creel or of the yarn with dirty or oily fingers leaves a mark. Sometimes oily fingers, if clean oil is on them, may not leave a mark that is observable, but in the bleaching and dyeing processes these places stand out very clearly, and are a serious cause of complaint. When cops remain on the spindle for a long time, as in spinning fine counts, there is a tendency for them to be coated with the impurities flying about in the atmosphere, especially in foggy weather. Special precautions are necessary to exclude fog, etc., and to pass all air admitted to the room through purifiers, and at the same time charge the air with pure moisture.

The immediate neighbourhood of the headstocks and under belts from line shaft to counter shaft are places likely to be spotted with oil and dirt, both on creel bobbins and the yarn. Oil on the leathers, due to careless use of the oil-can in putting too much oil on, or through a wrongly shaped oil spout, will spoil the yarn.

Faults.—A statement of some of these or the causes that may produce them will suggest the remedies required. Yarn may be weaker than it ought to be, through keeping it at too high a tension, or by changing the fallers too quickly, or by starting the carriage out too suddenly. If the scroll bands start on too large a diameter, they give a quick, jerky start to the carriage; and if they finish in drawing-up on too large a diameter, the carriage comes in with a bang. The scrolls ought to work in perfect unison, and not opposed to each other either through differences in the diameters of the bands, or differences in their starting and finishing positions on the scrolls. The check scroll, if set correctly, will keep a nice tension, and only show the slightest tension in preventing the carriage overrunning the drawing-up scrolls when the carriage runs in. The long and short bands from the back shaft scrolls must be carefully adjusted in regard to the amount of incline used. Usually this adjustment must be made experimentally; and when the correct amount has been found, a mark can be stamped on the scrolls as a guide.

The weighting of the fallers requires careful adjustment. The total weight must be such as to keep the wire in a steady position at a reasonable distance above the spindle points. A too sudden change puts a severe strain on the yarn, and too great a movement also has the same effect. On the other hand, too slow a movement and too low a position of the counter faller wire will cause snarls to develop from the slack yarn. Owing to the fact that the counter faller wire is equally loaded in its whole length by the force exerted by the pull of the yarns, the faller must be weighted to just balance this pull, and the weighting distributed along the length of the fallers to neutralise the torsion. Very often equal weights are put on each lever, but really they can be reduced at each lever from the headstock to the out ends. See that the backing-off chain-tightening motion is acting correctly. Serious results will follow if the **return band** fails to wind back the quadrant chain drum. Adjust it so that it does not touch the floor or bump against the framing. If the slightest sign of fraying is noticed, replace it at once with a new band.

Jacking or Ratching Motion.—This requires careful adjustment. When the rollers stop delivering, the carriage continues to move very slowly indeed. This draws out the thick places, which are much less twisted than the thin places, and the twist runs in to these drawn-out portions and levels the yarn. Excessive ratching will rupture the yarn. Long-stapled cotton will stand more ratching than shorter kinds. Sometimes a ratching effect is obtained by altering the amount of incline on the scrolls on the back shaft. It is extremely doubtful whether the Jacking effect does permit the twists to run up into the drawn-out thick places. The soft thick places may be drawn out into a thinner condition, but equality of twisting will not take place, so that, whilst the yarn may look a little more regular, it will contain the weak spots all the same.

Spindles, Length, Bevel, and Taper.—With the exception of the bevel, the spindles are more or less fixed. The length of spindle varies according to the cop required, the finer counts using a shorter spindle than the coarse counts. Taper and thickness of the spindle point are regulated by the average counts to be spun on the mule: fine ends for high counts and blunter ends for coarse yarns. The ends must be perfectly smooth.

The spindle tops must all be perfectly level, and adjustments are provided to effect this. Every slip must be quite level, so that there is no twisting of the carriage as it travels to and fro. Pack the slips if any show signs of having sunk, or the floor shrunk, warped, or otherwise become deranged. Keep the slips free from dirt, bands, waste, or anything that will cause the carriage bowls to jump. The carriage may require readjustment at times, so carefully scrutinise the running of the bowls, to see that they are running freely on the slips, and not rubbing on the flanges. Adjust faller rods after levelling the spindles or topping.

The bevel of the spindles may not be suitable for the yarn. The yarn may bunch at the point, or more than one coil may slip off. A little more bevel in one case and a little less in the other will be required. The general height of the spindles, in relation to their distance below the nip of the front rollers, may require adjustment; the angle of the yarn with the bevelled spindle naturally varies from the beam to the end of the stretch.

The Quadrant.—This mechanism controls the speed of the spindles during winding, as the carriage runs in. An elementary statement of its action may be made as follows:—

When the nut is at its lowest position on the quadrant arm, its forward movement is slight, so that as the carriage runs in a long length of chain is unwound from the winding drum, and this unwinding will be uniform. Since **the length of chain unwound gives us the rate at which the spindle revolves**, we are able to say that the spindle revolves quickly and practically uniformly the whole stretch. It is therefore revolving the spindle to wind on a given length of yarn on a small diameter, and on a diameter that does not vary; in other words, on a bare or almost bare parallel spindle.

When the nut is in its highest position on the quadrant arm, it describes an arc of a circle, and at the commencement of the run-in its movement follows the carriage, so that very little chain is unwound at this point, and the spindles revolve slowly. As the quadrant arm continues to move in its path of a quarter of a circle, the nut moves gradually in a downward direction, so a gradually increasing length of chain is unwound from the drum; the spindles therefore start slowly, and gradually increase in speed.

This shows that winding is taking place on a large diameter at the start and finishing on a small diameter.

The quadrant, therefore, revolves the spindles at suitable speeds to wind, at the start, on a parallel surface, and gradually alters the speed so that the yarn can be wound on a surface that becomes more conical at each layer of yarn added.

The shaper guides the yarn on as the spindle revolves.

The foregoing remarks apply to the winding layer. The **crossing** layer is also wound on a parallel layer at the start of a cop, and on a gradually increasing layer as the cop builds. In these crossing layers there is no variation of speed given to the spindles during any single layer.

This portion of the winding is done whilst the quadrant nut is moving in practically a straight path, usually that portion of the quadrant's movement that is outside a vertical line through the quadrant shaft. The shaper guides this crossing layer on the cop, and takes up the ten inches or so of yarn as the carriage moves in this distance before the winding layer begins.

The spindle winds on the same length of yarn every draw, from which it follows that, since the shape of the surface of the cop bottom is constantly changing, the number of coils of yarn on both winding and crossing layer is different in each layer. The coils are close together on the first layer, and wider apart on the last layer of the cop bottom.

The quadrant has nothing to do with the form of the cops; it must work in unison with the shape given by the shaper. The nut must travel up the quadrant screw to wind on each stretch at a uniform tension. This movement is effected by the minder by hand or by some automatic appliance, called a strapping or governor motion, which acts when the yarn between the rollers and the spindles alters in tension. Incorrect speeds of spindle will result in deformed cops, soft and hard cops, or partly soft and partly hard.

As the highest speed is given to the spindles when the quadrant is at its lowest position towards the rollers, it is possible that winding-on may be too keen and the yarn be strained. Such a condition can be remedied by moving the quadrant a tooth back, which will cause a slight decrease of speed throughout the stretch, and give a correct finishing speed. Alterations in stretch require a change of wheel driving the quadrant. The quadrant ought to finish its movement at the same spot or angle for any given finishing diameter. Nosing motions provide for unwinding more chain to allow for the finishing diameter becoming less on account of the taper of the spindle. Any stretching of the quadrant band or inequalities in its diameter, or even a difference in the diameter of the band when replacing it, will alter the winding, and give trouble until it is remedied. Some firms use a chain instead of a band, especially on fine mules.

Shaper.—This piece of mechanism is sent out by the makers in a condition that never requires any alteration to the special forms of the plates, rail, etc. Damaged plates due to accident or carelessness had better be replaced at once by new ones, unless the necessary skill can be displayed in filing and compensating for the amount filed off. Adjustments in the position of the plates and rail are readily made to suit the size and shape of cop that is desired. The cop bottom depends upon the coning parts of the plates. These parts are generally marked to show where to commence for twist and weft cops, as the diameter of the cop bottom is regulated by the amount or length of the coning used. Any faults in the cop bottom may be traced to these parts of the shaper if the shaper is the cause. The long parallel body of the cop depends on the straight inclined portion of the plates.

The smooth, even character of the chase depends upon the upper surface of the shaper rail.

The length of the chase depends upon the inclination of the rail; this inclination is controlled by the relative positions of the plates on which the rail rests.

The adjustment of the plates enables one to build small- or large-diameter cops, with varied lengths of chase and, within limits, any length of a cop.

By using a little more or less of the coning parts, and by careful adjustments of the height of the rail by means of the screw on the front of the long rail, it is possible to remedy faults in the cop bottom. Any alteration in the height of the rail, however, must be compensated for by a similar alteration in the faller leg. Raising the rail means shortening the faller leg, and *vice versa*.

Faulty Cops.—On examining a faulty cop, so far as its shape is concerned, one might readily say what part of the shaper could have produced it, and suggest a remedy by filing, etc., but this is not permitted. There are hosts of other causes that are responsible for faulty cops, a few of which will now be stated.

Ridgy Cops:

(*a*) Pieces of waste on surface of plates on rail.

(*b*) If the shaper bowl through any cause becomes worn in places and has what are termed flats, an eccentric movement will result and the faller leg will be given a jerky movement.

(*c*) Shaper bowl loose on its stud through wear.

(*d*) Shaper bowl loose through screws coming loose, or not screwed up tightly.

(*e*) Shaper bowl on the skew. The bowl should run evenly on its full width.

(*f*) When the faller leg locks over a bowl, and the bowl is badly fitted.

(*g*) The faller leg may not always lock exactly in the same position. There should be no room for variation in the locking.

(*h*) Waste under faller leg recess or on bowl or slide may adhere for longer or shorter periods.

(*i*) The copping faller rod loose in its bearings in places or in the full length, causing ridges in a few cops or generally.

(*j*) Shaper screw may be untrue or have become damaged, or the nut does not work smoothly. The nut may bind in one part of the screw and be loose in other parts.

(*k*) Failure of the tumbler to move the ratchet wheel regularly by missing teeth.

(*l*) Backing-off sector loose on the faller rod.

(*m*) Carriage loose in the square.

(*n*) Teeth of the quadrant not geared deep enough.

(*o*) Bent faller rods and badly fitted.

(*p*) Sector studs loose.

(*q*) Loose faller sickles.

(*r*) Weak faller wires and not well supported.

(*s*) Copping plates worn.

(*t*) Drawing-up friction cone slipping.

(*u*) Waste getting between quadrant pulley and rope.

Long and Short Cops in the same Set.—The cause is to be sought for in the fallers and wire.

(*a*) Weak faller rods.

(*b*) The faller rods may be binding at the out ends.

(*c*) The faller weighing too heavy at the out ends.

Soft Cops.—These may be made soft purposely, and may be produced—

(*a*) With a poor quality of cotton and light weighting of fallers to prevent breakages when backing off and winding.

(*b*) Good cotton with light twist.

(*c*) Starting the quadrant a little more forward.

If soft cops are not desired, their existence may be due to—

(*a*) The quadrant is not winding correctly; it is turning the spindles too slowly.

(*b*) The nut is too high up the quadrant.

(*c*) The quadrant starts too much forward.

(d) Driving strap touching the fast pulley on rim shaft.
(e) Worn part on the shaper rail where the two inclines are hinged.
(f) Faller rods binding in their stands.
(g) Difference in level between the slips on each side of the headstock.
(h) Tin roller loose.
(i) Neglect of or careless use of the nosing motions or nose peg.

Soft Cops near the Headstock.—These may be due to—

(a) Badly set drawing-up scrolls, or too large for the length of the stretch.
(b) Scrolls loose.
(c) Scrolls not working in unison.
(d) Weak back shafts.
(e) A coupling loose on back shaft.
(f) Scrolls loose on back shaft.
(g) Back shaft scrolls not set uniformly for start and finish of the inward run.
(h) Using bands that differ in their elasticity or stretching properties, often noticed in old and new ropes working together.

Thick and Soft Noses.—These may be due to—

(a) Delay in using the nose peg.
(b) Depressing the under or counter faller too soon, before the copping faller has unlocked.
(c) Backing-off chain too slack.
(d) Backing-off chain acting too quickly.
(e) A defect in the shaper which makes a hollow chase, causing soft noses and snarls.
(f) Bad adjustment of the quadrant.

Locking of the Faller Leg.—In a sense, the faller leg has no concern with the actual shape of the cop, provided it fits well on the slide carrying the bowl; yet, no matter how perfect the shape may be, the faller leg may have important influences on the formation of the cop, simply because it is the connecting link between the shaper and the faller wires. The faller leg must, therefore, lock perfectly and at the right time. The incline can be adjusted to suit the particular views of the overlooker, and

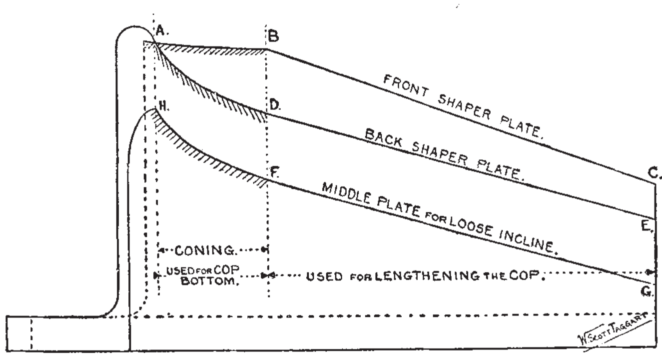


FIG. 11.—Copping Plates.

differences of opinion exist as to the position of the faller wire when locking should take place, both at the beginning and at the end of a set. A good plan is to lock when the wire is about $\frac{1}{8}$ of an inch below the nose when starting a set, and to so adjust the incline that locking takes place about $\frac{1}{4}$ to $\frac{3}{8}$ of an inch at the finish of the set. This is simply a matter of experience. Deep-locking will give a hard nose and probably not "ready" so easily.

The Curves on the Shaper Plates.—So far as the subject of the shaper has been considered in the previous pages, we have accepted the form of the shaper plates as a fact, and naturally they have been taken for granted. Some readers may, however, desire to know more definitely why the coning parts have their special shape, and also why there should be the wide difference between the coning part of the front plate as compared with the coning part of the back plate. To explain this fully would involve a full description of the method for the design of a complete shaper. This would be a task quite unsuitable for these pages, and would appeal to only a few who are interested in the mechanical side. The problem is a comparatively easy one if full-sized drawings and very exact measurements are made, but for our present purpose conventional diagrams will be sufficient, as the object is simply to explain the coning curves.

Fig. 12 gives a diagrammatic representation of a cop on its spindle, the copping faller, and the positions of the faller leg stud or sector stud. The cop is divided into layers to show the change in length of chase, and the paths moved by the faller wire and the sector stud during the building of the cop are clearly shown. Straight lines are used to indicate the sector, such lines passing from the faller wire through the copping faller to the centre of the sector stud.

Let us now examine the diagram in Fig. 12. The copping wire, in putting on layers at AB, CD, EF, GH, and JK, will occupy, at the **commencement** of each of these layers, the positions marked at 1, 2, 3, 4, and 5, and at the **finish** of the layer the wire will have moved up to the new positions shown at 1^1, 2^1, 3^1, 4^1, and 5^1 respectively. We may reasonably assume that the faller wire will guide the yarn on the cop at right angles to the spindle, so if lines are drawn from the start and finish of each layer to meet the circular path of the faller wire, we obtain the positions 1, 2, 3, etc., etc. It is quite clear that the lowest point or the start of each layer corresponds to the highest

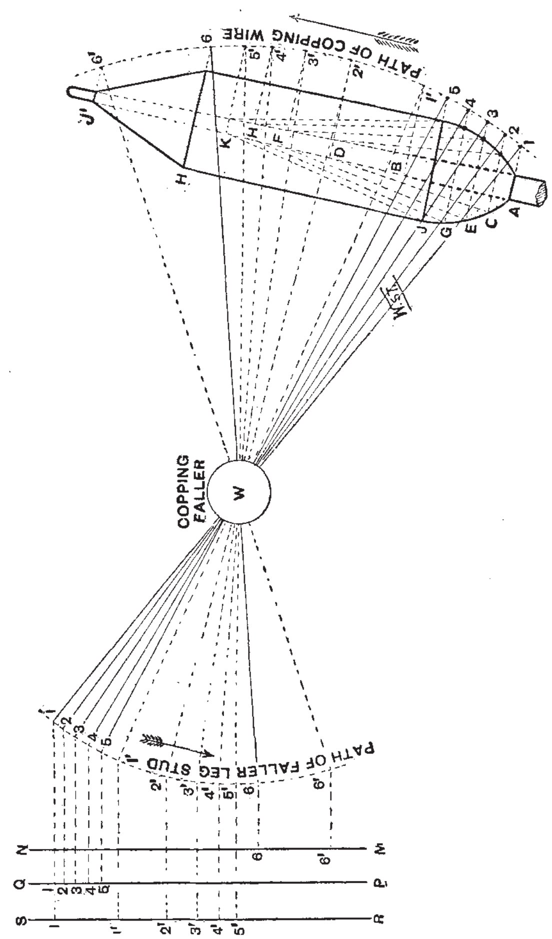


Fig. 12.

point of the shaper rail, viz. 1, so that, as the faller wire rises from 1 to 5 on the cop, the point 1 must fall from 1 to 5 on the shaper. In the same way the finishing points of each layer rise, so the end of the shaper rail J must fall in a corresponding manner. These respective rises and falls are obtained by drawing lines from the path of the faller wire, through the faller rod, to meet the sector stud path, and are indicated by similar numbers on this latter arc. Now, as the sector stud travels in a circular path, and the faller leg bowl in a vertical path, we must transfer the circular movement into a vertical one, and this can be done for our purpose by drawing a vertical line P Q, and from the points 1, 2, 3, etc., draw horizontal lines to meet it. All the points on the sector stud path, which correspond to positions of the faller wire, can be transferred to vertical lines in this way, and for the sake of clearness they have been split up into sets and marked out on separate vertical lines. Again, for the sake of simplicity we will assume that the point 1 on the shaper (see Fig. 13) falls at the angle of the steady bracket; from 1 downward are measured off divisions equal to the divisions 1 to 5 on the line Q P. Also on a vertical line from J on end of shaper mark off the divisions 1^1 to 5^1, as shown on the vertical line S R, these corresponding to the rise of the finishing points of each layer on the cop bottom. Now, since the plates all move together and at a uniform rate, we can mark out a set of equally spaced vertical lines, such as at A B C D E on the shaper diagram, and where these vertical lines cross the horizontal lines drawn from the points 1^1 to 5^1 we obtain intersections through which a curve can be drawn. This curve is shown, and it represents the coning part of the back plate and gives a good idea of this particular feature. To find the coning part of the front plate we must proceed as follows: From 1 to E represents the extension of the long shaper rail, and its end E rests on the start of the coning

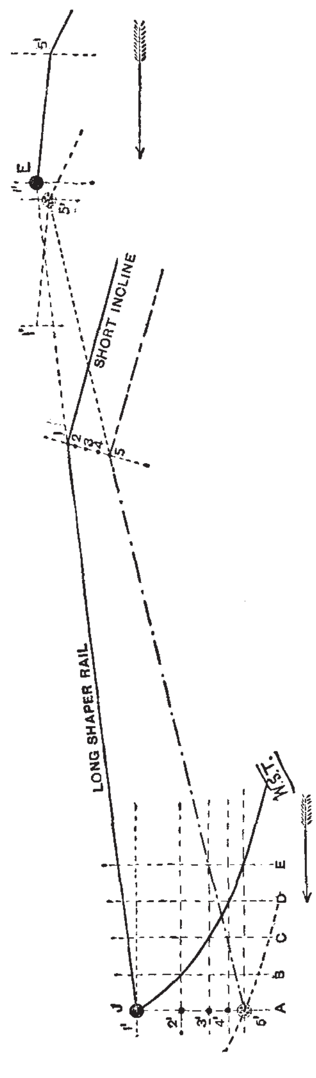

E
SHORT INCLINE
LONG SHAPER RAIL
J
A
B
C
D
E

FIG. 13.

