# PRACTICAL
# COTTON MILL
# MANAGEMENT

*Revised and Enlarged*
*particularly the Chapters*
*on*
*Yarn and Cloth Costing,*
*Designing*
*and*
*Questions and Answers.*

# PRACTICAL COTTON MILL MANAGEMENT

BY

B. S. BENJAMIN

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*Illustrated*

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# PREFACE.

This book includes within its pages the information which a student of "TEXTILE MANUFACTURE" should seek to thoroughly master.

The aim in education is to train reasonable beings, able to adapt themselves to life conditions and to take advantage of such opportunities as may come within their purview, in the particular branch of life work in which they, by choice or chance, have interest or employment. Whatever that branch of activity may be, the educational training is similar in its broad outlines.

(i) The development of the reasoning faculties.
(ii) Experience in some form of self-expression.
(iii) Knowledge of conditions obtained by practical experience.

A student is necessarily left to his own resources to a considerable extent of time as to what is best to be done under the circumstances that may occur, and the better he exercises his judgment and apply to his work, the more will he be left to exercise it under proper control. But to master it he must apply his whole energy to it, diligently and faithfully.

Every age has its outstanding men who led all others in their lines of thought. These men mastered their subjects by profound study and by a great amount of hard work. In every case they have added to the knowledge already existent just that necessary thing which would start something entirely new. These masters of knowledge were men who had learnt the best thoughts of those who preceded them in the art in which they were engaged. When the urge was great enough for them to take the subject to themselves and make it distinctly their own, they had but to improve upon what had already been accomplished to secure their place in the scheme of things. They would then forge ahead of their contemporaries. The satisfying thing that could be said about them was that they knew their business.

Many young men and women too, are in training today who are destined to carry our civilization to goal even to further distance. These men and women see clearly ahead and are taking the utmost advantage of their opportunities. They are to be found in the schools, the offices and the workshops.

Therefore the purpose of education is to provide a steady supply of highly tested, carefully graded, right–thinking human material to our national industries.

The libraries, those storehouses of knowledge, are operated mainly for their benefit; they find there the facts of the past that give them a firm starting point from which to go forward. *The things most worth among the scale of values are health of body and mind, friends, books, adequate money, inward peace, and service to others.*

All knowledge is lost that ends in mere knowing, for every truth acquired by keen observations or studies is a light given to us for a guide to work by. Gain all the knowledge you can then be sure to use it to good purpose either to help yourself or help others.

*The whole secret therefore, in the success of mastering the art of conducting a textile mill lies in finding out or enquiring personally into everything and every cause connected with it.*

In other words, technical education may be regarded as including instruction in the fundamental principles underlying an industry and training in the application of those principles to the practice of the industry. A student must not depend on his neighbours or any one else about it. He must reason out himself and ask for explanation or an enlightenment only whenever necessary. By working on this principle he trains the mind and will ultimately gain a perfect knowledge mechanically connected throughout his various departments thus lifting his work out of the mere rut of drudgery and placing it on scientific basis, which can only be maintained if everything is done thoroughly as near as possible to a perfection.

A broken part should never be replaced unless the cause of it is bottomed. Spare parts should always be kept handy.

Every unusual noise in a mill or machinery means a warning, so, a deaf ear must not be turned to it otherwise it might end with a very serious consequence. No student of the "TEXTILE INDUSTRY" should ever imagine that he is going to master the industry by being told or having simply gone through a technical college teaching. Each student must work hard and endeavour to the best of his abilities to acquire it for himself and this acquisition depends upon the developments of the student's own physical and intellectual senses.

Ability is often reinforced by necessity. He that will not suffer himself to be discouraged by fancied impossibilities may sometimes find his abilities invigorated by the necessity of exerting them at short intervals, as the force of a current is increased by the contraction of its channel.

Text-books give little direct assistance, speaking generally, the problems are to be solved by careful observation and records, a few simple tests, and the exercise of common sense.

Every student must try not only to make himself useful but to be better man as each day goes on, by developing the faculties of accuracy, reasonableness, smartness and application with courage and perseverance.

Quality of work is the most necessary thing that is required in the type of work which he will be asked to do. He should produce something useful which the work-people can easily reproduce.

Knowledge gained by the experience of others and put into practicc by one's own exertions develops the brain.

A man cannot gain sufficient knowledge by his own experience alone; he must gain some of it from other sources, say for instance, by associating himself with those that are in the same trade as himself, or by attending lecture classes, or by reading good books and papers, if he intends to be efficient and uptodate. Every student must read and study carefully, nay even analyse every word of each subject as he goes along, and even then it must not rest there, he must not pass to the next subject until he has mastered the previous one. Every important subject must be read over and over again very carefully or written over and over again or observations made over and over again in order to endorse permanently in his mind what he has read or seen or done. Endeavour to work in stages from the simple to the complex. Difficulties which are apparently unsurmountable become quite easy when approached by studies running in sequence from the simple to the complex. Do not be afraid to blacken your hands and clothes, and let this be in reality and not for the purpose of making an outward show.

*Bear in mind that no training is complete without a certain amount of works practice.* One perhaps learns more from one's failures than from one's successes. Never fail to solve your difficulties more than once and if you fail, never be backward to acquire it from your superior or even from your inferior if he knows better than you do.

A cultured man is quick and fond of learning and not afraid to learn from those beneath him. If possible and if you are capable always try to improve on a thing. Do not say to yourself, that my predecessor has done it and why should I interfere with it–that is merely wrong. When improving on a thing always bear in your mind the following objects :—

(*a*) Saving of labour, (*b*) saving of cost, (*c*) minimising work, (*d*) Systematizing work.

Plead ignorance whenever possible, and particularly if you are in doubt, thereby you will learn more and make few mistakes. Always learn more and teach less. Never cause friction nor carry from one person to another. Always keep things to yourself, lest they do not harm you, and if they escape from you benefit there can be none, as the spoken word can never come back. Never intrude where you are not wanted. There is plenty of room elsewhere. Never argue any point with your superior, whenever possible, but you can certainly suggest an improvement politely. A bitter tongue ruins home and kingdom.

Try to win and still more to deserve, the confidence of those with whom you are brought in contact. Many a man has owed his influence far more to character than to ability. Never hurry. Nothing done in a hurry is ever thorough. Haste is waste.

Obedience and willingness will help you a great deal towards your success. Try to meet the wishes of others as far as you rightly and wisely can, but do not be afraid to say "No." Many a man has been ruined because he could not do so.

Always try to be punctual, never fear to admit your faults or mistakes, fulfil your promise and be sure of the step that you are going to take, also use some discretion. Never profess to know a thing before you have mastered it. Keep mostly your eyes and ears open, but your mouth shut as much as possible. Treat all your work people alike and render assistance whenever needed. Never force anybody to do a thing which you cannot do yourself. Your day's work must be programmed each day. When you have done so, you must not rest unless it is carried out. Never miss to record anything of importance. Let your instructions if possible be in black and white from your superiors and when you get them see that they are carried out and recorded carefully. Never interfere with another man's department or business. Do not avoid checking either your own work or the work of the best man in the place. Nothing should be passed without being checked first to avoid losses and unnecessary worries.

A student must be impressed with the importance of the accurate work and careful forethought. Study your position first in every thing and then endorse it. Never attempt anything that is built on "perhaps and guesses." Figures cannot lie.

It is true that a bad workman quarrels with his tools. It is truer that a good workman employs good tools.

A successful man is one who has tried, not cried; who has worked, not dodged; who has shouldered responsibility not evaded it; who has borne the burden, not merely stood off looking on; giving advice and philosophise on the situation.

The average man is prone to believe that the golden days of opportunities to work from the bottom are past. They erroneously conclude that the poor man is handicapped in his climb up the ladder. In this they ignore existing facts.

The great men of the past, whether in industrial or other fields, come from and represent a normal cross section of the human race. True, they include men who have had unusual financial and educational advantages. However, they also include many who had struggled upward from humble beginnings rooted in poverty and ignorance. In the ultimate analysis, the success that a man will make in his chosen work must depend in great measure upon his personal effort, irrespective of his preparation for the work, his personal advancement will go hand in hand with his willingness and his successful effort to master the details of the business, its history, policies and economic problems. He must take the business unto himself and make its problem his own.

Whatever may be your station in life, if you will, you can rise inspite of the obstacles in your way, physical or otherwise, you can overcome them.

There is no romance that parallels the industrial lives of our great leaders of today and their climb.

*Big business is looking for young men who will stick to the job, shoulder the responsibilities as they arise and finally handle the helm.*

A lack of courtesy may be a lack of effectiveness. As courtesy is a consideration of the wishes and feelings of other people, and hence every forceful ambitious man should pay special attention to the value of courtesy, if he wants to be successful in his business.

Almost every strong man is accused of being arbitrary and ruthless. There must be arbitrary and ruthless in the sense that he carries out his own plans. But he need not be arbitrary and ruthless in the sense that he pays no attention to the thoughts, feelings and wishes of other people.

It is possible to be strong without being rough. And the self made man who makes the most complete success at the least cost to his own nature, is the one who has trained himself to be as courteous as he is efficient.

Courtesy is one of the principles of efficiency. Because it helps the strong man that drives forward to counteract the ruthlessness and to secure a higher percentage of result. It must come in because it prevents wastes, losses, friction and disloyalty. It must come in because it creates good-will——the greatest of all assets of any business.

We ought always to endeavour that everybody with whom we have any transactions should feel that it is a pleasure to act with us and should wish to come again. Business is a matter of sentiment and feeling far more than many suppose; every one likes being treated with kindness and courtesy, and a frank, pleasant manner will often clench a bargain more effectually than an offer of one or two per cent extra.

The shadow of feudalism is still dark over the mills and factories. The obsolete spirit of caste still keeps people in sets and classes. The position or place is still to be reached where a man is valued for his worth and not for the caste mark that has been put upon him.

The time has now come owing to the strenuous world-wide competition that courtesy must be studied and applied zealously to every department of business.

Politeness is better than logic you can often persuade when you cannot convince.

For the man who aspires to advance in his work there is no asset equal to personal effort. The great game must be to do the job better than it has ever been done before. The reward will be commensurate with this effort.

> " Fear kills effort and stultifies endeavour." Be not afraid. Remember, " I can is the son of I am.

> " The devotion of thought to an honest achievement makes the achievement possible."

If the perusal of this book should assist the student in mastering the details of his craft, the author will feel that his labour has not been all in vain and that he has done something to help a student on the road of his future career.

B. S. BENJAMIN.

CALCUTTA,

18*th September* 1934

## PREFACE TO THE SECOND EDITION.

In these days of highly organised effort it often falls to the lot of some of us to do the work that in the more leisurely days of the past occupied the energies of not two, but a far greater number of men. This has only been made possible by the facilities which modern inventions and improvements have placed at our disposal means and ways for quick and mass productions.

But remember, all the inventions and improvements in the world will be rendered utterly useless if the man who is entrusted with them lacks in "Self Confidence" and "Perseverence" also in "Originality" and "Commonsense."

"*Success*", as it is usually understood is generally the result of painstaking and laborious effort over a period of many years.

"*Perseverance,*" without which no great achievement was ever accomplished.

"*Originality*", or a creative mind Combined with Commonsense excite curiosity by its rarity—it commands notice unfailingly.

To acquire not only knowledge, but up-to-date knowledge—to know the "present as well as the past" and to be able, to a certain extent, to forecast the future—that is to-day, the aim, of every intelligent man, in the business world.

A business man must seek "his own" sort of knowledge, not only in his own trade or industry, but in the whole field of knowledge. He must gather facts and ideas from outside—from here and there and everywhere. He may learn from a Scientist, a novelist, a machaine, a lecturer, from books—from almost everyone.

There is a great scientific law that is known as environment. It means the influence that our surroundings have upon us. Certain outside influences are necessary in order to bring out the abilities that we have within us.

No matter how original a man may be, he must learn from others. The defect that keeps millions of men down in the rank and file is *unteachibility.*

It is a natural law that everything conceived by us mortals is imperfect and nothing can be achieved without an effort.

Things worth doing are seldom easy to perform. Consequently some of us lose patience and give up when, by just a little more striving and care, we might achieve success. Let us, therefore, not be discouraged in anything we attempt to do if our first efforts end in failure.

There is a great deal to be done in this world which cannot be put off till tomorrow.

Our forefathers, who established the trade, devised the processes and invented machines, had to force their way in the face of many handicaps—lack of opportunity—long hours—apathy of local authorities in catering for their needs in respect to technical education . To-day that no longer applies, and the door of progress is open to everyone who desires to enter. It is the duty of everyone to realize what he is, and he will soon rise to be what he should be. If all cannot be great, then at the very least it is open to all men to be good and truthful, and faithful, doing their work in their own sphere intelligently, honestly, and thoroughly.

In the business of "cloth production," irrespective of the type of yarns or fabrics involved, it is essential that ideal conditions should be kept constantly in mind with a view to all persons concerned working towards realization of the ideals. Even though the absolute attainment of such ideals as may be formulated is never actually achieved, the striving to reach a particular goal is certain to improve the individual and the organization, as well as the product. The improvement so gained is bound to result in the formulation of new ideals, of even more advanced type, and so the struggle towards perfection proceeds.

The author is very thankful to those who have helped him to make the first edition a success which has encouraged him to revise it in its present form. He has a great confidence that it will serve the purpose of the reader for his daily need or business, so that with sufficient steady concentration he will get what he wants and, when he does get it, he must try to move forward and, if he does not do it, he is certainly going to slip backwards.

Remember that "Time" is a great factor in the "Game of Life". Time is nothing, in itself. Time is what you do with it. If you wait, if you hesitate, your time is lost. Do it quickly—do it first—that is what pays best in business.

BOMBAY, B. S. BENJAMIN.

*January* 1942.

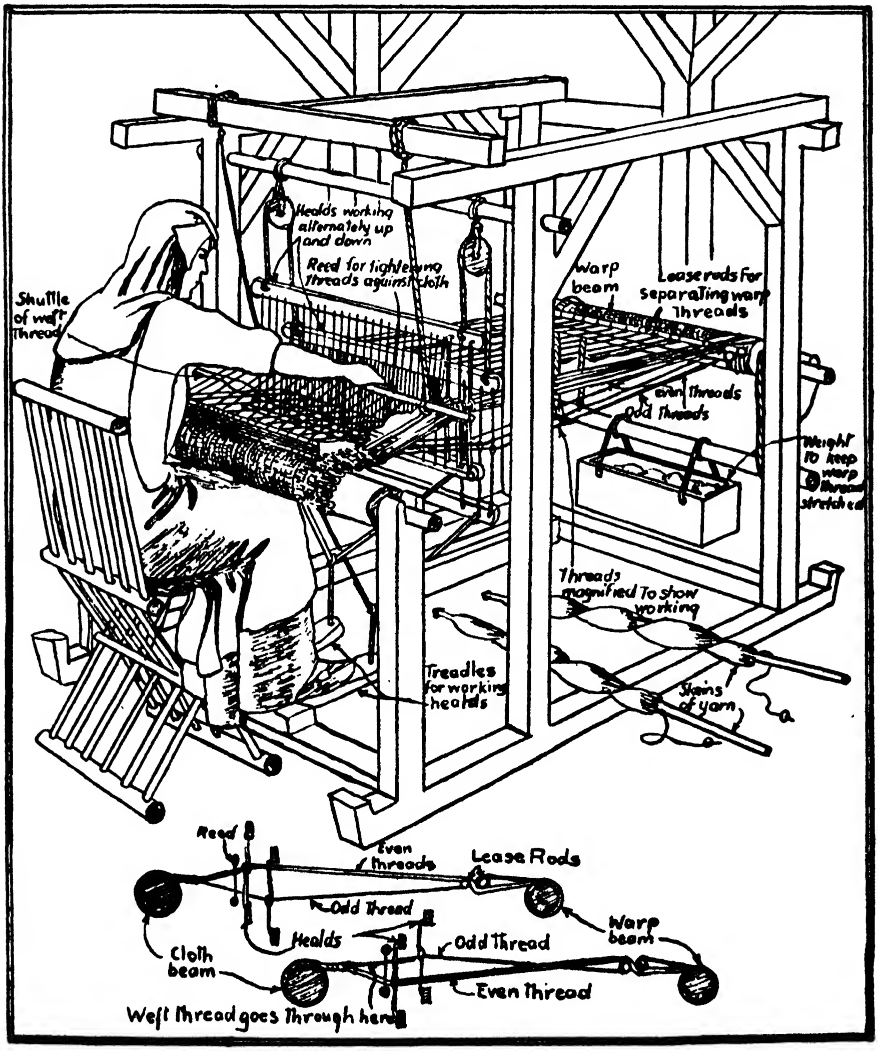
# Practical Cotton Mill Management.

## Chapter I.

## ART OF CLOTH MAKING.

The "Spindles" and the "Loom" the one for twisting fibre into thread and the other for weaving thread itself into cloth are prehistoric and almost universal tools.

WEAVING CLOTH IN PLANTAGENET TIMES




With acknowledgement to Romance of the Nations.

These tools and the methods of using them have never been subject to much variation whether invented by pre-historic men, the Skilful weavers of the ancient world or the ingenious craftsmen.

But a loom is such that only an artist in the line can put all the wonderful possibilities which can be derived from it into effect.