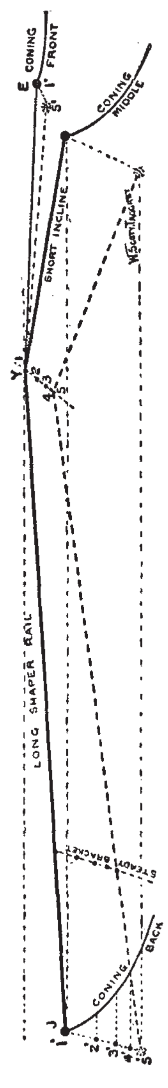

E CONING
FRONT
CONING
MIDDLE
SHORT INCLINE
LONG SHAPER RAIL
STEADY BRACKET
CONING
BACK
J

FIG. 14.

part. Now draw lines from each of the points 1^1 to 5^1, passing through points 1 to 5; the end E will be found to vary very little from its first position, so that the fall of E is extremely small. This can be seen clearly in the diagram. As the front plate passes under the point E, we can readily see that the outline of the plate must be almost straight, with an incline sufficient only to allow the end E to fall from 1^1 to 5^1. This outline is clearly shown, and it represents the coning part of the front plate. A comparison of the two coning parts shows a wide difference between them, and we can now easily understand that any slight alteration of shape in the coning part of the front plate will mean a considerable alteration in the back plate. As already said, this description makes no pretence to such accuracy as would enable a set of shaper plates to be designed; it is merely a rough-and-ready statement to explain how the coning parts of the plates come to differ so much in form.

A somewhat more exact drawing is given in Fig. 14, in order to show the influence of the steady bracket. All who know the shaper will note that it is guided at an angle somewhat near to the back end. The path of the shaper is fixed therefore at this point, and such being the case we have marked out the path made by each end of the shaper. The back end J falls at an angle; Y does the same at a different inclination. The end E has a short inclined path, and the end of the short incline of the shaper, where it rests on the loose shell or middle plate, is also clearly shown.

Now, several very important points must be impressed on the practical mind in connection with these diagrams. In the first place, all shapers must be designed to work under certain fixed conditions.

The position of the spindle; the position of the copping faller; the position of the sector stud or the faller leg stud with respect to the copping faller and the spindle; the circular paths traversed by the sector stud and faller wire whilst building a cop; the distance of the sector stud from the shaper bowl or the shoulder of the shaper; and the exact shape of cop required to be built;—all these must be known before a shaper can be designed, and, when once fixed, very little latitude is allowed for any future alteration. Some factors will permit of change; for instance, an alteration of the angle of spindle can be made. But, speaking generally, it will be found that there is no good purpose to be served by altering the conditions under which the shaper has been designed or worked out on the cut and carving method. If bad cops are made by a shaper that makes good cops on another mule, it is quite certain that conditions have been altered, if the shaper is responsible, and every effort should be made to get back to the correct positions for which it was designed.

Short Shaper.—The long shaper, to which attention has been drawn, is the one in most general use. It has a fixed length, and for all practical purposes is used for a fixed length of stretch, and no variation of stretch is necessary for the range of counts on which it is used. As the range of counts increases and higher numbers are spun, it is necessary to alter the stretch by shortening the distance traversed by the carriage. A fixed length of shaper is therefore useless for such a purpose, for the shaper must be shortened just as much as the stretch. For fine spinning a special type of shaper is used which lends itself to being shortened or lengthened to suit the stretch. It is a short shaper, but, instead of being a fixture so far as position is concerned, it is carried by the carriage square, and, by means of gearing, the shaping or copping mechanism moves under the shaper bowl and so actuates the copping wires.

A drawing is given in Fig. 15 which shows the chief features of the shaper. A strong bracket or guide R, called the slide cover, is bolted to the carriage square. A slide Q fits in the guide R, so that it can be moved to and fro quite freely in the grooves provided in the guide. Q is arranged with a vertical slot into which fits a pin on a short shaper rail A C B, this short shaper being a diminutive form of the long shaper, having a short hinged incline for crossing and a longer incline for winding. Any movement given to the slide Q will naturally cause Q to carry the short shaper along with it. At the out end of the slide Q is a projection, or a bolted bracket O, carrying the bearing for a screw, the other end of the screw being supported by a bracket N, also bolted to the slide Q. This screw will, therefore, partake of any motion given to Q. A projecting piece or table on Q acts as a support for the shaper plates, front, middle, and back plates, and these plates are connected to the shaper screw by the nut M carried by the front plate. These shaper plates, therefore, also move bodily when the slide Q moves. The movement of the slide Q is interesting. Fixed to Q is a short rack, and gearing into this rack is a small wheel T. This wheel T carries on its stud a large wheel U, which latter wheel gears into a long rack V fixed on the floor.

The compound wheel, T and U, is carried by the fixed slide cover R, so when the carriage makes its inward and outward runs, the wheel U, through its connection with the fixed rack V, must revolve, and in so doing the small wheel T causes the rack S to move in the opposite direction to the movement of the carriage. If the carriage is making the inward run for winding, as shown by the large arrow over the square, the slide and all the copping mechanism which it carries will move in the opposite direction, so

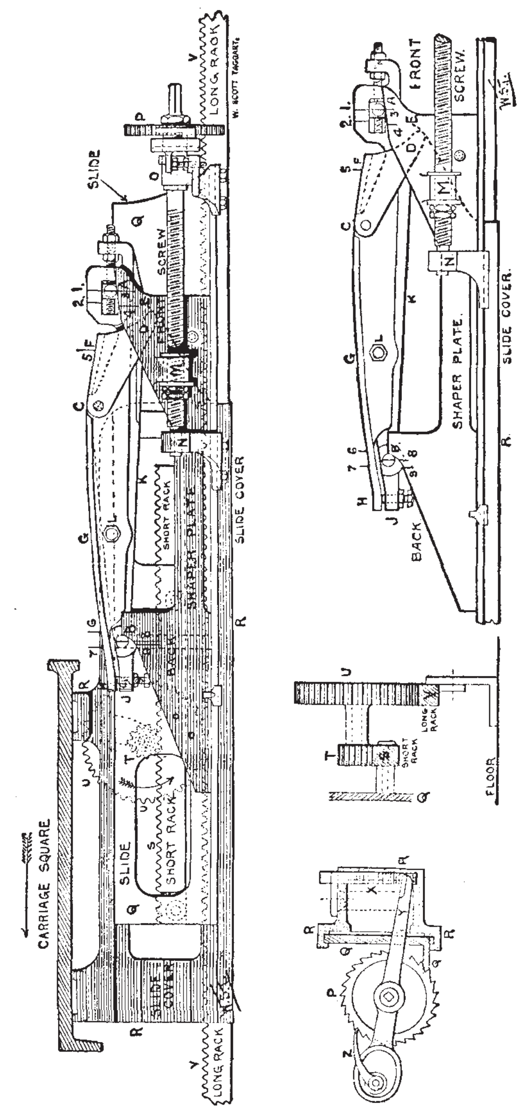

CARRIAGE SQUARE
SLIDE
SHORT RACK
SLIDE COVER
LONG RACK
SHAPER PLATE
SCREW
FRONT
BACK
W. SCOTT TAGGART
FLOOR

FIG. 15.

that the shaper bowl which rests on the shaper will be actuated through the shaper passing backwards underneath it. By suitable arrangement of the two wheels T and U, the bowl will be started at the correct position at F for crossing, and finish by occupying a position at 7 after winding, the length of the shaper between F and 7 having passed underneath the bowl during the run in of the carriage. If the length of the stretch is altered, we must alter the wheels T and U in order that the shaper may move slower for an increased stretch or faster for a less stretch. It will be noticed that the short shaper is far more adjustable than the long shaper. The setting arrangements require more delicacy, and they permit a wider range of work. The front, middle, and back plates are similar to those used on the long shaper, and marks are placed on them to indicate the type of cop to be built when the shaper is set to them, from the smallest pin cop up to the largest twist cop, for it must be remembered that the whole arrangement is equally effective for any work for which the long shaper is used. Setting of the supporting pin on the front plate is done by a fine adjusting screw, and of course the back plate is set by the shaper screw. The long incline of the shaper in this mechanism is adjustable by making the upper part of it hinged at C, so that its outer end can be raised or lowered by the set screw J, thus obtaining a variation in the length of the chase. The shaper screw is turned by a projection on the slide cover R, moving a tumbler catch Z.

Since the essential copping features are similar to those of the long shaper, it will be found that practically all that has been said about the principles, etc., of that mechanism is applicable to the short shaper.

A further interesting type of short shaper is given in

Fig. 16. Only a conventional outline is shown. As in the previous example, the whole of the shaper, except the long rack, is carried in a slide on the square, and it moves backwards as the carriage moves forwards, or *vice versa*. The front, middle, and back plates W, P, and R are inverted and form part of the copping rail, and the places of the pins are taken by projections or snugs S and T; in other words, the shaper and plates are supported on pins or snugs which move away and allow the copping rail to fall as the cop is built up. The copping rail falls vertically, being guided in this movement by an extension of the front incline W sliding along a guide pin I. Adjustments are provided for setting the various parts of the shaper for different-sized cops.

In addition to the advantages resulting from its use for varying stretches, it has the additional one of not being affected on weak floors or floors that vibrate, its only connection to the floor that matters being the gearing with the long rack. Much more care is necessary in dealing with the short shaper than the long type, so greater caution is called for before alterations are attempted.

Shaper Wheels.—Shaper plates are designed to build a cop up to a reasonable diameter of cop bottom on the coning parts, and the straight parts of the inclines enable this diameter to be carried up to any convenient length of cop.

With any given shaper, the long rail stud that rests on the shaper plates at the front is marked with a vertical line, and other lines are marked on the coning part of the plate, which indicate the diameter the cop will build if the stud mark is placed over the plate mark.

The distance from one of these plate marks to the point where the coning finishes and the incline for the parallel

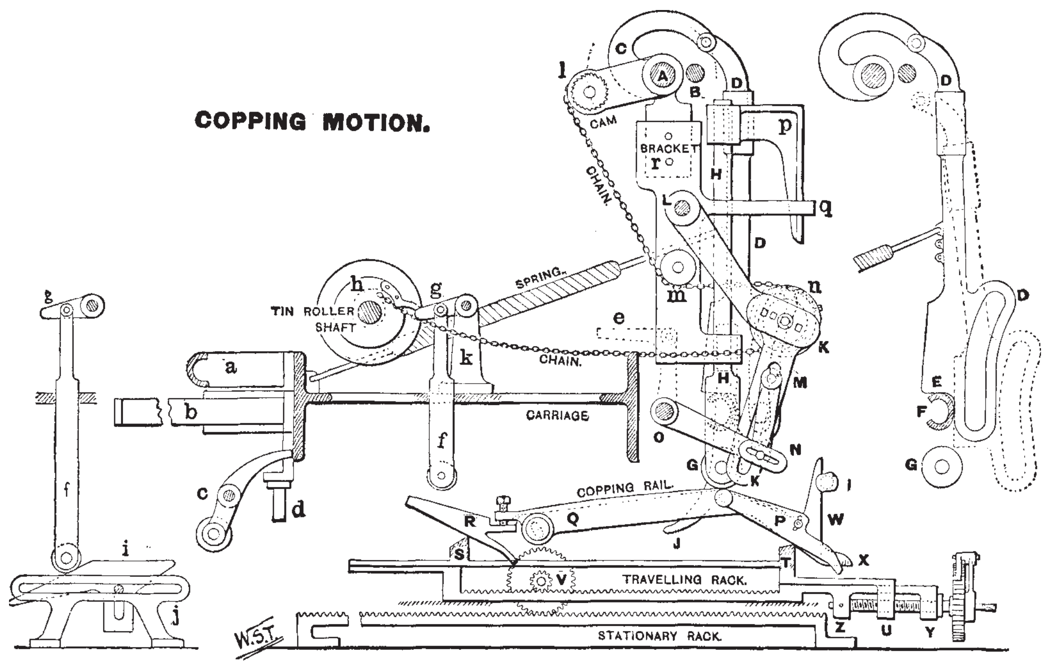

COPPING MOTION.
CAM
BRACKET
CHAIN.
SPRING.
TIN ROLLER SHAFT
CHAIN.
CARRIAGE
COPPING RAIL.
TRAVELLING RACK.
STATIONARY RACK.
W.S.T.

Fig. 16.

length of cop begins is carefully measured, and it gives us the length of coning that **must** be used to produce, say, a twist cop of $1\frac{1}{4}$-in. diameter. For any other lesser diameter, less coning part must be used. The length of the coning part used is, therefore, the basis upon which to reason out the shaper wheel.

If you are spinning 60's on $1\frac{1}{4}$-in. diameter cop the plates are set to the mark to give this diameter. The coning curves are designed to build up a nice convex surface on the cop bottom, and to produce this rounded surface a shaper wheel must be used that will move the plates at such a speed as will give the correct shape to the cop at its lower end. If moved too quickly the cop bottom will be straighter, whilst a slow movement will give a very bulgy cop bottom. Here we see that different wheels can be used for producing identical cops and counts, but there will be a difference, slight or very noticeable, in the shape of the cop bottom.

Further, the same counts are not always the same diameter of yarn; they may differ in twist, in the condition of the cotton composing them, in their diameter, in the tight or slack winding, etc. etc., and these variations result in more or less layers being put on a cop bottom of one 60's T. than of another 60's T. of the same size cop. As the ratchet wheel is actuated every draw, it follows that we have here a difference in the size of ratchet wheel being used on mules, spinning apparently identical cops and counts.

Now these differences must, of necessity, lead to a variety of rules for obtaining or changing the ratchet wheel, and overlookers are keen about any rule they find or use that gives them an approximate size of wheel. The fact that the rule used requires adjustment by one or two more or less teeth is based on their experience, and comes out fairly accurately with experienced overlookers. Although the yarn is the most important factor in spinning, it ought not to be disguised that the shape is an important selling factor. Well-shaped cops suggest skill and care, whilst badly shaped cops indicate that not only has the building been done carelessly, but that carelessness may have been perpetrated in other matters.

If the cop bottom has been made good by a suitable shaper wheel, the rest of the cop to any length will follow. Weight of a whole cop has no influence in settling ratchet wheels. Weight of the cop bottom may vary under certain fixed conditions. An overlooker would do well to have his notebook well stocked with the number of draws required to build a certain-sized cop for various counts, and remarks made as to the twists, speeds, soft or hard cops, kind of cotton, etc. He should also note carefully the position on the front plate of the starting-points for different-sized cops. A small steel blade can be used on which he marks the positions.

A factor that should be carefully noted is whether the counts spun are used as a basis or the counts sold after conditioning. When changing from one count to another there will be a difference in the diameter of the yarn, and consequently there will be more or less layers required to build up the diameter of the cop. The thickness of yarn, nominally, varies inversely as the square root of the counts. This means that the diameter of the yarn will become thinner as the counts become finer in the proportion of $\sqrt{\text{counts}}$, but in a shaper or builder wheel we must use a larger wheel as the counts become finer, so the proportion is not inversely as the square root of the counts, but directly proportional to the square root of the counts.

If a certain wheel is giving good results on a certain count, it is an easy matter to calculate the wheel to put on for a change of counts. For instance:

$$\frac{\text{Square root of new counts} \times \text{shaper wheel on}}{\text{square root of counts used}} = \text{new shaper wheel.}$$

EXAMPLE:

$$\frac{\sqrt{60} \times 32}{\sqrt{40}} = \frac{7{\cdot}651 \times 32}{6{\cdot}324} = 38{\cdot}7 \text{ teeth or, say, 39 teeth.}$$

On the face of it, it is foolish to use a rule in the above form. Two square roots must be taken and then a dividing process of decimals. The better form of the rule is as follows:

$$\sqrt{\frac{\text{New counts} \times \text{shaper wheel on}^2}{\text{counts in use}}} = \text{new shaper wheel.}$$

EXAMPLE:

$$\sqrt{\frac{6\not{0} \times \overset{8}{\not{32}} \times 32}{\not{40}}} = \sqrt{1536} = 39. \quad \text{Only one square root is required.}$$

Now the above rule has a real basis founded on our numbering system for yarns. Yet any overlooker would know that if he uses a shaper wheel of 32 teeth for 40's he could not use a 39 toothed wheel for 60's.

Let us explain why the rule, as it stands, is no good for changing shaper wheels. In the first place, the basis of the rule implies that the layers are placed one above the other as in Fig. 17 at A. The yarn, however, is not built up in a straight line on the cop bottom but in the form of a curve as at B, and it will readily be seen that more layers are put on the cop bottom at B than the rule assumes as at A; a larger number of teeth must therefore be on the builder wheel to allow for this, and the finer the counts the more of an allowance must be made, as can be seen from the series of smaller circles.

A good rule would be to work out the wheel by the rule given and then multiply the result by 1·15 if changing

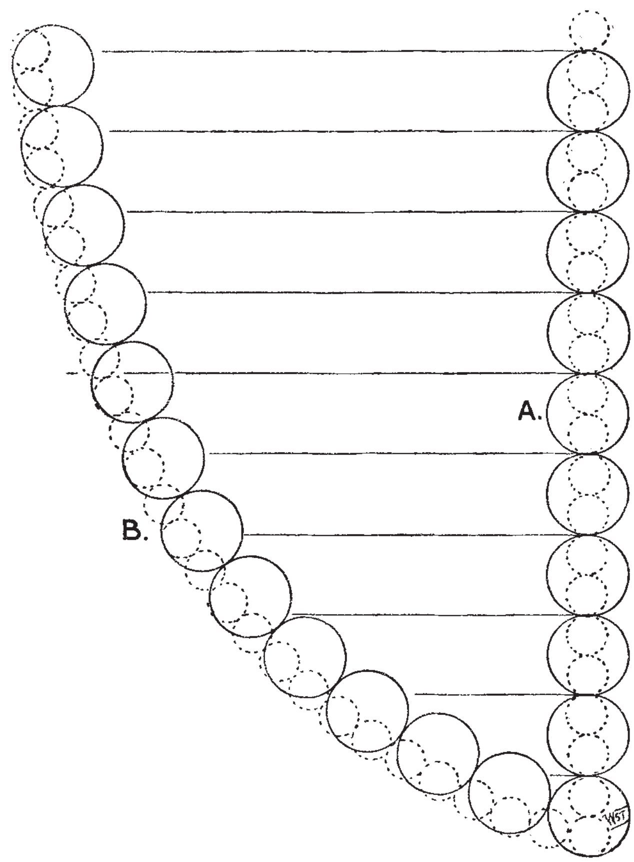


FIG. 17.

from a lower to a higher count, and divide by 1·15 if changing from a higher to a lower count.

Any overlooker who has his results tabulated for a series of counts can readily find the constant to use.

Quite frequently, overlookers, on changing counts that do not differ much, simply do it by simple proportion. If 30's require a certain wheel, then 32 will require proportionately more teeth, or

$$\frac{\text{Shaper wheel on} \times \text{new counts}}{\text{present counts}} = \text{new shaper wheel.}$$

This can only be done for small changes; if used for larger changes of counts it results in wheels that are too big.

Many overlookers find neither rule correct, so they split the difference between the too small a wheel of one rule and the too large a wheel of the other. They find the wheel by each rule, add them together, and divide by two. This pretty nearly always gives too small a wheel, so they add a little on their own in the form of an extra tooth or deduct a tooth, according as the change is up or down.

NOTE.—A complete series of drawings to illustrate the remarks in above chapter is given in the author's book, *Cotton Machinery Sketches.*

CHAPTER XII

RING FRAMES

Objects.—To draw out the roving by means of rollers, to twist the roving by the movement of a traveller round a ring, and to wind the twisted yarn on to a bobbin. All these operations being performed simultaneously, it is a continuous spinning process as compared with the intermittent process of the S.A. mule.

The yarn is wound on bobbins placed on spindles. The machine is composed of a number of spindles, and is a double machine, a row of spindles being on each side of the machine and the creel of roving bobbins in the middle.

Productions and Speeds.—The surface speed of the front roller and the counts spun control the production. If both these items are known, the production in hanks or pounds can be readily found.

All makes of ring frames are alike as to production and speeds.

Productions:

INDIAN COTTON. Twists = $\sqrt{\text{counts}} \times 4{\cdot}25$.

Counts.	Revs. of Spindle.	Dia. of F.R.	Revs. of F.R.	Twist per inch.	Production in 10 hours.		Dia. of Ring.	Lift.
		inch.			hanks.	lb.	inches.	inches.
8	6000	$\frac{7}{8}$	182·2	11·98	9·46	1·185	2	6
10	6000	,,	162·5	13·43	8·46	·846	,,	6
12	6000	,,	148·5	14·70	7·72	·642	,,	6
12	7500	,,	185·6	14·70	9·62	·803	$1\frac{3}{4}$	6
14	7500	,,	171·7	15·89	8·95	·639	,,	6
16	7500	,,	160·5	17·00	8·37	·518	,,	6
18	9000	,,	181·7	18·02	9·42	·363	$1\frac{5}{8}$	5
20	9000	,,	172·4	18·99	8·97	·447	,,	5
22	9000	,,	164·6	19·89	8·58	·389	,,	5
24	9000	,,	157·5	20·78	8·21	·341	,,	5
24	9500	,,	166·3	20·78	8·67	·359	$1\frac{1}{2}$	5
26	9500	,,	159·7	21·63	8·32	·318	,,	5
28	9500	,,	153·7	22·48	7·98	·266	,,	5
30	9500	,,	148·7	23·24	7·75	·258	,,	5
32	9500	,,	143·6	24·06	7·50	·233	,,	5

EGYPTIAN COTTON. Twists = $\sqrt{\text{counts}} \times 3{\cdot}75$.

Counts.	Revs. of Spindle.	Dia. of F.R.	Revs. of F.R.	Twist per inch.	Production in 10 hours.		Dia. of Ring.	Lift.
		inch.			hanks.	lb.	inch.	inches.
40	9500	$1\frac{1}{16}$	120·1	23·7	7·63	·191	$1\frac{5}{8}$	5
45	9500	,,	113·7	25·12	7·20	·159	,,	5
50	9500	,,	101·7	26·51	6·46	·129	,,	5
55	9000	,,	97	27·78	6·17	·111	$1\frac{1}{2}$	5
60	9000	,,	92·9	29·02	5·90	·097	,,	5
70	8500	,,	81·2	31·35	5·16	·073	,,	5
80	8500	,,	78·3	32·54	4·97	·062	$1\frac{3}{8}$	5
90	8000	,,	67·4	35·55	4·30	·048	,,	5
100	8000	,,	63·9	37·50	4·06	·040	,,	5

AMERICAN COTTON. Twists = $\sqrt{\text{counts}} \times 4$.

Counts.	Revs. of Spindle.	Dia. of F.R.	Revs. of F.R.	Twist per inch.	Production in 10 hours.		Dia. of Ring.	Lift.
		inch.			hanks.	lbs.	inches.	inches.
4	5000	1	198·7	8	11·73	2·934	$2\frac{1}{2}$	7
5	5000	,,	178	8·92	10·51	2·102	,,	7
6	5000	,,	162·7	9·76	9·64	1·608	,,	7
6	6000	,,	195·3	9·76	11·61	1·933	$2\frac{1}{4}$	7
7	6000	,,	180·2	10·56	10·65	1·522	,,	7
8	6000	,,	169·2	11·28	10·01	1·252	,,	7
10	7000	,,	176	12·64	10·51	1·051	2	6
12	7000	,,	160·7	13·84	9·57	·798	,,	6
14	7000	,,	148·5	14·96	8·86	·633	,,	6
12	7500	,,	172·1	13·84	10·23	·852	$1\frac{3}{4}$	6
14	7500	,,	159·2	14·96	9·47	·676	,,	6
16	7500	,,	149	16	8·85	·553	,,	6
18	8500	,,	159·6	16·96	9·52	·527	,,	5
20	8500	,,	151·1	17·88	9·03	·451	,,	5
22	8500	,,	146·2	18·48	8·72	·396	,,	5
24	8500	,,	138·3	19·56	8·25	·343	,,	5
26	9500	,,	148·3	20·36	8·85	·340	$1\frac{5}{8}$	5
28	9500	,,	142·7	21·16	8·53	·302	,,	5
30	9500	,,	137·7	21·88	8·21	·273	,,	5
32	9500	,,	133·6	22·6	7·84	·244	,,	5
34	9500	,,	129·7	23·32	7·73	·227	,,	5
36	9500	,,	126	24	7·52	·209	$1\frac{1}{2}$	5
38	9500	,,	124·8	24·64	7·32	·191	,,	5
40	9500	,,	119·4	25·28	7·15	·178	,,	5

Revolutions of Tin Roller and Spindles.—The tin roller is driven direct from the line shaft. The diameter is usually 10 in., but 9 in. is frequent. The diameter of warve is generally $\frac{7}{8}$ in., but for coarse counts may be larger.

The following table has taken account of the diameter of the spindle band:

$$\frac{\text{Dia. of tin roller} \times \text{speed of tin roller}}{\text{dia. of warve}} = \text{revs. of spindle.}$$

Revs. of Spindle.	Dia. of Spindle Warve.	Revs. of Tin Roller.	Dia. of Tin Roller.
per min.	inch.	per min.	inches.
9500	$\frac{7}{8}$	993	9
9500	,,	894	10
9000	,,	941	9
9000	,,	847	10
8500	,,	889	9
8500	,,	800	10
8000	,,	836	9
8000	,,	753	10
7500	,,	784	9
7500	,,	706	10
7000	,,	732	9
7000	,,	659	10
6500	,,	680	9
6500	,,	612	10

EXAMPLE: If $\frac{1}{16}$ in. spindle band is allowed,

$$\frac{10 + \frac{1}{16} \times 800}{\frac{7}{8} + \frac{1}{16}} = \frac{10\frac{1}{16} \times 800}{\frac{15}{16}}$$

$$= \frac{161 \times 800}{15} = 8580 \text{ revs. of spindles.}$$

Rings and Gauge of Spindles:

Counts.	Average Counts.	Dia. of Ring.	Gauge of Spindles.	Balloon Plates or Separators.	Lift.
		inches.	inches.		inches.
6 to 10's	8's	2	3	No	6 to 7
6 to 10's	8's	2	$2\frac{7}{8}$	Yes	6 to 7
10 to 16's	13's	$1\frac{7}{8}$	$2\frac{7}{8}$	No	6 to 7
10 to 16's	13's	$1\frac{7}{8}$	$2\frac{3}{4}$	Yes	6 to 7
16 to 24's	20's	$1\frac{3}{4}$	$2\frac{3}{4}$	No	6
16 to 14's	20's	$1\frac{3}{4}$	$2\frac{5}{8}$ or $2\frac{1}{2}$	Yes	6
24 to 40's	32's	$1\frac{5}{8}$	$2\frac{5}{8}$	No	5 to 6
24 to 40's	32's	$1\frac{5}{8}$	$2\frac{1}{2}$ or $2\frac{3}{8}$	Yes	5 to 6
40 to 60's	50's	$1\frac{1}{2}$	$2\frac{1}{2}$	No	5
60 to 80's	70's	$1\frac{3}{8}$	$2\frac{3}{8}$	No	5
Weft.					
10 to 16's	13's	$1\frac{5}{16}$	$2\frac{1}{4}$	Yes	5
16 to 24's	20's	$1\frac{1}{4}$	$2\frac{1}{4}$	Yes	5
26 to 40's	32's	$1\frac{1}{8}$	$2\frac{1}{4}$	Yes	5

There are no definite standards in rings or gauge of spindles. There are slight differences from the above for Indian and Egyptian cottons. Such differences as exist are due to the form of bobbin used, and the amount of yarn that it is required to wind on to it.

Diameter of Rollers and Settings:

Cotton.	Front.	Middle.	Back.
Indian and Low American .	$\frac{7}{8}$ in.	$\frac{3}{4}$ in.	$\frac{7}{8}$ in.
American	1 ,,	$\frac{7}{8}$,,	1 ,,
,, ...	1 ,,	$\frac{3}{4}$,,	1 ,,
Egyptian	$1\frac{1}{16}$,,	$\frac{7}{8}$,,	$1\frac{1}{16}$,,

The middle roller should always be on the small size, and set well up to the front roller. Top middle roller to be self-weighted.

The above rollers are as sent out by the makers, and the usual settings are as in the S.A. mule.

Drafts.—The draft will depend very much on the roving, and of course can be made high or low. Since yarn is spun on the ring frame up to 120's it is simply a question of convenience and how the drafting has been carried out in the card room. A good guide is to work the draft between 7 and 9 for single roving, and between 10 and 12 for double roving. At a pinch 10 of a draft for single roving could be used, but it is advisable not to exceed this as rollers are now arranged, and the limit of draft for double roving should be 13. If possible, the draft for the low numbers up to 10's ought not to be higher than $7\frac{1}{2}$.

Counts.	Draft.		Counts.	Draft.	
	Single Roving.	Double Roving.		Single Roving.	Double Roving.
6	6	...	32	8·0	11·5
8	6·5	...	34	8·5	12·5
10	7·5	...	36	9·0	11·0
12	7·5	9·5	38	9·5	11·75
14	8·75	11·25	40	...	10·0
16	8·75	10·75	50	...	10·0
18	7·25	12·0	60	...	10·0
20	8·00	10·00	70	...	10·0
22	8·75	11·00	80	...	10·0
24	8·00	10·25	90	...	10·0
26	8·75	11·5	100	...	10·0
28	8·00	10·25	110	...	10·0
30	8·5	11·00	120	...	10·0

The lap weight of course varies in the above table from 16 oz. to 11 oz. per yard. The draft in the card will vary from 90 for 6's to as high as 140 for 120's.

A high draft system will produce better and stronger yarn, and will certainly eliminate a number of fly frames because a much coarser hank roving can be put up in the creel of the spinning frame.

Roller Stands.—The angle of the stands, 5° to 35°, is frequently made the subject of serious consideration. It is usually a compromise. The main point is the nip of the front roller and the position of this roller, or rather the top front roller that regulates the position of the nip. The yarn gets a right angle turn and rubbing when going through the traveller. A rubbing and a good shaking are given to the yarn in the thread guide. The ballooning and variations of tension are disturbing factors, and if the yarn touches the front roller as it emerges from the nip there is another rubbing and disturbing action to the fibres. The object of inclining the stand is to get the twists right up to the nip so that the above-mentioned disturbing factors will not produce irregularities or cause breakages. The relative position of rollers, thread guide, and kind of yarn are the guiding factors.

Travellers.—This puts the twist into the yarn, a twist at each revolution it makes round the ring. As the traveller lags behind the spindle in order to wind the yarn on the bobbin it makes less revolutions than the spindle,

AMERICAN COTTON

Counts.	Revs. of Spindle.	Dia. of Ring.	No. of Traveller.
4	7500	2 or $1\frac{3}{4}$	14 or 16
6	,,	,,	14 ,, 12
8	,,	,,	12 ,, 10
10	,,	,,	9 ,, 8
12	,,	,,	8 ,, 7
14	,,	,,	7 ,, 6
16	,,	,,	6 ,, 5
18	,,	,,	5 ,, 4
20	,,	$1\frac{5}{8}$	4 ,, 3
22	,,	,,	3 ,, 2
24	,,	,,	3 ,, 1
26	,,	,,	1 ,, 1/0
28	,,	,,	1/0 ,, 2/0
30	,,	$1\frac{1}{2}$	2/0 ,, 3/0
32	,,	,,	3/0 ,, 4/0
34	,,	,,	4/0 ,, 5/0
36	,,	,,	5/0 ,, 6/0
38	,,	,,	6/0 ,, 7/0
40	,,	,,	7/0 ,, 8/0
42	,,	,,	8/0 ,, 9/0
44	,,	,,	9/0 ,, 10/0
46	,,	,,	10/0 ,, 11/0
48	,,	,,	11/0 ,, 12/0
50	,,	,,	12/0 ,, 13/0

EGYPTIAN COTTON

Counts.	Revs. of Spindles.	Dia. of Ring.	No. of Traveller. Carded.	No. of Traveller. Combed.
20	10,000	$1\frac{5}{8}$	5 or 6	
22	,,	,,	4 ,, 5	
24	,,	,,	3 ,, 4	
26	,,	,,	2 ,, 3	
28	,,	,,	1 ,, 2	
30	,,	$1\frac{1}{2}$	1/0 ,, 1	
32	,,	,,	2/0 ,, 1/0	
34	,,	,,	3/0 ,, 2/0	
36	,,	,,	4/0 ,, 3/0	
38	,,	,,	5/0 ,, 4/0	
40	,,	,,	6/0 ,, 5/0	
42	,,	,,	7/0 ,, 6/0	
44	,,	,,	8/0 ,, 7/0	
46	,,	,,	9/0 ,, 8/0	
48	,,	,,	10/0 ,, 9/0	
50	,,	,,	12/0 ,, 11/0	8/0 or 7/0
52	,,	,,	13/0 ,, 12/0	9/0 ,, 8/0
54	,,	,,	14/0 ,, 13/0	10/0 ,, 9/0
56	,,	,,	14/0 ,, 13/0	11/0 ,, 10/0
58	,,	,,	15/0 ,, 14/0	12/0 ,, 11/0
60	,,	,,	16/0 ,, 15/0	13/0 ,, 12/0
62	,,	,,	17/0 ,, 16/0	13/0 ,, 12/0
64	,,	,,	17/0 ,, 16/0	13/0 ,, 12/0
66	,,	,,	18/0 ,, 17/0	14/0 ,, 13/0
68	,,	,,	19/0 ,, 18/0	14/0 ,, 13/0
70	,,	,,	20/0 ,, 19/0	15/0 ,, 14/0
72	,,	,,	...	15/0 ,, 14/0
74	,,	,,	...	15/0 ,, 14/0
76	,,	,,	...	16/0 ,, 15/0
78	,,	,,	...	16/0 ,, 15/0
80	,,	,,	...	17/0 ,, 16/0
82	,,	,,	...	17/0 ,, 16/0
84	,,	,,	...	17/0 ,, 16/0
86	,,	,,	...	18/0 ,, 17/0
88	,,	,,	...	18/0 ,, 17/0
90	,,	,,	...	19/0 ,, 18/0

but not to an extent that makes much difference, and it is only of academic interest in ring spinning. The fact, however, that the high speed at which it revolves and the friction or the centrifugal force it exerts causes a lag, or retarding effect that results in winding, requires that its weight or size should be carefully graded to suit the cotton and the counts being spun.