The manufacture of yarns and fabrics is one of the most important occupations of mankind. They were part and parcel of the daily lives of the people of those days.

For thousands of years the preparation of textile fibres, the spinning of yarns, and the weaving of cloths were domestic occupations, known and understood by every member of the community The spinning wheel and the hand looms have become symbolic of old-time industry.

When and how the uses of cotton were first discovered it is impossible to say; but we know, at least, that it was before the opening of the Christian era. The origin of cotton is not known. But references of the manufacture of cotton into cloth are found in the historic "Rig Veda" written about 3400 years ago.

In the sacred books of the Hindoos written about 2700 years ago, cotton is frequently mentioned under the name of Kurpas or Kupas, which is still used in India up to this day.

The oldest known fabric in the whole world is a piece of painted muslin about 13″×18″ in size, found in an old Egyptian tomb said to date back to 2300 B.C. (about 4200 years old).

During the past 200 years the whole position of the textile industry has been completely changed. From being a hand industry practised in the homes of the producers it has become a mechanical industry carried on in power-driven factories. The making of fabrics became a specialised industry.

Every factory is divided into departments, each occupied with one or more details of the manufacturing process. Under the factory system the textile industry has expanded enormously, the cost of production has been reduced, and a variety of natural substances utilized. Synthetic fibres are being produced in ever-increasing variety by the chemist and the range of goods manufactured is greater to-day than ever before. With this expansion, specialization is inevitable.

Textile manufacture is based upon the simple fact that certain fibres, if twisted or felted together will maintain a permanent unity. These are the two primary principles of the textile industry.

Spinning is the art of drawing out and twisting a number of small fibres into a long thread. In itself the operation is simple and may be performed with the fingers without any kind of tool. Because spinning is the preparation of yarn for making fabrics. We are apt to lose sight of the individual of the industry and its place in the history of textile manufacture. The spinner existed long before the weaver. Mankind required tools whilst as yet they had no desire for clothes. Many a tribe of savages can spin. The rope or cord was the first of textile products. This is certain but when we attempt to trace the course by which fabrics arose, doubt arises. There are four methods of fabrication: (1) felting; (2) weaving; (3) netting; (4) knitting. The last is almost certainly the newest method of making fabrics. It is highly questionable, however, which of the other three came first. Netting appears to have been used to make fishing tackle at a very early stage in human existence, but as lace, which is an ornamental netted fabric, netting can hardly be supposed to have been regarded as a method of textile production till long after cloths had been made.

Felting more nearly rivals weaving as the primitive method of cloth production. If judged by structure only, felt would certainly be placed first. It utilises the clinging property of fibres as directly as spinning, and may therefore seem to claim equal rank with that craft in point of time. Because of the perishable nature of felt, it may have existed along with the very earliest of cloths without leaving a trace behind. Among races living at the primitive stage of human life the art of felting was known and practised. Easy in operation, and depending upon the primary textile qualities of wool fibres this would probably be the first method of cloth making.

Though the advent of machinery provided more efficient tools and made production more speedy and more varied, but the industry remained essentially a series of crafts, and will probably retain it even to a greater degree than other industries, because of the nature of its raw material.

## "VARIOUS FIBRES."

Natural fibres employed in weaving include Cotton, flax, wool, and silk, among synthetic fibres in Commercial use are Rayon, Paper Yarn, and various Metallic products.

It was cotton that inspired the invention of new machinery which changed the lives of men, and introduced the Technical Age. Millions of blacks (negros), were enslaved to drudge in the fields of America, all on account of cotton.

" Rayon "—The fundamental principles in the production of rayon may be briefly stated (a) the spinning solution must possess the property of tenacity and viscosity so that it can be drawn into fine filaments of great length. Further, it must be capable of producing a filament of sufficient strength and elasticity. The preparation of the solution depends upon the particular process to be used, but the ideal spinning solution for continuous production is one which has always the same composition and the same viscosity. In practice, however, this has so far proved unattainable. (b) there must be a contrivance forming them gathering the filaments following Coagulation (c) there must be a suitable coagulating medium for the fixation of the filaments.

Artificial silks owe their properties, in part, to their chemical composition, and partly to the shape and thickness of the individual filaments. Those artificial silks which consist of regenarated cellulose, viz., cellulose nitrate, cuprammonium, and viscose silks, naturally differ from one another to a less extent than they do from cellulose acetate silks. One of the most remarkable features in the history of textiles is the large increase, in the past few decades, in the ues of Artificial fibres as a supplement to or substitute for natural fibres. Among the former, Rayon or artificial silk has uniformly held the first position. The various types of rayon are manufactured from cellulose.

Because of its attractiveness, abundance and low price it has brought into humble homes fabrics of such rare beauty as could never have been possessed had this fibre remained unknown and hence it is increasing in popularity. Rayon will not take the place of other fibres. It has not the warmth of wool, the endurance of cotton or linen, nor the strength and elasticity of silk.

Rayon made from Coarse filaments feels much harsher than similarly twisted natural silk. The handle of the finest filament artificial silk is similar to that of natural silk, but less warm to the touch. As regards warmth, Celta and the cellulose acetate silks approximate fairly closely to natural silk.

Rayon absorbs moisture from the air without feeling damp. Of the four main types of rayon, cellulose nitrate absorbs the most moisture and cellulose acetate the least ranging from about 12 to 4 per cent. Viscose and cupramonium silks possess about the same absorptive capacity.

At present rayon has some serious faults which the scientists are striving to overcome. It is non-elastic, it has less tensile strength when either wet or dry than the other fibres, and there has not yet been found any successful way of water proofing rayon. But fabrics made from rayon are beautiful and comparatively inexpensive. They never mildew, and neither age nor washing will turn white fabrics yellow.

In 1928 the world production of rayon stood at over 344 million pounds, while in 1935 it exceeded the thousand million limit. Up to 1932 practically the whole of the rayon was produced in the form of continuous filaments, although as early as 1909 processes had been developed for the manufacture of the product in short definite lengths to which the name of "Staple fibre" has been given. Between 1931 and 1932 the world production of staple fibre jumped up from 8 to 21 million pounds, while since then its rate of development has been even more remarkable than that of rayon itself. In 1935 the world production of staple fibre stood at 156 million pounds or over 15 per cent of the total rayon output, while it is estimated that in the first six months of 1936, it reached the high figure of 126 million pounds.

Such phenomennal increase in the consumption of staple fibre, at a time when the world is carrying large stocks of natural fibres, is due to two sets of causes which are related to one another. It has been found that staple fibre possesses certain special characteristics as a result of which it can be put to a large variety of uses. It has the double advantage of possessing very nearly uniform length and cross section, each of which can be varied at will within certain limits. It is absolutely clean and therefore gives very little waste losses and it does not adhere so much to the processing machines as some other fibres. It has a full bodied but soft feel and its lustre is more subdued than that of the continuous filament. But more important than all these, it can be mixed and blended with cotton, wool, flax and silk, and spun on the existing machinery with very minor adjustments. As against these, it has the disadvantage that its wet strength is appreciably less than its dry strength, which makes the mechanical side of dyeing and other wet process rather difficult, and shortens the life of the garments made from it, if they are sent to laundry. But these disadvantages are being overcome gradually, and it is highly probable that the staple fibre of the near future will be free from them.

The particular feature that staple fibre can be mixed with natural fibres and spun on existing machinery is especially attracting and enables the practical spinner, weaver, dyer and finisher to produce a wide range of effects. It has been used in the manufacture of fancy yarns plyed, double, and single, in hosiery goods, in garments where a 'Crepe' effect is required, in union fabrics in which contrast effects are produced, in imitation of light worsteds, etc. etc., The type of staple fibre required in any one case depends upon the use to which it is put, for mixing with wool, staple fibre having a length of 3″ to 4″ and a filament denier of 3 to 4 is recommended, while for mixing with cotton 1″ to $1\frac{3}{4}$″ staple length and 1.5 to 2 denier has given the best results. It is found that the strength of the yarns spun from it increases with the length and fineness of the filament, but most cotton processing machines cannot easily manage fibres longer than $1\frac{3}{4}$″, while not only does the cost of manufacture increase rapidly with the fineness of the filament, but also finer fibres, possessing a filament denier of less than one, are more likely to be damaged in the processing machines. Protection of the woven fabrics by impregnation or coating treatments imparts many useful properties, greatly adding to their value and service. These treatments are of different types, varying as regards chemical composition and method of manufacture of the various coatings. Those of proxilin and rubber find a number of applications in the building industry. The characteristic appearance of fibres can be seen best under the microscope.