The foregoing table will serve as a guide to the traveller No. to be used.

Spindles.—These are all of the flexible type, but although they adjust themselves to an unbalanced state, it is not advisable to be careless in using badly made or distorted bobbins. Perfectly balanced and true bobbins must be used; the spindle has enough to do in compensating for irregularities of the yarn and of the yarn on the bobbin without having to carry a bad bobbin at an enormous speed.

If a spindle runs hot, take it out and with a little rouge rub the spindle gently along its length in straight lines; do not rub round the spindle in a circular manner. The rubbing will destroy or practically remove the microscopic screw-like lines left on in the polishing process at the works, and these lines are sometimes of a nature that prevents the circulation of the oil or clears it out quickly.

If oil becomes inky it is a sign of very inferior oil. Varnish-like substance on the spindle inside or out is another indication of bad oil. Only the best oil should be used, and always on the thin side. Do not use oil cups that are too easily removed. Always replenish oil cup when the machine is stopped.

Sea Island Cotton.—The travellers require to be five to six grades heavier than those given in the table.

Higher speed of spindle will require lighter travellers.

With **separators** it will be necessary to use a few grades lighter travellers.

Rollers.—The front line should be case-hardened throughout and the other two lines case-hardened at the necks. The weighting is usually by a suspended weight from the top front roller, and one weight does duty for both sides of the machine. Double boss rollers are used, two ends to a boss, so one weight covers four spindles. See that the covering of the double boss is perfectly parallel. The middle and back rollers are usually self-weighted; see that they are highly polished and kept so.

Saddle and bridle weighting is also used, but it is an unnecessary arrangement.

Loose boss rollers are an advantage in preventing cut yarn owing to the dead weight on a solid roller.

Builder Motion.—This is a fairly straightforward motion and seldom requires touching after being set by the makers. The cop bottom is made by an alteration in the length of chain used, and either a snug or cam piece is put on a carrier bowl or the chain is altered by a bowl on a lever. Adjustments can be readily made. The shaper or builder wheel is calculated for changes exactly as in the mule. Everything must be kept clean, such as the surface of bowls and cams and the teeth of ratchet wheels; bobbins kept from rolling beneath the builder lever.

See that the cam or builder lever is not disturbed from the setting made by the fitter. It is possible that the cam has been designed so that the lever is horizontal when at the middle of the lift, and in that case it can be easily tested. In any case it is almost certain to be designed from the line joining the centre of the lever and the centre of the cam bowl on the lever, so it is better to test the position of the lever from that line. If this lever is not set correctly, the diameter of the full bobbin will not be uniform.

Owing to the different methods of connecting the builder lever to the pokers, the question of raising or lowering the rail for the starting of a bobbin must be left for the make of the machine to decide the point.

A perfectly parallel movement of the ring rail is essential, so all pokers and poker tubes should be well adjusted. Any differences in length, sticky pokers, choked tubes, etc., will introduce variations in cop shapes.

As the building lever is depressed the ring rail rises, and *vice versa.*

The snug or screw for giving the chase and diameter can be adjusted, and in case of pirn or tubes a longer snug is necessary.

As the ring rail falls, see that it is weighted sufficiently to overcome friction of pokers, etc.

The diameter of the bobbin can be varied by changing either the size of the ratchet wheel or by varying the number of teeth taken at each lift. If the bottom is too thick, the bowl on the motion must be wound up a little and the rail put back to its correct position by the chain adjusting screw on the quadrant. A thin bottom will require letting chain off the bowl and adjusting the chain at the quadrant. In altering the chain on the builder bowl, always see that the stop is adjusted so that it winds back to the correct position for starting a new set.

Faults.—Many faults on ring frames are traceable to the same causes as in mules and fly frames—dirt, waste, bad piecings, weak rovings, dirty clearers, roller laps, single or double, etc.

Examine middle and back rollers for licking. Wrongly set thread guides; set centre of thread guide over the centre of spindle so that there is a uniform circular movement of yarn round the guide, due to ballooning. If the mill has a fad of setting the guide with its inner inside edge over the spindle centre it will not matter much; the yarn will still go all round the guide eye and bounce on to the wire unequally, at the highest point, from 7000 to 10,000 times per minute.

See that the roller settings throughout the frame are alike. Spindles must be perfectly central to the ring; test these with cone, if ends break too frequently. Bits of fly on ring, or worn rings, or rough edges on ring, or worn or rough travellers, will cause breakages. Travellers are constantly breaking out, but a periodic replacement of the whole of the travellers on a frame should be adopted. Wrong travellers will cause soft or hard bobbins to be produced, and may also result in frequent breakages, this of course depending on other conditions. Badly fitting bobbins will set up vibration, and unbalanced or warped or worn or eccentric bobbins will do likewise. Careless treatment of the spindle when cleaning it out may result in the spring on inner tube being broken off, and the flexibility of the spindle will be destroyed.

Ballooning is a natural result of the method of spinning on the ring frame. Excessive ballooning indicates slack winding. Reduced ballooning shows that there is too much tension on the yarn, and tight winding will result. A moderate amount of ballooning is correct, and this is best judged by noting if the yarn is tight when winding on the smallest diameter of the bobbin. There is always a great difference in ballooning between the winding on the largest diameter and the smallest diameter. The difference in these diameters is the limiting factor in winding, so that the ordinary ring frame method is unsuitable for spinning on the bare spindle as in the mule.

Variable Spindle Speed.—The difference in tensions mentioned above has been overcome to a considerable extent by introducing a variable speed of spindle. By speeding up the spindle, and of course the whole frame, when the winding is taking place on the larger diameter, increased production can be obtained at this part of the bobbin. As the winding approaches the smaller diameter, the speed of spindle is reduced in order to reduce the tension on the yarn, and enable winding to be carried on more easily. This reducing of the speed is not so great as the earlier increased speed, so that on the whole the spinning is greatly improved, and a greater production is obtained. Mechanical methods enable this variation of speed to be given, but usually electrical driving is the method adopted, as a motor lends itself to a variable speed throughout the bobbin or in two or more steps.

Separators.—These are provided to prevent the ballooning yarn from lashing into the ballooning yarn of the spindle on each side. They are conveniences, and incidentally they enable the spindles to be spaced closer, thus obtaining more spindles in a given length. Separator and anti-ballooning plates ought to be kept perfectly smooth and clear of fluff. Some makers go to the extent of nickel-plating the separators to ensure absolute smoothness.

As a bobbin builds, the ballooning effect is gradually reduced by the lessening of the distance between the ring rail and the thread guide.

Notes.—Test speeds of tin roller and spindles by tachometer, and do not rely on calculated speeds based on line shaft speed. Test spindles on both sides of frame to see if both are alike. The long spindle bands stretch, so care is required in putting on the band; such bands must be of the best quality. A rope driving is advisable for second tin roller in any case, but especially for long frames.

The tension on the spindle band should not be too much, otherwise extra power is absorbed, and the spindle will soon be strained. Too light a tension will cause excessive slip and irregular twisting. Four pounds tension is a good average. Testing is usually dependent on turning the spindle by finger and thumb. A test can also be made by hooking a spring balance to the tin roller on its shaft. Pass a band round the other end of spring balance and round the warve and tie up the band; the balance will then indicate the tension on the band. A spindle set up on a bench with a spring balance can be used for practice to judge of the tension of bands.

Cleaning and Lubricating. — The bearings of the front rollers should be oiled every two days and the other two rows once per week; the top front roller and weight hook every two days, and the other top roller pivots once a week. It is also advisable to oil all the frame end bearings once a week, and a wipe down and re-greasing of the wheels should be done occasionally.

The top roller pivots should be picked every day. Self-weighted rollers especially require this attention, as their motion can be so easily stopped; the slightest sign of the self-weighted top roller hesitating in its movement should be attended to at once. Top clearers should be stripped daily, but for loose short staple or other conditions twice daily is not too much. The bottom clearers get covered quickly with loose ends, and should be cleaned often, at least every two hours; see that all under clearers are made from well-seasoned timber, so that they do not warp; scour fluted rollers every three months, care being taken to rest the rollers on bearers during the scouring, to prevent straining them.

Wipe down the ring rail often, and thoroughly clean the rings once a week.

See that no thread guides have become bent out of position, and also that they have not had a nick worn in them. See that the bobbin fits the spindle cup exactly, and that no fluff or dirt accumulates in the cup. As the bobbin end wears through constant use, be careful to note that it does not touch the bottom of the cup without becoming wedged in position, otherwise it will not revolve as part of the spindle, but be subject to an irregular movement.

Give a little oil about every month, and all oil pumped out and re-oiled every three months. If the spindles have no detachable oil cup the oil ought to be pumped out monthly and the inner tube removed when doing this, so that dirt will not pass up on the outside of inner tube and probably settle there and block the tube. Spindles with oil cups containing a fair supply of oil need little attention, only every three months. Too much oil is often given to spindles. In such cases the oil is simply carried to the top of tube, flows over, and is dissipated from the edge of the warve. Signs of this carelessness are prominent on bands, floors, and fixed rail. A suitable thimble-like holder ought to be used which holds only just enough to fill the spindle to the right amount. Particularly notice that a self-contained spindle does get its right supply of oil, and has not a false appearance of being supplied through air bubbles in the bearing.

NOTE.—A complete series of drawings to illustrate the remarks in above chapter is given in the author's book, *Cotton Machinery Sketches*.

CHAPTER XIII

TESTING

Moisture.—Moisture is a natural constituent of cotton. To prevent excessive moisture being bought as cotton and on the other hand sold as yarn, a kind of standard has been recognised on which buying and selling is based. In any given bulk of cotton from a bale or any weight of yarn from a skip there must not be more than **7·834 per cent** of moisture present. If more moisture than this is present, a claim can be made for a refund of money paid or its equivalent value in cotton or yarn.

This percentage 7·834 of moisture has been fixed in the following manner. If a quantity of cotton is dried it has been found that, when it is exposed to normal atmospheric conditions, it will absorb **$8\frac{1}{2}$ per cent** of moisture. In other words, 100 lbs. of bone-dry cotton will absorb $8\frac{1}{2}$ lbs. of moisture and thus become $108\frac{1}{2}$ lbs. From this it will be seen that if $108\frac{1}{2}$ lbs. of cotton contain $8\frac{1}{2}$ lbs. of moisture, 100 lbs. of the cotton will contain 7·834 per cent of moisture; or

$$\frac{8\frac{1}{2} \times 100}{108\frac{1}{2}} = 7{\cdot}834 \text{ per cent of moisture.}$$

If cotton, in passing through the mill, loses all its moisture, the spinner is permitted to put back into the yarn $8\frac{1}{2}$ per cent of moisture or water. If only a part of the water has been evaporated in the mill, the spinner can put back an amount of moisture that will bring the total amount to $8\frac{1}{2}$ per cent.

Regain.—This $8\frac{1}{2}$ per cent is called the regain, and it must clearly be understood to mean the amount of moisture that has become added to the **dry** cotton.

Testing for Moisture.—A testing oven ought to be in every mill, and all deliveries tested for moisture. Any serious cause of complaint for excessive moisture, as shown by the mill test, can be certified by asking the Chamber of Commerce to make an independent test, which they will do by a method that gives an average condition of a bale, and not merely local spots on the bales that have been exposed to rain or other accidental causes. A small quantity of cotton is taken from the bale and weighed. It is now well dried and again weighed. The loss in weight will be due to evaporation of water. From the results the percentage can be easily calculated.

Suppose 2 lbs. of cotton are taken from the bale and dried for, say, 1 hour at 212° F. (no scorching should occur). The dried cotton may now weigh 1 lb. 5900 grains, so that $14{,}000 - 12{,}903 = 1100$ grains of moisture has disappeared from 2 lbs. of cotton.

Therefore $\frac{1100 \times 100}{14{,}000} = 7{\cdot}857$ per cent is the percentage of moisture in the cotton.

Now if we wish to put back this moisture into the cotton, we must add the lost moisture of 1100 grains to the 1 lb. 5900 grains of dried cotton, and this will, of course, be the exact **weight** of moisture, but as a **percentage** of moisture will be :

$$\frac{1100 \times 100}{12,900} = 8{\cdot}52 \text{ per cent regain.}$$

For exact results a well-designed testing oven is necessary where weighing is done whilst the cotton scales are exposed to the same temperature. Cotton absorbs and loses moisture rapidly. Dry cotton and yarn will absorb 3 per cent of moisture in three minutes, if exposed to normal atmospheric conditions. Care in testing is absolutely necessary.

Making tests by drying cotton and yarn on steam pipes, boiler flues, etc., are so unreliable as not to be even approximate. They are more or less a waste of time.

Humidity in the Mill.—This is a matter that concerns the mill authorities to a greater extent than is usually assumed. Waste, fluffy atmosphere, disturbed fibres, irregular results, and constant trouble with sticky laps, sliver, and roving, result from a dry atmosphere, not to mention the electrical effects. In most mills the cotton has undergone various changes in the moisture contents up and down, and it may be full of moisture one day or part of a day, and almost bone-dry at another part of the day or another day. This difference in the percentage of moisture the cotton contains makes a real difference in the tests for hanks and counts and affects the drafts required. Yarn spun for certain counts at the spindle point may be bone-dry, or approaching the full allowable amount of moisture, and it is always a variable factor. The drier the yarn is on the mule, the more regain is required in the conditioning and the coarser the counts become.

It is as well to note that moisture in the raw cotton is bought at the price of the cotton. If full regain is made, the same moisture is sold at the price of yarn. If the cotton passed through all the processes and retained the same moisture throughout, the water would be part and parcel of the cotton, and subject to the same operative costs so that it would be entitled to the yarn price. If the cotton loses moisture in the processes, such losses are similar to losses in waste, with this difference, that there is a loss on waste, but the water can be put back.

Conditioning.—This operation may be performed in a variety of ways, from the crude watering-can to the vacuum chambers and admission of saturated air. The yarn ought to be allowed sufficient time to absorb the necessary amount of moisture uniformly. If a vacuum or pressure system is not adopted, the conditioning cellar should have a spaced-out surface of absorbent bricks kept very moist on which the skips stand. The skips are moved gradually forward from a drier part of the cellar to a more humid part, and from this section they can be despatched.

Dipping skips of cops is crude, and unless each skip is well shaken whilst in the tank, the water is not well distributed. Sprinkling cops as the layers are formed in the skip, or doing so when a skip is full, results in the cops having excessive moisture on the outsides, whilst the inside is comparatively dry.

Steam admitted to a vacuum chamber filled with skips is also adopted, and white cotton becomes slightly tinted, of a creamy tint, by this method. Test for moisture in the cop ought to be made frequently.

Weighing Cotton.—So long as cotton is in an unordered state, as in bales, mixings, hoppers, and openers, the quantity of such cotton is denoted by the number of pounds avoirdupois. The production of blowing-room machinery, and even the card and draw-frame output, are usually given in lbs. per day, or per 10 hours, or per week.

In its earlier stages the cotton is simply in bulk without any definite dimensions, but when it attains an ordered condition such as a lap, sliver, roving, and yarn, it has length, breadth, and thickness. If we weigh any of this ordered cotton, we must associate the weight with the length of the cotton that is weighed, as, for instance, a yard of lap weighs 10 or 15 ounces, or one yard of sliver weighs 36 grains. The weight of one yard of lap and the weight of six yards of sliver have become kinds of standards for these respective forms of cotton.

Table of Weights and Measures.—A peculiar table of weights has arisen in the course of the development of the industry. It is a combination of Troy and Avoirdupois weights.

24 grains	= 1 pennyweight (dwt. troy).
18 dwts. $5\frac{1}{2}$ grains	= 1 ounce (oz. avoirdupois).
16 ounces or 7000 grains	= 1 pound (lb. „).

The standard measure of length is also of a peculiar type, viz:

54 inches	= 1 thread (the circumference of a wrap reel).
4320 „	= 80 threads or 1 lea or skein or 120 yards.
30240 „	= 500 threads or 7 leas or 1 hank or 840 yards.

All the tables used in a cotton mill, for ready reference, use the above measures. An absurd mixture of ounces, dwts., and grains, associated with various lengths of lap, slivers, and rovings, is the result. In up-to-date mills, the weighings of sliver, comber laps, rovings, and yarn are all taken in grains, with a consequent simplification in all directions.

Hanks and Counts.—The necessity arose of indicating the degree of thickness or quantity of fibres in the cotton, as the material is drawn finer in the processes until it becomes yarn. A method was adopted which set the standard that 840 yards of any ordered condition of cotton which weighed 1 lb. (7000 grains) should be called No. 1 counts. If it requires 1680 yards to weigh 1 lb., the yarn is called No. 2 counts simply because it is 2×840 yards to 1 lb. It will be seen that the word **counts** indicates the degree of fineness of the cotton, and as the cotton becomes finer, or thinner, the number representing this fineness will become larger. We speak therefore of low numbers or coarse counts, and fine counts or high counts or high numbers.

If we have 20's counts of yarn we know definitely that there will be $20 \times 840 = 16{,}800$ yards of this yarn to 1 lb., and 200's counts will have $200 \times 840 = 168{,}000$ yards to 1 lb. The counts increase in simple proportion to the length that weighs 1 lb. Since it is a question of simple proportion to find the counts, it is not necessary to measure off the full length that will weigh 1 lb. Any length will do for the purpose, even an inch, provided it is weighed accurately. For general purposes yarn is measured in 120 yards or 1 lea, and from its weight we can easily calculate the counts, or use a table of weights and lengths. For slivers and rovings 6, 20, 30, 40, and 60 yards are the usual lengths, all of which are convenient parts of 840 yards.

The term counts is used to designate yarns. When we come to laps, slivers, and rovings, we adopt the same standards and find the counts actually, but it has been found convenient to change the word counts to **hanks**; it is only a change of words, so that when speaking of hanks we know we are dealing with material in the card room. If one yard of card sliver weighs 36 grains we know that the counts of the sliver will be ·237. This number is not spoken of as the counts of the sliver (though that is what it really is), but the term hanks is used instead; we would therefore say ·237-hank sliver in describing the thickness or weight of the sliver. It is a system sanctified by tradition. Modern methods require that all weighings of the card room should be in grains, and properly constructed balances used for weighing.

There is another use of the term "hank" in cotton spinning. The standard length of 840 yards is called a hank. The word has therefore reference to the length that has passed through rollers, and is used to indicate the production of a machine or spindle expressed in so many times 840 yards. As an illustration we will suppose a mule to wind 5·66 hanks of 32's counts on each spindle in 10 hours. It will have wound on $5{\cdot}66 \times 840 = 4754$ yards in the 10 hours. But 32's counts have $32 \times 840 = 26{,}880$ yards in 1 lb., so that the actual production is $\frac{4754}{26{,}880} = {\cdot}177$ lb. in 10 hours.

It will be seen from this that the hank roving is something quite different from the hank production.

Testing Laps, Slivers, Rovings, and Yarn.—The testing of these items is more or less perfunctory in most mills. It ought to be an important element in the mill. All tests ought to be carefully noted and presented to the manager daily. The best scales or balances should be used for weighing, and the most accurate reels for measuring the lengths.

Two yard lengths are usually taken for the weight of lap per yard, and this only seldom, as reliance is placed upon the regulating motion for maintaining regularity, and only the full laps are weighed. Variations in the weight of the laps may call for attention, if beyond a fixed limit, say $\frac{1}{4}$ lb. over or under a 30-lb. lap. Six yards of sliver is a good length for testing, whether a card, draw frame, sliver lap, ribbon lap, or comber. It ought to be tested twice a day, and the last head of drawing, three or even four times a day.

Slubber should be tested on a 30 yards length.					
Intermediate	,,	,,	60	,,	,,
Roving and Jack	,,	,,	120	,,	,,

These machines should be tested for hank every set, back and front bobbins, and sometimes for partial and full bobbins. Cops are tested either in 120 yards length from a single cop, or several cops are taken and a lea run from all the cops; this is to get an average. Nobody relies upon the test of a single cop from a mule for the counts. A 2-oz. cop of 60's contains 50,400 yards, so that a dozen or so 840-yard length tests might give a good average, but this is seldom done, several cops being the usual rule.

Wrappings of slivers, rovings, card, and comber webs and yarn on blackboards for minute inspection ought to be a feature in the testing scheme. An intelligent young woman can do all the testing and keeping of records.

Notes on Testing.—Testing laps or wrapping slivers, rovings, and yarns has two distinct objects. One is to see if the cotton is coming through the processes in a reasonable condition and weight per length in accordance with prearranged gearing. The other is to use tests as detectives or exposures, whether of wrong calculations, bad judgment, carelessness, or ignorance. In one case the usual longish lengths taken for the tests are useful in a way, but are often carelessly carried out, and if bad slivers or rovings crop up, such tests have a way of being ignored. It is of real importance that a test should be of such a character as to exhibit actual conditions, and not merely average conditions of a bulk or long length. If yarn cannot be sold or complaints are common the tests should be of a detective form, for clearly the ordinary tests have not indicated poor yarn. Instead, therefore, of using the usual tests, get down to the inside of the matter and test closely, not with lumps, but small bits.

Testing with short lengths will give clear indications whether the slivers are being made more regular at each head of drawing, or the roving at each fly frame, or the yarn at the spinning machine. It is no use using machines unless they serve some really useful purpose. Real detective tests could be applied to finding out if the comber sliver is actually improved by passing it through, say, two or three heads of drawing instead of taking it direct to the slubber.

Testing ought to be the manager's real stand-by, and it is far more preferable that all testing should be done by some one outside the control of the card room or spinning room.

A real system of testing would soon show whether some of the things we harbour as fetishes are of little importance, and whether some features which we almost ignore are really the things that matter.

Testing Yarn for Counts.—This is often done carelessly. A lea test of four cops is the usual method. An average of these four cops is taken as the counts. If a number of tests of the four cops are taken they will all differ, but the average will improve slightly. If, however, the single cop of each four is tested there will be a wide difference between the results indicating irregularities, and if twelve yards are taken from each cop a still further disparity in the results will be shown.

For the internal management of the mill it is necessary to know exactly how the yarn is turning out, and this can only be found out by careful tests on short lengths. Such tests as these ought to form part of every mill organisation, and the manager provided with a copy of all tests made, so that he can place his finger on the weak spots in the processes, and prevent the recurrence of complaints.

A well-organised system of testing and of statistics would deal with the following factors, and reports made on them to the management; such reports being the property of the mill.

Raw Cotton:

1. **Class.**—Particulars of origin, local name, and any details of interest and locality.
2. **Grade.**
3. **Price.**
4. **Marks and No. of bales.**
5. **Sample and bale cotton compared.**
6. **Shipper, broker, merchant, etc.**
7. **Invoice weights, actual weights, difference.**
8. **Tare.**—Bands, wrappings, etc.
9. **Moisture contents.**—A good testing apparatus to be used.
10. **Lengths of fibres.**—An instrument to be used for this, and not the hand-pulling method.
11. **Natural twists.**—A microscope necessary. Counting the twists is advisable in order to denote quality and possible deterioration.
12. **Colour and appearance.**—Colour chart can be used. Blackboard necessary, and a good north light. Whether bright, lustrous, dull, rough, curly, straight, neppy, etc.
13. **Waste.**—Short fibres, sand, seed husks, leaf, neps, stains, bits of jute and hemp, etc.

14. **Samples.**—Report on these as per foregoing. If possible run a sample through sampling machines if such be in the mill.

Blowing Room:

1. **Length of fibres.**—Take a few samples of lap to test for length of fibres.
2. **Waste.**—Presence of good fibres and character of the droppings. Note if waste is of a kind that was already in the raw cotton in order to judge whether the action of the machine has produced neps, flocks, etc.
3. **Weighing.**—Completed list of all lap weights. Unroll laps and cut off yard lengths. Unroll laps and note weight of the length that causes the lap fleece to break away.
4. **Moisture.**—Test portions of finished lap for moisture contents.
5. **Humidity.**—Take readings of thermometers for percentage of humidity in room.

Card Room:

1. **Weights of sliver.**—Weigh successive lengths of card sliver, and occasionally short lengths.
2. **Web.**—Place blackboard under web from doffer and tear off a portion for close examination in testing room.
3. **Length of fibre.**—Test sliver for length of fibre and compare with similar raw cotton test. Also test the flat strips for length of fibre.
4. **Grinding and stripping.**—Keep a strict account of every card with date and times.

5. **Wire renewal.**—Account to be kept of renewal as each card is re-clothed, with particulars of wire, set, counts, etc.
6. **Speeds** of various parts to be booked.
7. **Settings** to be booked, and gauges to be compared with standards from time to time.
8. **Production.**—To be checked occasionally, and lost time noted.
9. **Quality of various cards.**—Compare the productions and quality from various cards.
10. **Strength of sliver.**—Test breaking length of sliver occasionally.
11. **Waste.**—Take waste percentage occasionally.

Fly Frames:

1. **Hanks.**—Test back and front bobbins. Test empty and full bobbins. Test short lengths occasionally. Compare hank produced with calculated hank to find if stretching has occurred. Keep exact records of every test made.
2. **Coils and layers.**—Count these occasionally. Examine bobbins for first layer and afterwards, to see if cone belt is being moved along cone drums at a correct rate. Record ratchet wheel and lifter wheel used.
3. **Bobbins.**—Diameter of bare bobbin and weight. Weight of full bobbin. Loss of time in piecing and doffing. Time to fill a bobbin.
4. **Samples.**—Take samples of rovings on blackboard and examine for thick and thin places, bad ends, dirty rovings, etc.
5. **Twist.**—Twists per inch. Multiplier for twists.
6. **Speeds.**—Speed of spindles and shafts by tacho-

meters. Speed and diameter of front roller. Draft in rollers. Settings of rollers.

7. **Production.**—Test occasionally for pounds produced and pounds paid for. Compare productions from each machine.
8. **Humidity.**—Keep records of humidity.
9. **Weighing apparatus.**—Use standard weights; send them to be tested occasionally. Use a good type of scales and keep protected.

Draw Frames, Combers, etc.:

1. **Hanks.**—Test frequently, and occasionally test a series of short lengths. Compare the condition, hanks, etc., of the slivers after each machine.
2. **Strength.**—Test breaking length after each machine and compare results.
3. **Stretching.**—Compare calculated hanks with actual hanks to detect stretching in slivers and laps.
4. **Speeds and productions.**—Speeds of front rollers. Calculated production and actual production to find lost time.
5. **Waste.**—Use percentage scale, or carefully weigh in good type scales with standard weights.
6. **Blackboard.**—Use for examination of slivers and laps. Use magnifying-glass.
7. **Needles.**—Examine with powerful magnifying-glass or microscope all half laps, strips, and top combs for level line of needles, and clean pointed tips of needles.
8. **Moisture.**—Test rovings for moisture.
9. **Humidity and temperature.**—Keep records.
10. **Draft and settings.**—Record these and give particulars of variations from normal.

Spinning Room:

1. **Humidity and temperature.**—Records to be kept.
2. **Hanks and counts.**—Test these. Differences of humidity in card room and spinning room; produce variations. Test short lengths occasionally to detect causes of variation and irregularities. Use fine scales for short lengths. Test for counts immediately they come from the spindle.
3. **Twists.**—Test these often from various cops. Use a good tester.
4. **Strength.**—Test single as well as leas. Use a moderate speed on tester and keep to one speed. Record the elasticity of yarn or its elongation before breaking. This is important.
5. **Blackboard.**—Wrap on blackboard. Examine for unevenness, cleanliness, and general condition. Use microscope for spots, neps, and other imperfections to find real cause. If jute, hemp, or other fibres are present, report on same. Collect the cleared stuff from back traverse guides and examine.

General.—Keep records of all the speeds of the main parts of the machines. Draws per minute. Speeds of spindles. Size of cop, twist, weft, bastard, etc., stretch, rim diameter and speed, twist wheels, etc.

Condition of stores.—No. of skips, bobbins, strapping, bands, brushes, varnish, roller leather, flannel, coal, etc. Consumption of stores at stated intervals and the cost of same.

Wages.—Compare wages paid to the various operatives and examine into cause of differences.

The manager should also make arrangements that would supply him with records of:

Production of yarn spun and counts as from the machines.

Production after conditioning and counts.

Percentage of moisture in the yarn from the spindle and in the yarn when it is conditioned and being sent out.

The balance of yarn in stock and counts.

NOTE.—A complete series of drawings to illustrate the remarks in above chapter is given in the author's book, *Cotton Machinery Sketches.*

CHAPTER XIV

MISCELLANEOUS

Square Root in Cotton Spinning Calculations.—The necessity of extracting the square roots comes about through our system of numbering yarns. The standard is a combination of length and weight; 840 yards is the standard length, and 1 lb. is the standard weight. If 840 yards of yarn weigh 1 lb. we call the yarn No. 1. If 2×840 yards $= 1680$ yards and this weighs 1 lb., it is called No. 2. If 50 times 840 yards weigh 1 lb. we know the yarn to be No. 50, and so on. We see, therefore, that the basis of the system depends upon the number of 840-yard lengths there is in 1 lb. weight of yarn.

It would be very inconvenient to have to unwind and weigh 25,200 yards of yarn to find that it was No. 30, so both length and weight are reduced to much smaller quantities, but they remain in the same proportion or relationship to each other. For this purpose, leas, or the one-seventh part of 840 yards, are frequently used, but any proportion can be used. When the lea is used we have $\frac{840}{7} = 120$ yards, and the corresponding weight is

$\frac{1 \text{ lb.}}{7} = \frac{7000 \text{ grains}}{7} = 1000$ grains.

To find Counts or Hanks.—Weigh any length in grains. Multiply the length by 7000 grains and divide by the grains multiplied by 840 yards.

EXAMPLE:

120 yards weigh 40 grains,

then $$\frac{120 \text{ yards} \times 7000 \text{ grains}}{40 \text{ grains} \times 840 \text{ yards}} = 25\text{'s counts.}$$

It will be seen that $\frac{7000}{840} = \frac{1000}{12} = 8{\cdot}\dot{3}$.

We can simplify the rule as follows:

Divide a length by its grain weight and multiply by $8{\cdot}\dot{3}$ to obtain the hank or counts.

EXAMPLE:

$$\frac{\text{yards}}{\text{grains}} \times 8{\cdot}\dot{3} = \text{counts or hanks.}$$

$$\frac{120 \text{ yards}}{40 \text{ grains}} \times 8{\cdot}\dot{3} = 25\text{'s.}$$

or $$\frac{\text{yards} \times 100}{\text{grains} \times 12} = \text{counts or hanks.}$$

EXAMPLE:

$$\frac{6 \text{ yards} \times 100}{186 \text{ grains} \times 12} = {\cdot}268 \text{ hank.}$$

If a lea or 120 yards is weighed the rule is to divide 1000 by the lea weight in grains to give the counts.

$$\frac{1000}{\text{grains in 1 lea}} = \text{counts.}$$

EXAMPLE:

A lea of yarn weighs 30 grains,

then $$\frac{1000}{30} = 33{\cdot}\dot{3} \text{ counts.}$$

It has been stated that a certain length of yarn must be weighed in order to obtain the counts; now one is apt to think that length is the important point, but our yarn must have length, breadth, and thickness in order to be weighed; the other dimensions of the yarn are therefore quite as important as length in numbering the yarn, and in mill work are far more important, so far as some of the mechanical operations are concerned.

When 840 yards weigh 1 lb. we call the yarn No. 1 counts; when twice 840 yards weigh 1 lb. we call the yarn No. 2 counts. It is quite clear, since the weight is the same in each case, that the bulk or volume of the cotton is the same in each case (assuming that the specific gravity of cotton is uniform). But No. 2's yarn is twice as long as No. 1's yarn, so that No. 2's yarn must have a **sectional area** only half that of No. 1's yarn, in order that the volume may be equal. Let us take a simple example to illustrate this point. Suppose we take a piece of iron 2 in. in diameter and 6 in. long; its volume will be: $d^2 \times \cdot 7854 \times 6$ in. $= 2 \times 2 \times \cdot 7854 \times 6 = 18 \cdot 85$ cu. in. If we now draw this piece of iron down to twice its length and make it 12 in. long we have not altered its volume or its weight, but we have made it thinner as a consequence of lengthening it. Let us see what its dimensions are now under the altered conditions:

$$d^2 \times \cdot 7854 \times 12 \text{ in.} = 18 \cdot 85 \text{ cubic in.}$$

$$d^2 = \frac{18 \cdot 85}{\cdot 7854 \times 12} = 2 \text{ in.}$$

$$d = \sqrt{2}$$

$$d = 1 \cdot 41\text{-in. diameter.}$$

This example shows clearly that, although the length of the iron has been doubled and the sectional area reduced to one-half, the diameter has not been reduced in the same proportion, for the original 2-in. diameter has only been reduced to 1·41-in. diameter.

Instead of using iron, we will now take two yarns for comparison, say No. 9's and No. 36's. From the system of indicating counts of yarn, it is known that there will be 9×840 yards in 1 lb. of No. 9's and there will be 36×840 yards in 1 lb. of No. 36's. Each of these lbs. of yarn will have exactly the same volume, so that their volumes will be found as follows :

No. 9's, $\pi r^2 \times 9 \times 840$ = volume of No. 9's.
No. 36's, $\pi r^2 \times 9 \times 840$ = volume of No. 36's,
so that $\pi r^2 \times 9 \times 840 = \pi r^2 \times 36 \times 840$
and $9r^2 = 36r^2$,
$r^2 = 4r^2$.
Extract the square root $r = 2r$.
$\therefore$ the diameter of 9's = twice the diameter of 36's.

In other words we see that although a pound of No. 36's is four times the length of No. 9's, the diameter of No. 9's has only been made twice the diameter of No. 36's in order to make the volumes equal. From this reasoning the important fact stands out very clearly that No. 9's yarn is not four times coarser or thicker than 36's, but only twice as thick, and this holds good throughout the whole range of counts, viz., that the fineness or coarseness of the diameter of yarn is not represented by the proportion between the count numbers.

It will also be noted that, in the examples, it has been necessary to compare diameters and obtain proportions between the diameters of counts of yarn. To obtain the diameters or proportions of the diameters, we first calculated the area of the cross sections and from these deduced the diameters by extracting the square root. From this we arrive at the conclusion that whilst we use numbers based on mere length as a standard for counts,

the real basis is the cross-sectional area of the yarn or its diameter.

We will present the case in another manner and deduce the same result. Take the two yarns No. 9's and No. 36's; we know that the volumes of one pound of each are equal.

$$\therefore \text{length} \times \text{area} = \text{constant},$$

so that $$9\text{'s} \times 840 \times \text{area of } 9\text{'s} = \text{constant},$$

and $$36\text{'s} \times 840 \times \text{area of } 36\text{'s} = \text{constant}.$$

Since the constants are equal,

then $9\text{'s} \times 840 \times \text{area of } 9\text{'s} = 36\text{'s} \times 840 \times \text{area of } 36\text{'s}$;

by cancelling out we get

$$9\text{'s} \times \text{area of } 9\text{'s} = 36\text{'s} \times \text{area of } 36\text{'s},$$

but $$9\text{'s} \times \frac{1}{9} = 36\text{'s} \times \frac{1}{36},$$

$$\text{the area of } 9\text{'s yarn} = \frac{1}{9}$$

and $$\text{the area of } 36\text{'s yarn} = \frac{1}{36},$$

or the sectional area of No. 9 yarn is four times greater than the sectional area of No. 36 yarn.

In other words, **the sectional areas of yarns can always be represented by unity divided by the counts**. This may also be expressed as follows: The sectional areas of yarns are represented by the reciprocal of the counts. Knowing this important fact, it is now possible to compare yarns more directly by representing them as their reciprocals in the form of a fraction as $\frac{1}{36}$, $\frac{1}{9}$, etc. It must be remembered that these fractions do not represent actual areas in square inches or other sizes, they simply give us numbers that enable us to compare one size of yarn with another, so that we are in a position to say, for instance, that No. 9's yarn is four times as large in sectional area as No. 36's yarn.