In the world census of production of Industrial Fibres (1937–38) cotton stood as the leading fibre providing three-quarters of the raw materials required for the manufacture of fabrics in the world; the production of cotton (1937–38) stood at unprecedented figure of 18,259,000,00 lbs. Equally, rayon and staple fibre continued their remarkable progress with an output of 1,210,000,000 lbs. and 619,000,000 respectively, for the same season wool production (1937–38) stood at the figure 3,862,000,000 lbs.

In 1938 world production of rayon nearly reached the record figure of 2,000,000,000 lbs. mark or an increase of 7 per cent, on the production of the previous year.

## The Jute Fibre.

Jute is the cheapest fibre in the world, and yet at the same time, the most valuable, and it grows only in India (Bengal particularly). In normal times there is an area of about 3 million acres under this crop, and the annual production is about ten million bales of 400 lbs. each.

The good yield and the ease with which the fibre can be extracted from its cellular matrix, together with its economic importance, makes its utility possible in the wide scope which it offers in the making of cheap materials in the nature of coarse bagging, sacks, wrappings, rugs and carpets, and as a backing or basic fabric for the preparation, of oil cloth, etc.

Jute mills were first started in Dundee in 1835, but it was not until 1854 that the first mill was established in India. This mill situated on the banks of the Hooghly at Risra, near Serampur, could produce eight tons of jute cloth a day. To-day the mills in Bengal are producing over 4000 tons per day.

The jute manufacturing industry is confined chiefly to Bengal, and the prosperity of the province and neighbouring districts is closely bound up with the welding of the industry.

Jute now ranks second to cotton in world textile production, and it is interesting to note the gradual expansion of the industry in this country during the past century.

Jute is also being cultivated in other parts of the world such as Egypt with some measure of success.

It is possible to mix jute waste with cotton waste for the purpose of manufacturing low quality of blankets and other materials which have good prospects of increasing in demand.

## Sunn Hemp.

India produces no small amount of the so called sunn hemp (Crotalaria Juncea). This plant is also extensively used as a green manure, particularly for sugarcane. The area grown for fibre is about 600,000 acres annually and annual exports amount to about 800,000 cwt. Another fibre plant widely grown is Hibiscus Cannabinus (known by various names such as ambadi mesta pat, and Bimlipatam Jute). This is of more local importance. It should be mentioned that both fibres are used for making ropes and twine for village use in India.

## Production, Mill Consumption and Exports.

| July to June Season. | Production. | Mill Consumption. | Exports. |
|---|---|---|---|
| 1929—30 | 103 | 64 | 45 |
| 1930—31 | 112 | 46 | 34 |
| 1931—32 | 55 | 43 | 31 |
| 1932—33 | 71 | 44 | 35 |
| 1933—34 | 80 | 43 | 43 |
| 1934—35 | 85 | 46 | 44 |
| 1935—36 | 72 | 50 | 41 |
| 1936—37 | 96 | 61 | 49 |

## Wool.

The term "wool" is applied to the outer covering of various species of sheep, and also the woolly covering of various goats (e.g.) mohair from the Angora goat, and the under down of camelidae, (Bactrian camel, Andean Alpaca, Vicumna, etc.). To a very small extent other miscellaneous species, such as, the Angora rabbit and the musk–ox are included. In common with all "hair," wool arises from a root or "hair follicles situated in the dermis or middle layer of the skin.

Three kinds of hair may be recorded in the sheep: (*a*) the true wool-hair, which is thin, soft curly, and possessing the valuable property of felting under the influence of water, soap and warmth; (*b*) the longer, stiff body hairs, and (*c*) on head and legs, a bristle hair which is devoid of the valued properties of wool.

There is variation between one fleece and another, even among sheep of the same flock. But there is also variation in staples from different parts of each fleece. In common with the other textile fibres, wool is hygroscopic, and may contain as much as 25% of its weight in water without appearing damp. The standard moisture content for clean wool is 16%, which may be compared with 8½% for cotton.

## Silk.

Silk differs from all other textile fibres in that it is not composed of cells, but is the secretion of several substances from special glands of certain caterpillars belonging to the Lepidoptera or scale–winged insects. The main species of importance to commerce belongs to the section of Nocturna or night flying moths, and the family Bombycidæ, the principal species being the mulberry worm (Bombyx–mori), which supplies the greatest quantity that comes into commerce.

The diameter of cultivated silk ranges from 0.019 mm. to 9.030 mm. while the separate brins range from 0.009 mm. to 0.014mm. The ribbon–width of wild silks ranges from 0.026mm. to 0.086mm, while the thickness is approximately 0.010mm. From the above measurements it will be observed that there are marked differences regarding the size of various silks.

Silk posseses, colour which ranges from white to dark yellow, but the colouring matter in the sericin fibroin is white.

## Popularity Of Cotton.

The great secret of the progress of the cotton trade had been that cotton was the cheapest material in the world for clothing and other purposes, and upon this its continued success depended. Cotton clothes nine-tenths of mankind. Cotton is still the world power. To-day it will be found that the textile industry is one of the most important industries in the world. The total number of persons occupied is estimated at 14 millions or between 3 and 4 per cent of the world total of persons in gainful occupations. Of these persons about 700,000 are engaged in India compared with one million in the United Kingdom, U.S.A., Germany and Japan.

Cotton was used to mix with almost every other fibre and article of clothing, because of its utility, Strength, or ornamentation.

In fact it was supreme in its uses to mankind for these particular purposes. Cotton had crept into the manufacture of most goods because of its cheapness, and that was the reason why it had grown to such tremendous proportions. It is indispensable as cotton wool for medical purposes. It forms the basis of 'pneumatic tyres', and of explosives. Bear in mind that the extensive usage of cotton could only be maintained to an economical competitive point.

It should be remembered that the demand to-day is continually increasing for finer cotton goods. Fashions throughout the world now demand cotton goods softer in feel and lighter in texture in order to stand the competition against artificial silk. Shades demanded from the dyeing are more delicate.

## Evolution In Cloths.

With the gradual change and evolution in cloths from heavy white and grey shirtings to finer and more fancy materials, we have now arrived at the silk age, real and artificial. The present day demand for fabrics of a silky texture is having a disastrous effect on cotton goods which were formerly used for ladies' apparel. Even the lower middle classes are using artificial silk materials in preference to cotton.

## Importance of Clothing.

Clothing is one of the three fundamental activities of life—the provision of "food", "Shelter" and "Clothing."

The Indian mill hands are satisfied with a shirt or a vest, a cap and dhoty. But in Bengal the majority of the Bengaleees go about their business scantily dressed and with their heads uncovered.

The poorer class such as the agriculturists are generally found with a piece of cloth (about 40″ to 42″ wide by 4 to 4½ yds. long) or a loongi with which he covers the lower part of his body from waist to just below the knee. The upper part of his body remains uncovered. Short trousers are commonly used with a shirt hanging down instead of being tucked in the trousers.

## Romance of Cotton.

In very early times cotton cloths from India gradually found their way into the markets of Persia, Arabia, Palestine and Egypt.

The Bible makes reference to "white and violet coloured cottons" in the description of the Palace of Shusan in the book of Esther, and frequent references to cotton are made by Greek writers.

Cotton goods imported from India were used by the noble families of the Roman Empire.

By the opening of the Christian era the import trade in cotton goods from India to Asia Minor, Africa and Sourthen Europe had grown to large proportions. Thereafter the trade spread all over Europe and helped to build up the wealth of the great Mercantile cities of "Middle Ages" such as " Venice and Genova."

The Moorish chieftan Abdulrahman the great, introduced both the growing of cotton and the manufacture of cotton cloth into Southern Spain.

The rest of Europe, however, continued to import its cottons from Asia until the fifteenth century, when the conquest of Constantinople by the Mohamedans cut off the trade routes between Europe and the East.

In search of a new road to India, Columbus sailed Westward from Spain and Vasco da Gama sailed eastward from Portugal. Rounding the Cape of Good Hope, Vasco da Gama reached the Indian port of Calicut, from which the word "Calico" is derived. Eventually cargoes from India, instead of coming through the Red Sea and enriching the ports of the Mediterranean, came around the Cape of Good Hope and enriched the ports of Western Europe particularly of England.

The East India Company having been founded for trade in spice it naturally followed that the early voyages were made to the Spice Islands. There the natives were invited to exchange pepper and cloves for English Money and English manufactured goods. English Money was probably not very acceptable to the Javanese except, perhaps, for its metallic contents. The staple industry of England at the time was woollen manufacture, but there was very little demand for woollen goods in the tropics. Pure cotton goods were neither made nor used in England, but it was for those where there was a ready market and that was in the East Indies. It was known that such cotton was made in India, and accordingly the Company's Agent Bantam wrote Home and suggested that two ships should be sent to Surat and Cambaya to purchase cotton goods, which should be exchanged for spices in the Island. And so factories were established at Surat and Muslipatam to collect the cotton goods and export them to the Spice Islands.