If the area of a circle is given to us, it is an easy matter to calculate its diameter; for instance:

$$\sqrt{\frac{\text{area}}{3{\cdot}1416}} = \text{radius, or} \sqrt{\frac{\text{area}}{{\cdot}7854}} = \text{diameter.}$$

This would give the actual diameter of a circle, but if it is desired to simply compare diameters, 3·1416 or the constant ·7854, whichever is used, is common to all calculations, so it would cancel out and therefore can be ignored. Thus we can compare diameters by simply taking the square root of the areas of any two or more yarns, and the numbers so obtained enable one to say definitely how much thinner or thicker one yarn is than another.

Diameters of yarn, therefore, can be represented by taking the square root of the sectional area of the yarn, such sectional area being represented by the reciprocal of the counts. For example:

Counts $= 36,$

sectional area $= \frac{1}{36},$

diameter $= \sqrt{\frac{1}{36}}$ or $\frac{1}{\sqrt{36}},$

$\therefore$ diameter of 36's $= \frac{1}{6}.$

The following list will emphasise this way of presenting the case:

Counts—

1 2 4 25 49 100 225 400

Length in 1 lb.—

840, 1680, 3360, 21,000, 41,160, 84,000, 189,000, 336,000.

Sectional area—

$$\frac{1}{1} \quad \frac{1}{2} \quad \frac{1}{4} \quad \frac{1}{25} \quad \frac{1}{49} \quad \frac{1}{100} \quad \frac{1}{225} \quad \frac{1}{400}$$

Diameter—

$$\sqrt{\frac{1}{1}} \quad \sqrt{\frac{1}{2}} \quad \sqrt{\frac{1}{4}} \quad \sqrt{\frac{1}{25}} \quad \sqrt{\frac{1}{49}} \quad \sqrt{\frac{1}{100}} \quad \sqrt{\frac{1}{225}} \quad \sqrt{\frac{1}{400}}$$

Diameter—

$$1 \quad \frac{1}{1 \cdot 4} \quad \frac{1}{2} \quad \frac{1}{5} \quad \frac{1}{7} \quad \frac{1}{10} \quad \frac{1}{15} \quad \frac{1}{20}$$

It is seen from this table that whilst the length of 1 lb. of each yarn increases in a direct proportion, **the diameter varies inversely as the square roots of the counts.** This statement means that whilst counts 400's is 400 times longer than counts 1's, its diameter is only 1/20 that of the diameter of No. 1's; or *vice versa*, No. 1's counts is 400 times shorter per lb. than 400's counts, but its diameter is only 20 times greater. It will be interesting to point out also that No. 4's is half the thickness of No. 1's, and yet there are only three counts between them, but there are three hundred counts between 100's and 400's, and yet No. 400's is only half the thickness of 100's, so that an irregularity of 1/4 of a count in spinning No. 4's would correspond to an irregularity of 25 counts in spinning 400's.

The question as to how much thinner or thicker one yarn is than another may be now easily answered. For instance, how much thicker is 25's than 81's?

$$\text{The relative area of 25's counts} = \frac{1}{25}.$$

$$\text{,, \quad ,, \quad ,, \quad 81's \quad ,,} = \frac{1}{81}.$$

$$\text{The relative diameter of 25's counts} = \sqrt{\frac{1}{25}} = \frac{1}{5}.$$

$$\text{,, ,, ,, 81's ,,} = \sqrt{\frac{1}{81}} = \frac{1}{9}.$$

The 25's yarn is the thickest, and by dividing $\frac{1}{5}$ by $\frac{1}{9}$ we obtain how much thicker it is; thus:

$$\frac{1}{5} \div \frac{1}{9} = \frac{1 \times 9}{5 \times 1} = \frac{9}{5} = 1\frac{4}{5},$$

or 1·8 times thicker in diameter.

It would be easy to draw up a table showing the relative number of layers of yarn on a bobbin or cop, now that we know how to obtain relative diameters; for instance:

Counts—								
1	2	4	25	49	81	100	225	400
Relative diameters—								
$\sqrt{\frac{1}{1}}$	$\sqrt{\frac{1}{2}}$	$\sqrt{\frac{1}{4}}$	$\sqrt{\frac{1}{25}}$	$\sqrt{\frac{1}{49}}$	$\sqrt{\frac{1}{81}}$	$\sqrt{\frac{1}{100}}$	$\sqrt{\frac{1}{225}}$	$\sqrt{\frac{1}{400}}$
Relative No. of layers per inch—								
10	14	20	50	70	90	100	150	200

It has been presumed there are 10 layers per inch of No. 1's, so that the number of layers for the other counts are found by dividing 10 by their diameters; in this way the relative number of layers per inch are obtained.

This table is interesting, for from it we are in a position to say that **all wheels controlling the building of a bobbin or cop are directly proportional to the number of layers per inch**, and also the further important statement that **the number of layers of yarn in a bobbin or cop is directly proportional to the square root of the counts.** This explains the reason why the shaper wheel on the mule, the ratchet wheel, twist wheels, and lifter wheels, on the fly frames, etc., are calculated direct from the square root of the counts; it is simply because we assume layers and not diameters; but, as explained above, the diameters are the real foundation upon which the whole argument depends.

Doubling Counts.—When two or more yarns are doubled together, the resulting thread is usually found as follows:

If A and B are the two yarns, the rule is

$$\frac{A \times B}{A + B} = \text{the counts of the doubled yarn.}$$

If A, B, and C are three yarns, the rule is

$$\frac{A \times B \times C}{(A \times B) + (A \times C) + (A \times C)} = \text{the counts of the doubled yarn.}$$

Of course hank rovings can be used instead of yarn counts. The above rules are very convenient and exact, if due account is taken of the shortening due to the twisting of doubled yarns together, but few seem aware of their origin, and still fewer of a much simpler form of the same rule.

When two yarns are doubled we simply add their areas together and the sum will naturally give us the area of the doubled yarn. We have already shown that the area of any yarn or roving is found by dividing unity by the counts, so that if we double two yarns, each 40's counts, we proceed as follows:

$$\frac{1}{40} + \frac{1}{40} = \frac{2}{40} = \frac{1}{20} \text{ area of doubled counts.}$$

If $\frac{1}{20}$ is the area of yarn, then 20's is the counts of that yarn, so that doubling two yarns each No. 40's the resulting doubled yarn is No. 20's.

Now take **two yarns**, Nos. 20's and 60's,

then $\frac{1}{20}+\frac{1}{60}=\frac{3}{60}+\frac{1}{60}=\frac{4}{60}+\frac{1}{15}$ area of doubled yarn, so that the doubled yarn is No. 15's.

Now take **three yarns**, Nos. 20's, 50's, and 100's,

then $\frac{1}{20}+\frac{1}{50}+\frac{1}{100}=\frac{5}{100}+\frac{2}{100}+\frac{1}{100}=\frac{8}{100}=\frac{1}{12\frac{1}{2}}$, so that the doubled yarn is No. $12\frac{1}{2}$'s.

Now take **four yarns**, Nos. 4's, 6's, 12's, and 24's,

then $\frac{1}{4}+\frac{1}{6}+\frac{1}{12}+\frac{1}{24}=\frac{6}{24}+\frac{4}{24}+\frac{2}{24}+\frac{1}{24}=\frac{13}{24}=\frac{1}{1\frac{9}{24}}$, so that the doubled yarn is No. $1\frac{9}{24}$'s or 1·7's nearly.

If this has been made clear we are in a position to see how the rule usually used has been derived. Suppose we wish to double two yarns A and B; let X equal the resulting doubled yarn,

then $$\frac{1}{A}+\frac{1}{B}=\frac{1}{X}.$$

Multiply both sides by A B,

then $$\frac{A\times B}{A}+\frac{A\times B}{B}=\frac{A\times B}{X},$$

so $$B+A=\frac{A\times B}{X},$$

and $$\frac{B+A}{B\times A}=\frac{1}{X},$$

$$\therefore \quad \frac{B\times A}{B+A}=X, \text{ the counts of the doubled yarn.}$$

Suppose three yarns are taken and twisted into one; let the three yarns be A, B, and C, and X the resulting doubled yarn, then $$\frac{1}{A}+\frac{1}{B}+\frac{1}{C}=\frac{1}{X}.$$

Multiply by $A\times B\times C$,

then $$\frac{A\times B\times C}{A}+\frac{A\times B\times C}{B}+\frac{A\times B\times C}{C}=\frac{A\times B\times C}{X},$$

so $$B\times C+A\times C+A\times B=\frac{A\times B\times C}{X},$$

$$\therefore \frac{A\times B\times C}{B\times C+A\times C+A\times B}=X \text{ counts of the three-fold yarn.}$$

We thus arrive at the rule commonly used in doubling problems, and the chief point to be noted is that it is based on the fact that $\frac{1}{\text{counts}}$ represents the sectional area of yarn, and from it we obtain diameters. By adding these areas we obtain the rules which give the result of combining two or more slivers, rovings, or yarn together.

Another Rule.—Combine 20's and 60's counts.

EXAMPLE:

$$\frac{20}{\frac{20}{60}+1}=\frac{20}{\dot{3}+1}=\frac{20}{1\cdot\dot{3}}=15\text{'s counts.}$$

Diameter of Yarn.—Approximately for twist yarns

$$\frac{1}{\sqrt{\text{counts}}\times 24}=\text{diameter in inches.}$$

EXAMPLE:

$$\frac{1}{\sqrt{40\text{'s}}\times 24}=\frac{1}{6\cdot\dot{6}\times 24}=\frac{1}{160}\text{ of an inch dia.}$$
$$=\cdot 00625 \text{ inch dia.}$$

or

$$\frac{\cdot 04166}{\sqrt{\text{counts}}}=\text{dia. of yarn in inches.}$$

EXAMPLE:

$$\frac{\cdot 04166}{\sqrt{40\text{'s}}} = \frac{\cdot 04166}{6\cdot 66} = \cdot 00625 \text{ inch dia.};$$

or $$\frac{1}{\sqrt{\text{number of yards in 1 lb. of yarn}}} = \text{dia. in inches.}$$

or $$\frac{1}{\sqrt{\text{number of yards in 1 lb. of yarn}}} - 13 \text{ per cent} = \text{dia. in inches.}$$

EXAMPLE: 40's counts.

$$\frac{1}{\sqrt{40 \times 840}} - 13 \text{ per cent} = \frac{1}{183 - 13 \text{ per cent}},$$

$$= \frac{1}{\frac{183 \times 87}{100}} = \frac{1}{160} \text{ in. dia.}$$

Strength of Yarn.—The fact that the strength of yarn varies directly as the area of the cross section would be correct if all yarns contained the same internal conditions among the fibres, but they vary considerably in many respects. As a guide, however, to the strength, the following rule is frequently used:

$$\frac{1880}{\text{Counts of yarn}} = \text{lea strength in lbs. American cotton.}$$

Add 10 per cent for the increased strength of Egyptian cotton.

Angle of Twist.—The angle of the twist put into yarn is the same for all yarns that have the same twist "constant" or twist "multiplier." The angle of the twist will be altered if the twist multiplier is changed. This applies to all rovings as well as yarns.

Examining Cotton.—Cotton, in any of its states, should be placed on a black surface; the surface should be matt and not polished. A good magnifying-glass should be used for preliminary examinations.

Instructions to Overlookers.—All instructions to overlookers to make changes of gearing, settings, and other important matters should be written down in a book provided for that purpose and a duplicate given to the overlooker. Responsibility can then be traced easily.

Card-room Particulars.—The manager or managing director should be supplied weekly with a list of all the particulars of the different preparations going through the mill. The form on p. 244 is a convenient one.

Notebooks. — Every one occupying a responsible position in the mill should have a notebook containing particulars of the gearing and the **constants** for calculating the change wheels. All the makers will supply you with a list of the whole of the change wheels and constants for all their machines. Paste or copy out the list in the notebook, and be particular to note any alterations that may be due to any special circumstances. Try and get the whole of the gearing alike on a passage of machines doing the same work. If this is not possible at first, find out the cause. Different makers' machines may of course lead to some differences, but note the differences.

Take notes of how long leathers last, belting, bands, bobbins, skewers, weights, thickness and hardening tendency of flannel. Work out the costs of the renewals of various items in the department, so that economies may be effected without a sacrifice of efficiency.

Make the job as easy as possible by displaying skill in organisation and method, and not in a constant round of skilfully solving problems or complaints. Notebooks will help you if you use them to reason upon in your leisure time. Use the contents of your notebooks for building purposes; do not let them lie in a mere heap.

Doubling Yarns.—Doubled yarns are made for a variety

Mill.. Date................................

Quality or kind of Cotton..

Counts...

Machine.	Weights and Hanks.	Ends up.	Draft.	Twists per inch.	Speeds.	Waste.
Opener . . .	... oz. per 1 yd.	....	....	....	... cyl. ... beater	
Scutcher . . .	... oz. ,, 1 yd.	... laps			... cyl. ... beater	
Card	... grains ,, 1 yd.	....	....	....	... cyl. ... doffer ... taker-in	
Draw frame . .	... grains ,, 1 yd.	... ends			... Front roller ... dia.	
Sliver lap . . .	... grains ,, 1 yd.	... ends			... Calender	
Ribbon lap . .	... grains ,, 1 yd.	... laps			... Front roller ... dia.	
Comber . . .	... grains ,, 1 yd.	... laps			... Nips ... feed	
Draw frame . .	... grains ,, 6 yds.	... ends			... Front roller ... dia.	
Slubber . . .	... grains ,, 30 ,,	....	....	....	... Spindles ... F.R.	
,, . . .	... hanks				... ,, ,,	
Intermediate . .	... grains per 30 yds.	... ends			... ,, ,,	
,, . .	... hanks	... ends			... ,, ,,	
Jack	... grs. per 120 yds.	... ends			... ,, ,,	
,, ...	... hanks	... ends			... ,, ,,	
Mule	... counts	... ends			... ,, ,,	
Ring	... counts	... ends			... ,, ,,	

NOTES.—

of purposes. All kinds of twisting is done to suit these varied purposes, so that, generally speaking, no rules are applicable. If the yarns are doubled and a **balance twist** is desired, then judgment is required. If the two yarns, when doubled, curl up when hanging loose between the two hands, it is not balanced. The doubled yarn should **just** show a tendency to curl.

If the single yarn is made and doubled in the same mill the twists per inch will be known for each yarn used and the twist multiplier will be known. When doubling the yarns, find the resulting counts and multiply the square root of this count by a 20 to 25 per cent less twist multiplier than is used for the single counts. If yarns are bought or supplied to be doubled and twists per inch of the single not given, it can easily be found on the twist measurer. In any case it is always best to test the twist even when the particulars are given on the order. If a length of the doubled yarn is taken between the two hands and it curls up or does not curl, you can put in or take out twists until you get a balance; then count the twists per inch and use a multiplier to suit.

Flyer Doubler makes a stronger and more compact thread than the ring doubler; it is also a much smoother thread. The flyer limits its speed, so slow spindle speeds are necessary and production low; more power is required. Spindles ought to be driven by tape to reduce power. For coarse counts and the use of self-contained spindles, and in some cases of ball-bearings, the flyer is extensively used. Lost time in doffing is a disadvantage of the flyer doubler.

Ring Doubler.—The usual type used for general doubling: high speeds, quick doffing, and big production. For low and medium counts or twists there result a stronger yarn, twist more regular, female labour, and less room, as compared with the twiner. Tape driving is a great advantage in maintaining tension of the band, a saving in power, saving in cost of bands, and a narrower machine.

Twiner.—Still used in Yorkshire and one or two districts of Lancashire. Two cops are put up in the creel. By winding the two ends on a cone-shaped bobbin, this bobbin is put in the creel and eliminates creeling of cops and all the attendant supervision, piecing up, etc., of cops.

Twist on Ring Doubler (as a guide):

Doubled Yarns.	Purpose.	Twists per inch.
30's/3	Heald yarn	$\sqrt{\text{counts}} \times 5$
30's/3	Sewing cotton, finishing	$\sqrt{\text{counts}} \times 7$
60's/6	,, ,, finishing	$\sqrt{\text{counts}} \times 7$
60's/2	,, ,, preparing	$\sqrt{\text{counts}} \times 5$
60's to 100's/2	Weaving	$\sqrt{\text{counts}} \times 5$
60's/2	Gassing, soft	$\sqrt{\text{counts}} \times 3{\cdot}75$
30's/2	Selvedges	$\sqrt{\text{counts}} \times 4{\cdot}5$
30's/5	Fish-nets, preparing	$\sqrt{\text{counts}} \times 5$

Twist for Flyer Doubler:

100's to 200/2	Crepe, lace, and net	$\sqrt{\text{counts}} \times 5$
50's to 100/2	Crepe	$\sqrt{\text{counts}} \times 6\frac{1}{2}$
40's to 60/2	,,	$\sqrt{\text{counts}} \times 5$
30's to 150/3	Heald yarns, preparing	$\sqrt{\text{counts}} \times 5$
30's to 150/9	,, ,, finishing	$\sqrt{\text{counts}} \times 8$
20's to 30/5	Fish-nets, preparing	$\sqrt{\text{counts}} \times 5$
20's to 30/15	,, finishing	$\sqrt{\text{counts}} \times 10$
10/21	Cords	$\sqrt{\text{counts}} \times 8$
36/16	,,	$\sqrt{\text{counts}} \times 8$

It is a general rule to use equal counts for doubling purposes, but a wide range of special yarns can be spun in the single or produced by doubling.

Special Yarns, Fancy Yarns, Effect Yarns.—Single yarns may be tinted by using stained or dyed cotton, mixing darker cottons with lighter-coloured cottons such as red Coconada.

Alterations in twist for very soft or very hard yarns where strength is not important. Better cottons must be used for high twist if strength is required. **Double-spun** yarn is hard-twisted yarn to imitate doubled yarn. Instead of doubling ends of 100's to produce 100's/2, a single yarn of 50's is wound and then passed through a wet doubler, where it receives extra twist. The yarn becomes greatly improved in strength and quality, and is cleared, gassed, and reeled in the usual way.

All kinds of special yarns can be spun as specialities that as ordinary yarns would be considered very poor yarn. Very neppy yarn, very irregular yarns with prominent thick and thin places. Long and short cottons mixed. Mixed spotty cottons used for yarns. Dyed and white cottons mixed.

Slubs are produced in a variety of ways requiring mechanical methods such as intermittent changes of speed of the back roller.

It is in the doubling frame that many special yarns are produced. Quite a variety of effects may be produced by doubling a two-fold of, say, 30's by inserting twists varying from 6 to 60 twists per inch.

Other prominent effects are produced by doubling equal or unequal counts of different directions of twists. Two yarns, one twist way and one weft way, if doubled, will produce spiral effects due to one of the yarns becoming untwisted and the other more twisted.

Single coarse yarn and a fine but little twisted two-fold yarn when doubled will have a spiral of soft yarn on the outside and a strong double thread as a centre.

The expanding or contracting of single or doubled yarn, when they are combined by again doubling, will always produce spiral effects, differing according to the twists put in.

Sponge Yarn is a general term for a spiral type of doubled yarn; it is sometimes known as Gimp, Truffle, Ratine, etc.

A variety of fancy yarns are produced by combining other textile yarns, coloured or undyed, with cotton.

Lace, Curtain, and Net Yarns.—Several kinds of doubled yarns are required for these. The most important is that used in the brass bobbin; it is the weft of the material and is made in two-fold, varying from 20's/2 to 400's/2. As a rule, the ring doubler is used for the lower counts and the flyer doubler for the finer counts. The ground warp is also a two-fold, gassed. The outline thread may be from 30's/2 to 80's/2. The filling threads of the patterns are termed gimp threads, and may be two- or three-fold. Double-spun yarn is extensively used as a substitute for the two-fold yarn.

Voile and Crepe.—This is extensively produced in cotton; 60s'/2 to 100's/2 is usual. The yarn is produced by twisting the two-fold in the same direction as the singles, and $\sqrt{\text{counts}} \times 5$ is the usual twist. This twisting produces an elastic and wiry yarn. It is gassed and then wound in a form to suit either warp or weft. Crepe yarns are doubled with a lighter twist than voile yarns, and 140's/2 may have as high as 70 turns per inch.

In **winding**, most of the causes of ends breaking are to be traced to the yarn from the spinners. A cop ought to unwind throughout without a break; there is so little that can cause a breakage beyond carelessness of the operative. Dirt, fluff, and broken ends blocking thread guides, or flannel or brushes, will break an end. Spindles set out of the centre line to the clearers or thread guides will cause breakages. Acute angle or too many angles in the yarn as it passes to the bobbin will strain the yarn and break it. Heavy clearing is a cause of breakages.

Cotton and Yarn Prices.—It is advisable that all should become conversant with cotton and yarn prices. These are readily obtainable from newspapers and the official records. A good general idea of the financial position, so far as turnover is concerned, can be estimated by means of drawing up a table similar to the following:

No. of Spindles in the Mill.	Counts spun.	Price of Cotton.	Price of Yarn.	Margin.	Value of Cotton bought per Week.	Value of Yarn sold per Week.	Difference per Week.
		pence.	pence.	pence.	£	£	£
80,000	32's	15	21·75	6·75	4500	5740	1242
80,000	60's	$17\frac{1}{2}$	$29\frac{3}{4}$	12·24	2220	3330	1100
80,000	100's	19	45	26	1110	2030	920

The amount in the difference column has to bear the whole of the expenses of working the mill and paying a dividend. The price of the yarn is of course fixed in the first place after taking into account all expenses and changes, waste, moisture, etc., and then an assumed profit is added. Competition, bad trade, etc., will lower the profit item until it may disappear. Margin is not the real criterion unless counts, quality, and capital charges are known.

The above table is not to be looked on as an accurate set of figures, but simply as a method of working out the position and as an exercise for rough estimates.

Managers, before taking over new positions, can form some idea of what will be required of them and of the remuneration to be expected. Incidentally also, the carder and all under-men may deduce their probable value to a firm.

YARN TABLE OF TWISTS PER INCH AND SQUARE ROOT OF COUNTS

Counts.	Square Root of Counts.	Indian and American Cotton.			Egyptian Cotton.		
		Mule Twist.	Mule Weft.	Ring Frame Twist.	Mule Twist.	Mule Weft.	Ring Frame Twist.
1	1·000	3·75	3·25	4·00	...	...	...
2	1·414	5·30	4·60	5·65	...	...	...
3	1·732	6·49	5·62	6·92	...	...	...
4	2·000	7·50	6·50	8·00	...	...	...
5	2·236	8·38	7·26	8·94	...	...	...
6	2·449	9·18	7·96	9·79	...	...	...
7	2·645	9·92	8·59	10·58	...	...	...
8	2·828	10·60	9·19	11·31	...	...	...
9	3·000	11·25	9·75	12·00	...	...	...
10	3·162	11·85	10·27	12·64	11·44	10·10	11·44
11	3·316	12·43	10·77	13·26	11·95	10·55	11·95
12	3·464	12·99	11·25	13·85	12·47	11·01	12·47
13	3·605	13·52	11·71	14·42	13·00	11·57	13·00
14	3·741	14·03	12·16	14·96	13·46	11·89	13·46
15	3·872	14·52	12·48	15·49	13·96	12·32	13·96
16	4·000	15·00	13·00	16·00	14·40	12·72	14·40
17	4·123	15·46	13·40	16·49	14·86	13·12	14·86
18	4·242	15·90	13·78	16·97	15·27	13·48	15·27
19	4·358	16·34	14·16	17·43	15·71	13·87	15·71
20	4·472	16·77	14·53	17·88	16·09	14·21	16·09
22	4·690	17·58	15·24	18·76	16·88	14·91	16·88
24	4·898	18·37	15·92	19·59	17·63	15·57	17·63
26	5·099	19·11	16·57	20·39	18·35	16·21	18·35
28	5·291	19·84	17·19	21·16	19·04	16·83	19·04
30	5·477	20·54	17·80	21·90	19·75	17·42	19·75
32	5·656	21·21	18·38	22·62	20·40	18·00	20·40
34	5·830	21·86	18·95	23·32	21·02	18·55	21·02
36	6·000	22·50	19·50	24·00	21·64	19·09	21·64
38	6·164	23·11	20·03	24·65	22·23	19·61	22·23
40	6·324	23·71	20·55	25·29	22·81	20·13	22·81
42	6·480	24·30	21·06	25·92	23·37	20·62	23·37
44	6·633	24·87	21·55	26·53	23·92	21·10	23·92
46	6·782	25·43	22·04	27·12	24·45	21·58	24·45
48	6·928	25·98	22·51	27·71	24·98	22·04	24·98
50	7·071	26·51	22·98	28·28	25·50	22·50	25·50
52	7·211	...	...	...	26·00	22·94	26·00
54	7·348	...	...	...	26·50	23·38	26·50
56	7·483	...	...	...	26·98	23·81	26·98
58	7·615	...	...	...	27·46	24·23	27·46

YARN TABLE OF TWISTS—*Continued*

Counts.	Square Root of Counts.	Indian and American Cotton.			Egyptian Cotton.		
		Mule Twist.	Mule Weft.	Ring Frame Twist.	Mule Twist.	Mule Weft.	Ring Frame Twist.
60	7·745	...	...	...	27·93	24·54	27·93
62	7·874	...	...	...	28·39	25·05	28·39
64	8·000	...	...	...	28·85	25·45	28·85
66	8·124	...	...	...	29·29	25·87	29·29
68	8·246	...	...	...	29·73	26·23	29·73
70	8·366	...	...	...	30·17	26·62	30·17
72	8·485	...	...	...	30·60	27·00	30·60
74	8·602	...	...	...	31·02	27·37	31·02
76	8·717	...	...	...	31·44	27·74	31·44
78	8·831	...	...	...	31·85	28·10	31·85
80	8·944	...	...	...	32·25	28·47	32·25
82	9·055	...	...	...	32·65	28·81	32·65
84	9·165	...	...	...	33·05	29·16	33·05
86	9·273	...	...	...	33·44	29·50	33·44
88	9·380	...	...	...	33·83	29·84	33·83
90	9·486	...	...	...	34·21	30·18	34·21
92	9·591	...	...	...	34·59	30·52	34·59
94	9·695	...	...	...	34·96	30·85	34·96
96	9·797	...	...	...	35·33	31·17	35·33
98	9·899	...	...	...	35·70	31·50	35·70
100	10·000	...	...	...	36·06	31·83	36·06
102	10·099	...	...	...	36·41	32·14	36·41
104	10·198	...	...	...	36·77	32·46	36·77
106	10·295	...	...	...	37·12	32·76	37·12
108	10·392	...	...	...	37·47	33·07	37·47
110	10·488	...	...	...	37·81	33·32	37·81
112	10·583	...	...	...	38·16	33·68	38·16
114	10·677	...	...	...	38·50	33·98	38·50
116	10·770	...	...	...	38·83	34·28	38·83
118	10·862	...	...	...	39·17	34·57	39·17
120	10·954	...	...	...	39·50	34·86	39·50

Weight of Slivers of Given Lengths, together with the Corresponding Hanks and Decimals of Hank

CARDING, DRAWING, AND SLUBBING

6 Yards.				6 Yards.				6 Yards.			
Decimal of Hank.	Oz.	Dwts.	Grains.	Decimal of Hank.	Oz.	Dwts.	Grains.	Decimal of Hank.	Oz.	Dwts.	Grains.
·05	2	5	5	·145	...	14	8·82	·295	...	7	1·49
·055	2	1	10·09	·146	...	14	6·46	·3	...	6	22·66
·06	1	16	11·83	·148	...	14	1·80	·305	...	6	19·93
·065	1	13	19·73	·15	...	13	21·33	·31	...	6	17·28
·07	1	11	12·5	·152	...	13	16·94	·315	...	6	14·73
·075	1	9	13·21	·154	...	13	12·68	·32	...	6	12·24
·08	1	7	19·5	·155	...	13	10·58	·325	...	6	9·84
·085	1	6	6·73	·156	...	13	8·51	·33	...	6	7·51
·09	1	4	22·05	·158	...	13	4·45	·335	...	6	5·25
·095	1	3	16·81	·160	...	13	0·5	·34	...	6	3·0
·098	1	3	0·7	·163	...	12	18·74	·345	...	6	0·92
·099	1	2	19·55	·165	...	12	15·3	·35	...	5	22·85
·1	1	2	14·5	·167	...	12	11·4	·255	...	5	20·94
·101	1	2	9·05	·17	...	12	6·0	·36	...	5	18·88
·102	1	2	4·69	·173	...	12	1·01	·365	...	5	16·98

·103	1	1	23·93	·175	...	11	21·71	·37	...	5	15·13
·104	1	1	19·26	·177	...	11	18·48	·375	...	5	13·32
·105	1	1	14·68	·179	...	11	15·32	·38	...	5	11·58
·106	1	1	9·91	·18	...	11	13·77	·385	...	5	9·87
·107	1	1	5·78	·183	...	11	9·22	·39	...	5	8·2
·108	1	1	1·46	·185	...	11	6·27	·395	...	5	6·58
·109	1	0	21·21	·187	...	11	3·37	·4	...	5	5·0
·11	1	0	17·04	·189	...	11	0·55	·41	...	5	1·95
·111	1	0	12·95	·19	...	10	23·15	·42	...	4	23·05
·112	1	0	9·46	·193	...	10	19·06	·43	...	4	20·28
·113	1	0	4·97	·195	...	10	16·41	·44	...	4	17·63
·114	1	0	1·09	·197	...	10	13·8	·45	...	4	15·11
·115	...	18	2·78	·2	...	10	10·0	·46	...	4	12·69
·116	...	17	23·03	·205	...	10	3·9	·47	...	4	10·38
·117	...	17	19·35	·21	...	9	22·1	·48	...	4	8·16
·118	...	17	15·72	·215	...	9	16·55	·49	...	4	6·04
·119	...	17	12·16	·22	...	9	11·27	·50	...	4	4·0
·12	...	17	8·63	·225	...	9	6·22	·52	...	4	0·15
·122	...	17	1·83	·23	...	9	1·38	·54	...	3	20·59
·124	...	16	19·22	·235	...	8	20·76	·56	...	3	17·28
·125	...	16	16·0	·24	...	8	16·33	·58	...	3	14·2
·126	...	16	12·82	·245	...	8	12·06	·60	...	3	11·33
·128	...	16	6·62	·25	...	8	8·0	·65	...	3	4·92
·130	...	16	0·6	·255	...	8	4·07	·70	...	2	23·42
·132	...	15	18·78	·26	...	8	0·3	·75	...	2	18·66
·134	...	15	13·13	·265	...	7	20·67	·80	...	2	14·5
·136	...	15	7·74	·27	...	7	17·18	·85	...	2	10·82
·138	...	15	2·31	·275	...	7	13·81	·9	...	2	7·55
·14	...	14	21·0	·28	...	7	10·56	·95	...	2	4·62
·142	...	14	16·11	·285	...	7	7·43	1·0	...	2	2·0
·144	...	14	11·22	·29	...	7	4·41				

SLUBBING AND ROVING

30 Yards.				30 Yards.			120 Yards.			120 Yards.		
Decimal of Hank.	Ozs.	Dwts.	Grains.	Hank Roving.	Dwts.	Grains.	Hank Roving.	Dwts.	Grains.	Hank Roving.	Dwts.	Grains.
·5	1	2	14·3	1·65	6	7·6	4·8	8	16·3	15·25	2	17·57
·51	1	2	4·7	1·7	6	3·0	4·85	8	14·1	15·5	2	16·51
·52	1	1	19·1	1·75	5	22·8	4·9	8	12·0	15·75	2	15·49
·53	1	1	10·1	1·8	5	18·8	4·95	8	10·0	16·0	2	14·5
·54	1	1	1·8	1·85	5	15·1	5·0	8	8·0	16·25	2	13·6
·55	1	0	17·0	1·9	5	11·5	5·1	8	4·0	16·5	2	12·6
·56	1	0	8·9	1·95	5	8·2	5·25	7	22·4	16·75	2	11·7
·57	1	0	1·1	2·0	5	5·0	5·3	7	20·6	17·0	2	10·82
·58	...	17	22·8	2·05	5	1·9	5·4	7	17·1	17·25	2	9·9
·59	...	17	15·6	2·1	4	23·0	5·5	7	13·8	17·5	2	9·14
·6	...	17	8·4	2·15	4	20·2	5·6	7	10·5	17·75	2	8·33
·61	...	17	1·83	2·2	4	17·6	5·75	7	5·9	18·0	2	7·55
·62	...	16	19·2	2·25	4	15·1	5·8	7	4·4	18·25	2	6·8
·63	...	16	12·8	2·3	4	12·6	5·9	7	1·5	18·5	2	6·05
·64	...	16	6·6	2·35	4	10·3	6·0	6	22·6	18·75	2	5·3
·65	...	16	0·61	2·4	4	8·1	6·1	6	19·9	19·0	2	4·63
·66	...	15	18·0	2·45	4	6·0	6·25	6	16·0	19·25	2	3·94
·67	...	15	13·3	2·5	4	4·0	6·3	6	14·7	19·5	2	3·28
·68	...	15	7·6	2·55	4	2·0	6·4	6	12·2	19·75	2	2·63
·69	...	15	2·3	2·6	4	0·1	6·5	6	9·8	20·0	2	2·029
·7	...	14	21·1	2·65	3	22·3	6·6	6	7·5	21	1	23·64
·71	...	14	16·1	2·7	3	20·6	6·75	6	4·1	22	1	22·48
·72	...	14	11·2	2·75	3	18·9	6·8	6	3·0	23	1	19·503
·73	...	14	6·4	2·8	3	17·2	6·9	6	0·9	24	1	17·69
·74	...	14	1·8	2·85	3	15·7	7·0	5	22·8	25	1	16·023
·75	...	13	21·3	2·9	3	14·2	7·1	5	20·8	26	1	14·48
·76	...	13	16·8	2·95	3	12·7	7·25	5	17·9	27	1	13·058
·77	...	13	12·6	3·0	3	11·3	7·3	5	17·0	28	1	11·734

·78	...	13	8·4	3·05	3	9·9	7·4	5	15·1	29	1	10·502
·79	...	13	4·4	3·1	3	8·6	7·5	5	13·3	30	1	9·352
·8	...	13	0·3	3·15	3	7·3	7·6	5	11·5			
·81	...	12	20·6	3·2	3	6·1	7·75	5	9·0			
·82	...	12	16·8	3·25	3	4·9	7·8	5	8·2			
·83	...	12	13·2	3·3	3	3·7	7·9	5	6·5			
·84	...	12	9·6	3·35	3	2·6	8·0	5	5·0			
·85	...	12	6·1	3·4	3	1·5	8·25	5	1·2			
·86	...	12	2·7	3·45	3	0·4	8·5	4	21·6			
·87	...	11	23·3	3·5	2	23·4	8·75	4	18·2			
·88	...	11	20·0	3·55	2	22·4	9·0	4	15·1			
·89	...	11	16·9	3·6	2	21·4	9·25	4	12·0			
·9	...	11	13·8	3·65	2	20·5	9·5	4	9·2			
·91	...	11	10·7	3·7	2	19·5	9·75	4	6·4			
·92	...	11	7·7	3·75	2	18·6	10·0	4	4·0			
·93	...	11	4·8	3·8	2	17·7	10·25	4	1·56			
·94	...	11	1·9	3·85	2	16·9	10·5	3	23·23			
·95	...	10	23·1	3·9	2	16·1	10·75	3	21·04			
·96	...	10	20·4	3·95	2	15·3	11·0	3	18·9			
·97	...	10	17·7	4·0	2	14·5	11·25	3	16·88			
·98	...	10	15·1	4·05	2	13·7	11·5	3	14·95			
·99	...	10	12·5	4·1	2	12·9	11·75	3	13·1			
1·0	...	10	10·0	4·15	2	12·2	12·0	3	11·33			
1·05	...	9	22·0	4·2	2	11·5	12·25	3	9·6			
1·1	...	9	11·2	4·25	2	10·8	12·5	3	8·0			
1·15	...	9	1·4	4·3	2	10·1	12·75	3	6·43			
1·2	...	8	16·3	4·35	2	9·4	13·0	3	4·92			
1·25	...	8	8·0	4·4	2	8·8	13·25	3	3·47			
1·3	...	8	0·3	4·45	2	8·1	13·5	3	2·07			
1·35	...	7	17·2	4·5	2	7·5	13·75	3	0·72			
1·4	...	7	10·5	4·55	2	6·9	14·0	2	23·42			
1·45	...	7	4·4	4·6	2	6·3	14·25	2	22·17			
1·5	...	6	22·6	4·65	2	5·7	14·5	2	20·96			
1·55	...	6	17·2	4·7	2	5·2	14·75	2	19·79			
1·6	...	6	12·2	4·75	2	4·7	15·0	2	18·66			