## THE ENGLISH TRADE.

The massacre of Amboyna in 1623, which compelled the English to leave the Spice Islands, closed that market to Indian cottons. Previous to that date a few cotton bales had been exported to England, but the greater trade was in indigo. Now cottons were sent in increasing quantities, and the demand for them grew rapidly. Plain calicoes were imported into England and printed, and displaced wools as dress fabrics and hangings. The woollen manufacturers, while recognising the fact that the introduction of cotton must affect their sales, did not at first realize how serious the competition was to be. In fact, the problem which chiefly occupied the minds of authorities of the early seventeenth century was how to encourage the young linen and silk industries without embarrassing the woollen trade.

### Ban on Calico.

By the end of the century, however, the sale of cotton had expanded so greatly that urgent petitions were presented to Parliament by the affected industries for protection against the 'Upstart'. In 1700 a bill was introduced to prohibit the Indian cottons altogether. These attacks failed, largely because the company was a generous money-lender to the Government.

The development of the party politics and the increasing interest in theories of trade finally found the Whigs in opposition to the Company.

The accession of the Hanoverians established the Whigs firmly in power, and the expected blow fell upon the cotton trade. The calico act of 1721 prohibited "the ues and wear of all printed, painted, flowered or dyed Calicos in apparel, household stuffs, furniture or otherwise," whether imported or made at Home. Any person who wore Calico garments was liable to a fine of £20. It is probable that never in history has the result of a policy been so different from what was expected. The ultimate effect was the rise of cotton manufacture to the premier place in English industry.

But how it started this is not quite clearly known. It is said that the manufacture of cotton goods was established in northern Italy in the sixteenth century, that it was introduced from there to the Netherlands, and that the Flemish Spinners and weavers, driven from the Netherlands by religious persecution at the beginning of the seventeenth century, introduced the industry into England; and it was in England that the great impetus was given to cotton manufacturing, and the foundations of the industry as we now know it were really laid, by the invention of the spinning jenny, the spinning mule and the power loom was started in a small English cotton industry, in the year 1786, but the secret of making fine material lay in India. The English manufactured goods of a mixture of cotton and linen, or cotton and wool. At first these Cottons suffered just as much as 'true' cottons from the inforcement of the Calico Act, and the result was, more petitions to Parliament to relieve the English Industry. In consequence the Manchester Act was passed in 1735, which permitted weaving of so-called 'Manchester Cottons.' Now this Act applied equally to Indian as to English goods, but India produced little, if any, of this class of cottons. The result was that the English industry securely protested against the competion of the Indian fine cottons which grew with extreme rapidity. The import of raw cotton rose from 1,500,000 lbs in 1720 to 6,700,000 lbs in 1776, while the export of cotton goods was valued at £16,000 in 1720 and £855,000 in 1780.

## The Fame of Dacca Muslin.

The fabrics produced by the art of its hand loom weavers found their way to most countries of the civilised world. Cotton was grown near most villages, and spun and woven on the spot, each little community producing for its own consumption. The fame of Dacca Muslin, in particular, was world-wide, neither human hand nor machine has ever produced a finer or more delicate fabric.

Many interesting stories are told concerning the fineness of some of the muslins. The Hindus relate two amusing stories (*a*) that the Emperor Aurangzeb was very angry with his daughter for showing her skin through her clothes, whereupon the young princess stated that she had seven "jamahs" or (suits) on (*b*) that in Nabob Allaverdy Khan's time, a weaver was chastised and turned out of the city of Dacca for his neglect in not preventing his cow from eating up a piece of Abroan which he had spread and carelessly left on the grass. The very poetic name "Shubnam" (evening dew), as this particular type of muslin was called, suggests that the fabric could scarcely be distinguished from the dew on the grass when spread over a bleaching field.

The following list gives particulars of some "Dacca Muslins.'

| No. | Name. | No. of Threads. | Average Weight. | Dimensions. | REMARKS |
|---|---|---|---|---|---|
| 1. | Mulmul khas | 1,800 to 1,900 | 3ozs. 2dwts. 14 grs. | Yards. 10×1 | Made and reserved for the private use of the King. It is described as so fine that "it will pass through a ring." |
| 2. | Jhuna .. | 1,000 | 8¼ ozs. | 20×1 | "Jhuna" (thin). Net like muslin, worn only by Indian dancers, singers, and ladies of wealthy class. |
| 3. | Rang .. | 1,200 | 8 ozs. 4 drs. | 20×1 | Net-like texture, 1 in a dent. |
| 4. | Abrawan | 700 to 1,400 | 9to 11½ ozs. | 20×1 | "Ab" (Persian water. 'Rewan" (Persian) to flow. |
| 5. | Circurali | 1,900 | 4 to 4½ ozs. | 10×1 | Manufactured for the use of the Nabobs of the Province. It was included among the articles for the Viceregal Court, the cost of which was defrayed from the revenues of the Jaghire circur ali. |
| 6. | Khasa .. | 1,400 to 2,800 | 10½ to 21 ozs. | 20×1 to 1½ | "Khasa" (elegant). |
| 7. | Subnam .. | 700 to 1,300 | 10 to 13 ozs. | 20×1 | "Subnam" (evening dew) It has been described that this fabric, when spread over the bleaching field, could scarcely be distinguishable from the dew on the grass. |
| 8. | Alaballe .. | 1,100 to 1,900 | 9¾ to 17 ozs. | 20×1 | "Alaballe" (very fine.) |
| 9. | Tauzeb .. | 1,900 | 10 to 18 ozs. | 20×1 | "Tauzeb" ((ornament of body.) |
| 10. | Turundum. | 1,900 to 2,700 | 15 to 27 ozs. | 20×1 | Agreeable to the eye. |
| 11. | Nayansook. | 2,200 to 2,700 | .... | 20×1½ | "Nayan" (eye.) "Sook" (pleasure.) |
| 12. | Buddunkhas. | 2,200 | 12 ozs. | 10 to 24×1½ | Here the weft is not so compact as in "Nayansook." |
| 13. | Sirband .. | 2,100 | 12 ozs. | 20 to 24×½ to 1 | Head dress as used for turban. |
| 14. | Kumese .. | 1,400 | 10 ozs. | 20×1 | Cloths used for making garments like shirts. |
| 15. | Jamdanee .. | 1,700 | — | — | Embroidered on loom. It resembles the tappet weaving of the present day. |

### THE EXPORT OF DACCA MUSLIN.

In 1787 the exports of Dacca Muslin to England amounted to 30 lakhs of rupees in 1817 thcy had ceased altogether.

It is often thought that the industrial expansion of England in the 18th century was due to inventions. The reverse was probably the case. The increased demands for goods led to attempts to cope with the demand by the introduction of mechanical means. Hence there followed the series of inventions in the cotton industry, which culminated in Crompton's "MULE" in 1779.

## How India Lost its Supremacy in Cotton Goods.

Before the emergence of modern industrial methods in the manufacture of cotton goods, Indian cotton was noted for its quality. In fact India has been the home of textiles, from the very earliest times. India saw the birth of cotton textile industry in the modern sense in the years 1851.

At a time when the west of Europe, the birth-place of the modern industrial system, was inhabited by uncivilised tribes, India was famous for the wealth of its rulers and for the high artistic skill of its craftsmen, and that even at a much later period when traders from the West made their first appearance in India, the industrial development of India was at any rate not inferior to that of the more advanced European nations.

For centuries India continued to enjoy a large and widely scattered market for products, and it was only when the industrial age came and foundations of a large scale industry were laid in Lancashire and other places that its supremacy came to an end.

### BABYLON TRADED WITH INDIA.

There is evidence that Babylon traded with India in 3000 B.C. Mummies in Egyptian tombs, dating from 2000 B. C. have been found wrapped in Indian muslin of the finest quality. There was a very large consumption of Indian manufactures in Rome. The Muslins of Dacca were known to the Greeks under the name of Gangetika.

### CROMPTON'S MULE.

The year 1774 was a most critical one for English cotton manufacture. In that year Crompton began his work on the "MULE" and in that year the Calico Act was also repealed. English manufacture was again open to Indian competition, but now on more than level terms. Thanks to the new machines, the thread spun in England was even finer and stronger than Indian thread, and English 'true' cotton goods were both better and cheaper.

## Levy of Excise Duty.

By 1884 the quantity of imported raw cotton had reached 17,91,600,000 lbs. per annum, while the value of exported cotton goods in that year was £72,700,000. Not only did Lancashire Cottons hold their own in England, but they actually came out to India and competed successfully on its own ground with the indigenous industry.

The sales of English cottons in India were further assisted in 1877 by the abolition of the 5% ad valorem duty. This was carried out by Sir John Strachey, finance member under Lord Lytton, as part of a general policy of free trade, not without very considerable opposition in India, especially from the cotton interest, who pressed for protection. In 1896 the deficit in the Indian budget compelled Lord Elgin to reimpose import duties. A 3½ per cent duty was levied on cottons but at the same time a 3½ per cent excise duty was levied on Indian cottons much to the exasperation of Indian Manufacturers.

## Lancashire Vs. India.

The old thorny question of Lancashire *Vs.* India was, however finally settled during the great war when the duty on imported Cotton was increased to 7½ per cent without any corresponding increase in excise duty on Indian cotton. It is interesting to note how factors, which are political in themselves although economic in effect, have influenced the cotton industry. Although it will be too much to say that the Lancashire cotton industry was built up by the Calico Act, nevertheless the Act dealt a crushing blow to Indian export trade, and sheltered the English industry until it was strong enough to withstand all competition.

## Abolition of Excise Duty in 1926.

The assistance given in 1925 by suspension, after considerable agitation by the Millowners, of the excise duty of 3½ per cent. ad valorem on all goods manufactured in Indian mills, from 1st October 1925 and its total abolition in 1926.

## Factors in favour of India.

India, having several factors in her favour against her competitors, such as being close to the cotton fields ginning plants and the home market for cloth, is gradually producing more piece goods, and consequently catering more and more for the Indian consumer. The mill owners are also beginning to realise that there is more profit in proportion in fine Spinning and Weaving than in coarse and medium counts. Several mills have started producing fine counts combed or double carded. This is substantiated by the fact that during the financial year 1937–38, India imported 12–13 crores worth of foreign cottons (mainly East Africans and Egyptians), which compares with the previous two years totals of Rs. 5.85 Crores and Rs. 6.74 crores, respectively. In 1936–37 Indian mills consumed 64,988 tons of foreign cottons and in 1937–38 about 131,414 tons were consumed. But owing to want of efficient labour the success is rather unsatisfactory to a certian extent with the exception of a very limited number of mills. For fine Counts and expensive yarns labour must be of the best. Owing to the agitation that has been created by Mr. Gandhi and with the depression in the trade helping in general, the Indian Community, barring a very limited number, got themselves used to wearing Dhoty manufactured from Coarse Counts; this was looked upon as a patriotic and hence a dhoty made from fine counts does not find so much sale in bulk compared to Dhoty made from coarse counts. Sarees woven with fine counts and made in attractive designed borders of artificial silk yarn that has been dyed in delicate colours find a good market in general. Sarees dyed in various shades have also a good demand.

*"It is necessary for all those Indians that have the interest of their country in their heart to contribute and help the Home Industry."*

## Japan's Competition.

A very important question may be asked thus :—Is the present chaos which certainly exists in many directions being the result of the multifarious changes brought about by Japan in World markets, with her policy of mass selling to enter the markets of the world to be considered a great problem ? The answer is yes.

The Japanese cotton industry is the greatest existing or potential competitor to any nation engaged in the export trade in cotton goods. The post war development of the textile industry had resulted in the substitution of Japan for the United Kingdom as the world's leading exporter of textile fabrics. Her main advantages are her proximity to the greatest consuming centres of cotton yarn and piece goods, her cheap and efficient power supplies, and her coordination of the buying of the raw material and the distribution of the finished product. The growth of the spinning industry dates from 1889—1890, when Mr. R. D. Tata exported to Japan 32 bales of Indian cotton, and taught the Japanese how to open the hard pressed bales, which from that time onwards were destined to replace the loose chinese cotton.

The rate of growth, from that time onwards, has been continuous and steady. This rate was as fast before 1914 as it has been since. It is possible, however, that the rate would have been slower after 1914 if the war had not given the advantage of sheltered markets, and rendered easy the access of them without competition. It is to the credit of the Japanese that they seized their opportunity, and developed in a most efficient manner the trade which was opened up for them. The energy and resource, however, which Japan has shown in entering new markets and exploring new channels is the greatest problem to which any competitor must give attention.

## Reasons of Cheapness of Japanese Goods.

(1) Japanese buy cotton in bulk. They keep in close touch with the cotton fields, and possess their own gins and their selling organization is wonderful.

(2) The up-to-dateness of their mills.

(3) Her capacity to produce every article of stores and machinery required for her industry.

(4) Low rate of wages paid in Japan.

Owing to the difference of mode of living the Japanese and the Westerners, the wages in Japan are very low. The male and female beginners start at 60 and 40 Sen, i.e. Annas 15 and Annas 10 daily respectively and gradually their wages rise up to Yen 1.75 in case of female and Yen 3.00 in case of male workers. The operatives get free lodging, working uniforms and washing but they pay about 16 Sen i.e. about Annas 4 per day for their food. The mills have a special cooking arrangement for the whole staff and a dining hall wherein several hundreds of people can conveniently sit and take their meals. Besides this the mills maintain a well-equipped hospital, school, lecturing and theatrical hall, music room, sewing class and play grounds.

(5) The supply of labour is abundant and hence another reason for cheapness.

(6) Compared to India and European countries the labourers in Japan work longer hours and more days.

(7) The standardising and mass production of piece goods.

(8) Owing to the traditional technique of silk industry the Japanese have easily and efficiently adapted themselves to the manufacturing of cotton goods very successfully.

(9) Another good reason for the development of Japan's cotton industry is the moisture of the country, moisture being necessary for the strength of cotton yarn. In Europe, England is the only country where the industry developed due to the moist climate.

(10) A good factor in favour of Japan is that it is geographically situated between two great producers of raw cotton—the United States and India.

The Japanese method of mixing raw cottons of various staples in order to produce yarns of various grades to meet the respective tastes and requirements of the countries to which they are shipped is a secret jealously guarded by all mills. The proportion of the various materials in the mixture varies to harmonize with the local conditions of the purchasing countries. This is why the Japanese yarns or fabrics are capturing the world market.

(11) The fostering of mutual trade with cotton-growing countries by advantages to shipping lines.

(12) The astonishing cheapness of electrical power in Japan The wholesale prices as quoted by the Power Companies range from $\frac{1}{8}$ to $\frac{1}{4}$ anna per unit, and some is sold as cheap as 1/41th of an anna per unit depending on the size and up-to-dateness of Japanese factories etc.

(13) Depreciation of the Yen.

The above factors help the Japanese to a great extent to be in that happy position of being able to compete with other countries by selling their goods at a low price. How long they can maintain the selling of their goods cheaper than other countries is rather difficult to answer. But the consequence of Japan's struggle for domination on the textile markets of the world will eventually prove to be as dangerous as it proved to England. Japan should cooperate with the world manufacturer both in production and price.

## Reasons of the Foreigners Success in the Indian Market.

(1) The majority of the Indian mill-owners indulge in speculation or other business and hence being thus entangled they find very little time to interest themselves efficiently and devotedly to the working of the mills economically etc.

(2) Foreigners move from district to district to introduce their goods, whether due to economical pressure or natural aptitude they succeed in capturing the market by their enterprising spirit and self sacrifice.

(3) The internal business secrets that the foreigners acquire in details and very minutely too are utilised as dynamites to shatter the business of their competitors.

(4) Quality taste and prices change daily, foreigners take advantage by being on the spot to introduce their goods and note the changes and the local requirements which they communicate promptly and efficiently to their respective organisation and thus they avail themselves of the demands that arise from time to time.

(5) Foreigners succeed because they go at times out of their way to render a service by way of a favour.

(6) The cotton industry in India make losses due to internal competition in under cutting and by imitating one another's qualities instead of specialising in their original products.

(7) Some of the Indian mills spin their counts of yarn much below the nominal (2 to 4 counts down) due (in majority of cases) to the use of inferior cotton mixings and yet while calculating the weight of the cloth the nominal count of yarn is taken instead of actual and thus they give away the extra weight as a gift to the dealers without being aware (in the majority of cases) the extent of losses the mills sustain. Some mills work out the weight in a piece of cloth by taking for their calculations one count lower than the nominal count.

(8) The needs of the actual consuming centres (be it in the interior or exterior) should be closely watched and studied. Growing centres must be given all necessary facilities.

## No Progressive Business Should Lack in Enterprise.

It is essential that all manufacturing concerns should send out a competent all round representative at regular intervals to study the condition, peculiarities and demand of the local markets and to train and assist the merchants in exploitation of their goods. Good sense is always needed to remove business difficulties.

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 should exist a natural aptitude in applying reasoning and principles to practical purposes. Investigation on Scientific lines would probably show that better and cheaper results would be obtained by alterations in method and material.

" 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 thē actual spot that produces any given abnormal result.

## THE COTTON TRADE DEPRESSION.

(*a*) What is the cause of depression ? (*b*) Is there a solution ? (*c*) If so what is the solution ?

These are questions that are very often asked by people in the trade.