Weight of Yarn of different Counts for 1, 2, 5, and 7 Leas

1 LEA = 120 YARDS = 80 THREADS ON WRAP REEL

Counts or Nos	1 Lea.			2 Leas.			5 Leas.			7 Leas.			Counts or Nos.
	Ozs.	Dwts.	Grains.	Ozs.	Dwts.	Grains.	Ozs.	Dwts.	Grains.	Ozs.	Dwts.	Grains.	
1	2	5	5·071	4½	1	7·267	11	7	19·606	16	0	0·000	1
2	1	2	14·535	2	5	5·071	5½	3	21·803	8	0	0·000	2
3	½	4	18·649	1½	0	10·422	3½	5	15·493	5	6	1·924	3
4	½	1	7·268	1	2	14·536	2½	6	12·339	4	0	0·000	4
5	0	8	8·114	½	7	13·353	2	5	5·071	3	3	15·549	5
6	0	6	22·762	½	4	18·649	1½	7	9·185	2½	3	0·958	6
7	0	5	22·939	½	2	19·003	1½	2	10·070	2	5	5·071	7
8	0	5	5·071	½	1	7·267	1	7	19·607	2	0	0·000	8
9	0	4	15·174	½	0	3·474	1	4	22·123	1½	5	1·597	9
10	0	4	4·057	0	8	8·114	1	2	14·536	1½	1	19·775	10
11	0	3	18·961	0	7	13·922	1	0	17·055	1	8	6·977	11
12	0	3	11·381	0	6	22·762	½	8	6·030	1	6	1·917	12
13	0	3	4·967	0	6	9·934	½	6	21·960	1	4	5·019	13
14	0	2	23·469	0	5	22·939	½	5	18·472	1	2	14·536	14
15	0	2	18·705	0	5	13·410	½	4	18·649	1	1	5·183	15
16	0	2	14·536	0	5	5·071	½	3	21·804	1	0	0·000	16
17	0	2	10·857	0	4	21·714	½	3	3·411	½	8	1·125	17
18	0	2	7·587	0	4	15·175	½	2	11·062	½	7	2·236	18
19	0	2	4·662	0	4	9·323	½	1	20·433	½	6	5·757	19
20	0	2	2·029	0	4	4·057	½	1	7·268	½	5	11·325	20
21	0	1	23·646	0	3	23·293	½	0	19·256	½	4	18·649	21
22	0	1	21·481	0	3	18·961	½	0	8·528	½	4	3·489	22
23	0	1	19·503	0	3	15·006	0	9	1·516	½	2	13·647	23
24	0	1	17·690	0	3	11·381	0	8	16·452	½	3	0·958	24

25	0	1	16·023	0	3	8·046	0	8	8·114	½	2	13·285	25
26	0	1	14·484	0	3	4·967	0	8	0·417	½	2	2·509	26
27	0	1	13·058	0	3	2·116	0	7	17·291	½	1	16·532	27
28	0	1	11·734	0	2	23·469	0	7	10·673	½	1	7·268	28
29	0	1	10·502	0	2	21·005	0	7	4·512	½	0	22·642	29
30	0	1	9·352	0	2	18·705	0	6	22·762	½	0	14·591	30
31	0	1	8·276	0	2	16·553	0	6	17·382	½	0	7·060	31
32	0	1	7·268	0	2	14·535	0	6	12·339	½	0	0·000	32
33	0	1	6·320	0	2	12·641	0	6	7·602	0	8	20·242	33
34	0	1	5·428	0	2	10·857	0	6	3·143	0	8	14·000	34
35	0	1	4·588	0	2	9·176	0	5	22·939	0	8	8·114	35
36	0	1	3·793	0	2	7·587	0	5	18·968	0	8	2·555	36
37	0	1	3·042	0	2	6·085	0	5	15·212	0	7	21·297	37
38	0	1	2·331	0	2	4·661	0	5	11·654	0	7	16·316	38
39	0	1	1·656	0	2	3·311	0	5	8·278	0	7	11·589	39
40	0	1	1·014	0	2	2·028	0	5	5·071	0	7	7·100	40
41	0	1	0·404	0	2	0·808	0	5	2·021	0	7	2·829	41
42	0	0	23·823	0	1	23·646	0	4	23·115	0	6	22·762	42
43	0	0	23·269	0	1	22·538	0	4	20·346	0	6	18·884	43
44	0	0	22·740	0	1	21·480	0	4	17·701	0	6	15·182	44
45	0	0	22·235	0	1	20·470	0	4	15·174	0	6	11·644	45
46	0	0	21·751	0	1	19·503	0	4	12·758	0	6	8·261	46
47	0	0	21·289	0	1	18·577	0	4	10·444	0	6	5·021	47
48	0	0	20·845	0	1	17·690	0	4	8·226	0	6	1·916	48
49	0	0	20·420	0	1	16·840	0	4	6·099	0	5	22·939	49
50	0	0	20·011	0	1	16·023	0	4	4·057	0	5	20·080	50
51	0	0	19·619	0	1	15·238	0	4	2·095	0	5	17·333	51
52	0	0	19·242	0	1	14·483	0	4	0·208	0	5	14·692	52
53	0	0	18·879	0	1	13·757	0	3	22·394	0	5	12·151	53
54	0	0	18·529	0	1	13·058	0	3	20·645	0	5	9·703	54
55	0	0	18·192	0	1	12·384	0	3	18·961	0	5	7·345	55
56	0	0	17·867	0	1	11·734	0	3	17·336	0	5	5·071	56
57	0	0	17·554	0	1	11·108	0	3	15·769	0	5	2·877	57

Table of the Weight of Yarn of different Counts—*Continued*

Counts or Nos.	1 Lea.			2 Leas.			5 Leas.			7 Leas.			Counts or Nos.
	Ozs.	Dwts.	Grains.	Ozs.	Dwts.	Grains.	Ozs.	Dwts.	Grains.	Ozs.	Dwts.	Grains.	
58	0	0	17·251	0	1	10·502	0	3	14·256	0	5	0·758	58
59	0	0	16·959	0	1	9·918	0	3	12·794	0	4	22·712	59
60	0	0	16·676	0	1	9·352	0	3	11·381	0	4	20·733	60
61	0	0	16·403	0	1	8·806	0	3	10·014	0	4	18·820	61
62	0	0	16·138	0	1	8·276	0	3	8·691	0	4	16·967	62
63	0	0	15·882	0	1	7·764	0	3	7·410	0	4	15·175	63
64	0	0	15·634	0	1	7·268	0	3	6·169	0	4	13·437	64
65	0	0	15·393	0	1	6·787	0	3	4·967	0	4	11·754	65
66	0	0	15·160	0	1	6·320	0	3	3·801	0	4	10·121	66
67	0	0	14·934	0	1	5·868	0	3	2·670	0	4	8·537	67
68	0	0	14·714	0	1	5·428	0	3	1·571	0	4	7·000	68
69	0	0	14·501	0	1	5·002	0	3	0·505	0	4	5·507	69
70	0	0	14·294	0	1	4·588	0	2	23·469	0	4	4·057	70
71	0	0	14·093	0	1	4·185	0	2	22·463	0	4	2·648	71
72	0	0	13·896	0	1	3·793	0	2	21·484	0	4	1·277	72
73	0	0	13·706	0	1	3·413	0	2	20·532	0	3	23·945	73
74	0	0	13·521	0	1	3·042	0	2	19·606	0	3	22·648	74
75	0	0	13·341	0	1	2·682	0	2	18·705	0	3	21·380	75
76	0	0	13·165	0	1	2·330	0	2	17·827	0	3	20·158	76
77	0	0	12·994	0	1	1·989	0	2	16·972	0	3	18·961	77
78	0	0	12·828	0	1	1·655	0	2	16·139	0	3	17·791	78
79	0	0	12·665	0	1	1·331	0	2	15·327	0	3	16·658	79
80	0	0	12·507	0	1	1·014	0	2	14·535	0	3	15·550	80
81	0	0	12·352	0	1	0·704	0	2	13·761	0	3	14·465	81

82	0	0	12·202	0	1	0·404	0	2	13·010	0	3	13·414	82
83	0	0	12·055	0	1	0·110	0	2	12·275	0	3	12·386	83
84	0	0	11·911	0	0	23·823	0	2	11·557	0	3	11·381	84
85	0	0	11·771	0	0	23·543	0	2	10·857	0	3	10·400	85
86	0	0	11·634	0	0	23·269	0	2	10·173	0	3	9·442	86
87	0	0	11·501	0	0	23·002	0	2	9·504	0	3	8·506	87
88	0	0	11·370	0	0	22·740	0	2	8·850	0	3	7·591	88
89	0	0	11·242	0	0	22·485	0	2	8·212	0	3	6·697	89
90	0	0	11·117	0	0	22·235	0	2	7·587	0	3	5·822	90
91	0	0	10·995	0	0	21·991	0	2	6·976	0	3	4·967	91
92	0	0	10·875	0	0	21·751	0	2	6·379	0	3	4·130	92
93	0	0	10·759	0	0	21·518	0	2	5·794	0	3	3·312	93
94	0	0	10·644	0	0	21·288	0	2	5·222	0	3	2·510	94
95	0	0	10·532	0	0	21·065	0	2	4·661	0	3	1·726	95
96	0	0	10·422	0	0	20·845	0	2	4·113	0	3	0·958	96
97	0	0	10·315	0	0	20·630	0	2	3·576	0	3	0·206	97
98	0	0	10·210	0	0	20·420	0	2	3·049	0	2	23·469	98
99	0	0	10·107	0	0	20·213	0	2	2·534	0	2	22·747	99
100	0	0	10·005	0	0	20·011	0	2	2·028	0	2	22·040	100
101	0	0	9·907	0	0	19·813	0	2	1·533	0	2	21·346	101
102	0	0	9·809	0	0	19·619	0	2	1·047	0	2	20·666	102
104	0	0	9·621	0	0	19·243	0	2	0·104	0	2	19·346	104
106	0	0	9·439	0	0	18·878	0	1	23·197	0	2	18·075	106
108	0	0	9·264	0	0	18·529	0	1	22·322	0	2	16·851	108
110	0	0	9·096	0	0	18·192	0	1	21·480	0	2	15·672	110
112	0	0	8·933	0	0	17·867	0	1	20·668	0	2	14·535	112
114	0	0	8·777	0	0	17·554	0	1	19·884	0	2	13·438	114
116	0	0	8·625	0	0	17·251	0	1	19·128	0	2	12·379	116
118	0	0	8·479	0	0	16·959	0	1	18·397	0	2	11·356	118
120	0	0	8·338	0	0	16·676	0	1	17·690	0	2	10·366	120
122	0	0	8·201	0	0	16·403	0	1	17·007	0	2	9·410	122
124	0	0	8·069	0	0	16·133	0	1	16·345	0	2	8·483	124
126	0	0	7·941	0	0	15·882	0	1	15·705	0	2	7·587	126

Table of the Weight of Yarn of different Counts—*Continued*

Counts or Nos.	1 Lea.			2 Leas.			5 Leas.			7 Leas.			Counts or Nos.
	Ozs.	Dwts.	Grains.	Ozs.	Dwts.	Grains.	Ozs.	Dwts.	Grains.	Ozs.	Dwts.	Grains.	
128	0	0	7·817	0	0	15 634	0	1	15·084	0	2	6·718	128
130	0	0	7·696	0	0	15·393	0	1	14·483	0	2	5·877	130
135	0	0	7·412	0	0	14·823	0	1	13·058	0	2	3·881	135
140	0	0	7·147	0	0	14·294	0	1	11·731	0	2	2·028	140
145	0	0	6·900	0	0	13·800	0	1	10·500	0	2	0·300	145
150	0	0	6·670	0	0	13·341	0	1	9·352	0	1	22·693	150
155	0	0	6·455	0	0	12·910	0	1	8·275	0	1	21·185	155
160	0	0	6·253	0	0	12·506	0	1	7·265	0	1	19·771	160
165	0	0	6·063	0	0	12·126	0	1	6·315	0	1	18·441	165
170	0	0	5·885	0	0	11·770	0	1	5·425	0	1	17·195	170
175	0	0	5·717	0	0	11·434	0	1	4·585	0	1	16·019	175
180	0	0	5·558	0	0	11·116	0	1	3·790	0	1	14·906	180
185	0	0	5·408	0	0	10·816	0	1	3·040	0	1	13·856	185
190	0	0	5·266	0	0	10·532	0	1	2·330	0	1	12·862	190
195	0	0	5·130	0	0	10·260	0	1	1·650	0	1	11·910	195
200	0	0	5·002	0	0	10·004	0	1	1·010	0	1	11·014	200
205	0	0	4·880	0	0	9·760	0	1	0·400	0	1	10·160	205
210	0	0	4·764	0	0	9·528	0	0	23·820	0	1	9·348	210
215	0	0	4·653	0	0	9·306	0	0	23·265	0	1	8·571	215
220	0	0	4·547	0	0	9·094	0	0	22·735	0	1	7·829	220
225	0	0	4·446	0	0	8·892	0	0	22·230	0	1	7·122	225
230	0	0	4·350	0	0	8·700	0	0	21·750	0	1	6·450	230
235	0	0	4·257	0	0	8·514	0	0	21·285	0	1	5·799	235
240	0	0	4·164	0	0	8·328	0	0	20·820	0	1	5·148	240
245	0	0	4·083	0	0	8·166	0	0	20·415	0	1	4·581	245
250	0	0	4·002	0	0	8·004	0	0	20·010	0	1	4·014	250

DECIMAL EQUIVALENTS OF FRACTIONS OF AN INCH

$\frac{1}{64}$	·01563	...	...	...	...	...	...
$\frac{1}{32}$	·03125	$\frac{9}{32}$	·28125	$\frac{17}{32}$	·53125	$\frac{25}{32}$	·78125
$\frac{1}{16}$	·0625	$\frac{5}{16}$	·3125	$\frac{9}{16}$	·5625	$\frac{13}{16}$	·8125
$\frac{3}{32}$	·09375	$\frac{11}{32}$	·34375	$\frac{19}{32}$	·59375	$\frac{27}{32}$	·84375
$\frac{7}{64}$	·10938	...	...	...	...	...	...
$\frac{1}{8}$	·125	$\frac{3}{8}$	·375	$\frac{5}{8}$	·625	$\frac{7}{8}$	·875
$\frac{5}{32}$	·15625	$\frac{13}{32}$	·40625	$\frac{21}{32}$	·65625	$\frac{29}{32}$	·90625
$\frac{3}{16}$	·1875	$\frac{7}{16}$	·4375	$\frac{11}{16}$	·6875	$\frac{15}{16}$	·9375
$\frac{7}{32}$	·21875	$\frac{15}{32}$	·46875	$\frac{23}{32}$	·71875	$\frac{31}{32}$	·96875
$\frac{1}{4}$	·25	$\frac{1}{2}$	·5	$\frac{3}{4}$	·75	1	1·00000

CIRCUMFERENCES OF CIRCLES, ADVANCING BY 8THS

Diameter.	Circumferences.							
	0	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$
0	...	0·3927	0·7854	1·178	1·570	1·963	2·356	2·748
1	3·141	3·534	3·927	4·319	4·712	5·105	5·497	5·890
2	6·283	6·675	7·068	7·461	7·854	8·246	8·639	9·032
3	9·424	9·817	10·21	10·60	10·99	11·38	11·78	12·17
4	12·56	12·95	13·35	13·74	14·13	14·52	14·92	15·31
5	15·70	16·10	16·49	16·88	17·27	17·67	18·06	18·45
6	18·84	19·24	19·63	20·02	20·42	20·81	21·20	21·59
7	21·99	22·38	22·77	23·16	23·56	23·95	24·34	24·74
8	25·13	25·52	25·91	26·31	26·70	27·09	27·48	27·88
9	28·27	28·66	29·05	29·45	29·84	30·23	30·63	31·02
10	31·41	31·80	32·20	32·59	32·98	33·37	33·77	34·16

COUNTS OF DIFFERENT KINDS OF YARNS

Cotton is calculated by the hank of 840 yards.
Worsted ,, ,, ,, 560 ,,
Spun Silk ,, ,, ,, 840 ,,
Linen ,, ,, ,, 300 ,,
Woollen Yorkshire, Skein hank of 256 ,,
,, Dewsbury ,, 16 ,,
,, West of England ,, 320 ,,
,, Galashiels (cut) ,, 300 ,,
Raw Silk (1000 yards per oz.)

INDEX

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The relative diameter of 25's counts $= \sqrt{\frac{1}{25}} = \frac{1}{5}$.

" " " 81's " $= \sqrt{\frac{1}{81}} = \frac{1}{9}$.

The 25's yarn is the thickest, and by dividing $\frac{1}{5}$ by $\frac{1}{9}$ we obtain how much thicker it is; thus:

$$\frac{1}{5} \div \frac{1}{9} = \frac{1 \times 9}{5 \times 1} = \frac{9}{5} = 1\frac{4}{5},$$

or 1·8 times thicker in diameter.

It would be easy to draw up a table showing the relative number of layers of yarn on a bobbin or cop, now that we know how to obtain relative diameters; for instance:

Counts—								
1	2	4	25	49	81	100	225	400
Relative diameters—								
$\sqrt{\frac{1}{1}}$	$\sqrt{\frac{1}{2}}$	$\sqrt{\frac{1}{4}}$	$\sqrt{\frac{1}{25}}$	$\sqrt{\frac{1}{49}}$	$\sqrt{\frac{1}{81}}$	$\sqrt{\frac{1}{100}}$	$\sqrt{\frac{1}{225}}$	$\sqrt{\frac{1}{400}}$
Relative No. of layers per inch—								
10	14	20	50	70	90	100	150	200

It has been presumed there are 10 layers per inch of No. 1's, so that the number of layers for the other counts are found by dividing 10 by their diameters; in this way the relative number of layers per inch are obtained.

This table is interesting, for from it we are in a position to say that **all wheels controlling the building of a bobbin or cop are directly proportional to the number of layers per inch**, and also the further important statement that **the number of layers of yarn in a bobbin or cop is directly proportional to the square root of the counts.** This

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