The cause is the seriously unsettled state of the world's politics, national and international, the chaotic, the plunging and the unstable state of the world's exchanges; the break down of credit and the wrecking of confidence in international trading. The purchasing power of most people is reduced, and there is the continued feeling of uncertainty in future world events, the result of the breakdown of confidence following the shattering effects of the late war-time and time alone will heal all difficulties.

## EFFECT OF DEPRESSION.

People owing to depression have learnt to economise in clothing materials. It is wonderful how the mentality has changed both of the rich and the poor alike in adapting themselves to buying of less and less of wearing materials at the same time they also go about seeking cheaper articles than what they were used to do. A manufacturer that can give to the consumer the highest possible quality at the lowest possible price, with prompt deliveries, is bound to be a leader in business, with a reputation for reliability and honesty. But bear in mind that "quality" is wasted if "taste" is lacking. One of the first principles of decorative art is that in all manufactures ornament must hold a place subordinate to that of utility. When, by its exuberance, ornament interferes with utility it ceases to be art and becomes vulgarity.

## The Cycles of Business.

The individual business man, must make group predictions for his own business. Some experts claim that the cycle has definite predictable fluctuations, and passes through five phases.

(1) Depression.
(2) Revival.
(3) Prosperity.
(4) Financial Strain.
(5) Industrial crisis.

The seasonal variation or movements of items within the year must not be lost sight of. Just as the temperature changes within the year, so certain business rise and fall systematically year after year. This seasonal variation is of vast importance for sale of cloth. An example of seasonal variation is that of marriages, auspicious holidays such as Divali, Doorga Pooja, etc. The marriages (very important for sale of cloth) take place generally during the months of January to April of each year.

The Divali holidays fall generally during the month of November of each year. The Doorga Pooja falls generally during the month of September or October of each year.

All statistical measures of the rise and fall of general business and Specific industries are based upon the past. They can be used as a guide for the future only when the underlying economic conditions remain the same or when proper allowances are made for the differences that have occured. The main difficulty in making safe predictions regarding the future lies in international affairs, banking conditions, the public mind toward Speculation in business, and other factors of influence are changing so frequently and pronouncedly that reliable forecasts are rather difficult at times.

## Textile Industry is a Stable Industry.

The Textile Industry, as a whole, is one of the most stable industries which are neither hazardous nor venturesome, but are the root of the seeds that were sown by most intellectual, clever and wise people. People must wear clothing. The greatest populations in the world use only cotton, these including such tremendously populated countries as India, China and Japan, as well as central America. Most of the others, however, use cotton in some form or other either for clothing or household purposes to a very great extent. The fact that cotton cloths form such a large portion of the world's demand makes it all the more important that this demand should be properly catered for. Fabrics must be made to suit the buyer.

## Increase Demand to Capacity.

Cotton is so mixed up in our daily lives that nobody bothers about salesmanship. Its manifold uses are seen everywhere in the home, in the office, and in the factory. The average motor-car contains about 25 lbs of cotton. It has kept its place in the march of civilisation, and because cotton is such a necessary article the manufacturers think it ought to sell itself and thus console themselves with those lines of a silly poet :—

> " Serene I fold my hands and wait ;
> I know my own will come to me."

It is absolutely necessary that an attempt should always be made by a manufacturer to increase demand to capacity and not reduce capacity to demand by working out a definite policy of making his goods widely known in the markets where demand exists. To do this it is the duty of every manufacturer to attract favourable attention by advertisement etc.

New uses for cotton are continually cropping up. Millions of yards of cotton cloth are used in America for the reinforcing of second-class roads, wallpapers, ordinary stationery, menu cards, and posters. Many more uses such as gloves, imitation leather trunks, cotton carpets, and waterproof cloth for wet and humid walls could be found for the use of cotton by an organised effort to exploit them. The Cotton-Textile Institute Inc., of New York, maintains a big organisation for boosting cotton. One of its most successful seasonal Schemes is to invite manufacturers to send in their best and most "novel design." These are adjudicated upon by a Committee of experts and fifty samples chosen. They are pasted on to pattern cards, with the names of the manufacturers printed underneath, and circulated to 20,000 retail stores in the states. There are no petty jealousies of somebody stealing their designs and the firms consider it an honour to have their work chosen. Every mill should make only what it knows how to make, in quantities and if possible a mill should be so designed as to produce one class of material to reduce cost and then it follows that the profits will be greater as the consequence of lower cost.

## The Law of Supply and Demand.

An excess of production leading to lowered prices generally results in an increased consumption. This free working of the inexorable law of supply and demand, due to man's normal reaction to the law, is responsible in a large measure for his industrial development and the improvement of his living conditions with each generation. There is just one law that can regulate prices in any Commodity, and which will always, without a single exception, treat the public fairly. That is the law of supply and demand. The unrestricted operation of this law offers the sovereign remedy for most of the market ills of the world. It is not enough to be able to make cloth; one must be able to make cloth that sells. In order to do this the cloth must be made attractive to the prospective buyer, that is to say, it must be bleached, dyed, printed and finished so that it makes its appeal, and thus tempt the public to buy more and more.

*Manufacture the right goods at the right prices and let people know that you have them.*

## The Needs of the Consumer.

The determining market factors are the needs and the wants of the consumer rather than the needs and the wants of the producer. It is the problem of the producer, therefore, to study the consumer and base his production and sales plans upon consumers' wishes. The manufacturer must find out what and how much the public wants. The Consumers' wants must be predicted and production must be regulated to fit him rather than the producer.

Every manufacturer must determine in advance before he introduces a new sort or quality in the market the following three points :—

(1) What the Consumer wants ?
(2) How much of it he wants ?
(3) What he will pay for it ?

Forecasting and planning is nothing more or less than a system of control, whereby production, purchase of materials, and the employment of capital are co-ordinated with sales requirements.

## Cotton Mills Prosperity Depends on Agriculturists Prosperity.

The prosperity of the Indian Cotton Mills depends chiefly on the proceeds in value the agriculturists receive from the products of their land as they are consumers as well as producers and yet the poor farmer who grows cotton is subject to many adverse factors. Though some of these may be beyond his control, there is one factor which can be controlled in his advantage, namely the marketing of his crop.

Though the Cotton textile industry has grown considerably in recent years, India is not yet able to consume all the cotton produced in the country and hence it has to depend on other countries for the disposal of its most important product. On the other hand what is far more important is that the defective methods of cultivating cotton and the need for rationalisation of the mills should be a warning against concentrating attention on industry to the neglect of agriculture or vice versa.

## CLIMATIC STATISTICS.

### TEMPERATURE IN DEGREES FAHRENHEIT.

| | Height in Feet. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Allahabad | 309 | 59 | 65 | 77 | 88 | 92 | 91 | 84 | 83 | 83 | 78 | 67 | 60 |
| Bombay | 37 | 74 | 75 | 78 | 82 | 85 | 82 | 79 | 79 | 79 | 81 | 79 | 76 |
| Calcutta | 21 | 65 | 70 | 79 | 85 | 86 | 84 | 83 | 82 | 82 | 80 | 72 | 65 |
| Delhi. | 718 | 58 | 62 | 74 | 86 | 92 | 92 | 86 | 84 | 84 | 78 | 68 | 60 |
| London | 20 | 38 | 40 | 43 | 49 | 55 | 61 | 64 | 63 | 58 | 50 | 44 | 40 |
| Lahore | 702 | 54 | 57 | 69 | 81 | 89 | 94 | 89 | 87 | 85 | 76 | 63 | 58 |
| Lucknow | 368 | 59 | 64 | 75 | 86 | 92 | 90 | 85 | 83 | 83 | 77 | 66 | 59 |
| Madras | 22 | 75 | 76 | 79 | 84 | 89 | 88 | 86 | 84 | 84 | 81 | 78 | 76 |
| Moscow | .. | 12 | 12 | 22 | 37 | 52 | 63 | 65 | 64 | 52 | 40 | 30 | 17 |
| Nagpur | 1102 | 69 | 74 | 82 | 91 | 94 | 87 | 80 | 79 | 80 | 78 | 72 | 67 |
| Ootacamund | 7327 | 54 | 55 | 59 | 61 | 61 | 58 | 57 | 57 | 57 | 57 | 55 | 54 |
| Para. | 5 | 82 | 82 | 83 | 83 | 83 | 82 | 80 | 79 | 80 | 80 | 82 | 83 |
| Patna | 183 | 61 | 65 | 77 | 86 | 88 | 86 | 83 | 83 | 83 | 79 | 70 | 62 |
| Rangoon | 57 | 75 | 77 | 81 | 85 | 82 | 79 | 79 | 79 | 79 | 80 | 78 | 76 |
| Smyrna | 26 | 50 | 50 | 51 | 58 | 64 | 72 | 80 | 78 | 73 | 65 | 65 | 52 |
| Tokyo | 70 | 38 | 38 | 44 | 54 | 60 | 68 | 78 | 75 | 71 | 62 | 52 | 40 |
| Vienna | 700 | 30 | 35 | 43 | 52 | 60 | 70 | 70 | 70 | 62 | 53 | 43 | 35 |
| Valparaiso (Chile) | 20 | 69 | 69 | 60 | 61 | 60 | 55 | 53 | 53 | 59 | 60 | 65 | 69 |

## CHAPTER II.

## INDIA.

India is a vast and greatly diversified country.
The area of India is :—

| | | | | |
|---|---|---|---|---|
| British India .. .. | 1097,171 | Sq. Miles | — | 61% |
| Indian States & Agencies | 712,508 | ,, | — | 39% |
| Total .. | 1809,679 | | | 100% |

Its surface is equal to that of the whole of Europe excluding Russia, whilst its population is larger than that of any other country except China, and is in fact one fifth of the whole world.

## POPULATION.

The population of India (1931 Census) is :—

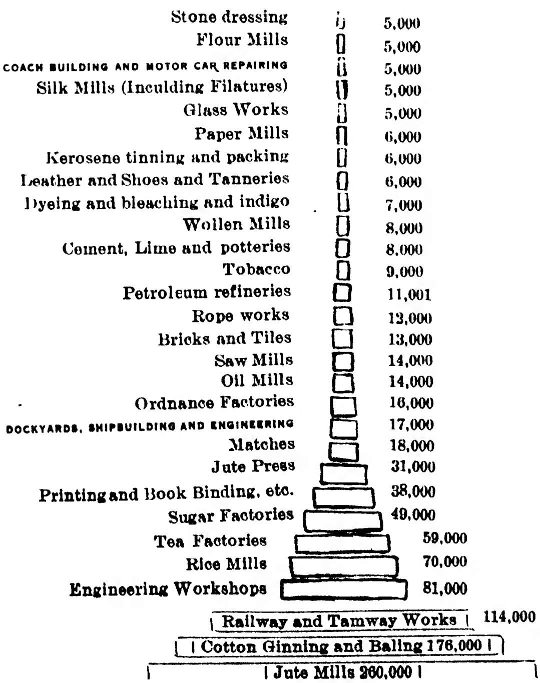
| | |
|---|---|
| British India .. .. .. .. .. | 2,71,526,933 |
| Indian States .. .. .. .. .. | 81,310,845 |
| Total .. .. | 3,52,837,778 |

For the last decade, the population of India shows a steady increase of three millions per annum. The mean density of population per square mile in the whole of India is 195, varying from a maximum of 814 in Cochin State, and in British India of 646 in Bengal to a minimum of 5 in Baluchistan States, and 9 in British Baluchistan. Eleven per cent of the population live in towns.

India is, as a rule, a warm country with greatly varying degrees of temperature. In summer the temperature ranges from 84° to 114° fah. in the shade. The conditions of life and work in India, having in view the peculiar climatic circumstances, are therefore very different from a country such as England. The avocations of life are not possible to be pursued with such vigour in the former country as in the latter country.

## Population of Large Cities (*including Cantonments*) Census of 1931.

| City | Population | City | Population |
|---|---|---|---|
| Calcutta (including Suburbs and Howrah) .. .. | 1,485,582 | Allahabad .. .. | 183,914 |
| Bombay City and Island .. .. | 1,161,383 | Madura .. .. | 182,018 |
| Madras City .. .. | 647,220 | Srinagar .. .. | 173,573 |
| Hyderabad .. .. | 466,894 | Patna .. .. .. | 159,690 |
| Delhi .. .. .. | 447,442 | Mandalay .. .. | 147,932 |
| Lahore .. .. | 429,747 | Sholapur .. .. | 144,654 |
| Rangoon .. .. | 400,415 | Jaipur .. .. | 144,179 |
| Ahmedabad .. .. | 313,789 | Bareilly .. .. | 144,031 |
| Bangalore .. .. | 306,470 | Trichinopoly .. .. | 142,843 |
| Lucknow .. .. | 274,659 | Dacca .. .. .. | 138,518 |
| Amritsar .. .. | 264,840 | Meerut .. .. | 136,701 |
| Karachi .. .. | 263,565 | Indore .. .. | 127,327 |
| Poona .. .. | 250,187 | Jubbulpore .. .. | 124,382 |
| Cawnpore .. .. | 243,775 | Peshawar .. .. | 121,866 |
| Agra .. .. .. | 229,764 | Ajmer .. .. .. | 119,524 |
| Nagpur .. .. | 215,165 | Multan .. .. | 119,457 |
| Benares .. .. | 205,315 | Rawalpindi .. .. | 119,284 |
| | | Baroda .. .. | 112,862 |
| | | Moradabad .. .. | 110,562 |



## The Working Population.

Farming is a primal need, because we get our food etc. out of the soil. Next in importance to farming comes "Transportation" because a certain thing has to be at a certain place at a certain time in order to possess value. The third most important thing in the world is "Manufacturing" which is taking raw products and combining them into forms of use. The fourth most important thing is "Distribution"......Warehouses gather together products of the farm, the factory, the mine and the sea and distribute them to the people who need them. The fifth most important thing in the world is "Banking" and the sixth is Advertising.

The proportion of the working population engaged in agriculture is 66.4%. Those engaged in trade number 5.13% in the industries 9.35% and in transport 1.52% in administration 2.60% and in miscellaneous 15%. The principal Indian Agricultural products are rice, wheat, fruits, vegetables, spices, cotton, jute, oilseeds, tea, and tobacco.

## Industrial Output.

In industrial output U. S. Stands in the premier position in the world then comes Russia.

## The Lancashire Cotton Industry.

The majority of firms comprising that group of industries which form the cotton industry, perform only a single process or group of related processes, few both produce and sell. Thus Lancashire Cotton trade is based upon specialisation and segregation of production and marketing. Over, 3000 firms, representing an invested capital of over £150,000,000 employing nearly half a million work-people, are directly engaged in this industry.

Of these 3000 firms, approximately 10 per cent are raw Cotton merchants and brokers, 10 per cent. are spinners, and another 10 per cent. are yarn agents and merchants. The percentage engaged in weaving is 25, and 14 per cent. account for bleaching, dyeing, printing and other finishing processes. Some firms combine Spinning and Weaving, these forming some 5 per cent. of the total. Seven per cent. are represented by grey cloth agents and merchants, 1.4 per cent. are packing firms and 7 per cent, are home trade merchants. By far the largest proportion are export merchants, accounting for more than 33.3 per cent. of these grouped industries. While most spinning firms are limited companies, the bulk of the Weaving business is undertaken by private firms, many of the family type.

It may at first, seem remarkable that a country with a population of 45,000,000 should have a textile industry larger than that of the United States with its population of 130,000,000 or Russia, China or India with populations estimated to be 250,000,000, 400,000,000 and 350,000,000 respectively.

The cotton industries of the United States, Japan, India and Russia do actually consume more raw cotton than does the British Cotton industry. The textile industries in these other countries usually work in Shifts whereas the British cotton industry only works a single Shift, and maintains very strictly the International Labour Office convention of the 48-hour week. This explains, to some extent, the lower consumption of cotton with the higher British figures of the number of spindles.

One main feature, however, of the British cotton industry is that it spins and uses yarns which on the average are very much finer, that is of higher count, than those of other national industries. The finer yarns take longer to produce because they must be drawn out to a finer degree, and more twists per inch have to be inserted. The fine yarns are spun on self-actor mules which work intermittently to deal with each length of yarn, compared with the ring frame which delivers and twists continuously so that the production is greater for each spindle. The cotton Spinning Mills around Bolton buy the whole of the Sea Island cotton crop which is the finest cotton grown, and in addition most of the long-stapled, strong, lustrous and valuable Egyptian and Sudan crops such as Giza 7 and Sakellaridis cottons. The yarns produced from these cottons are utilised in making gloves, ladies stockings, embroidery, etc., etc.

The cotton Spinning industry can be divided into the fine yarn trade counts of 56s up to 200s or more, the American cotton Spinning trade producing counts of 24s to 60s, the coarse counts industry producing sometimes from Indian cotton counts 10s to 28s, the waste cotton industry producing thick, soft yarns up to 16s, and for the yarn doubling trade.

The cotton weaving industry could be divided into specialized sections, those weaving plain goods and those weaving coloured goods and striped warps. It is usual for all firms to be very highly specialized. One firm will weave sheets another shirtings or light fancy goods such as muslin or voiles or cloths for printing etc.

Not only are the firms very Specialized but different districts are also Specialized, and so have become very highly skilled.

Gross Income per Capita—Pre-war period.

| | £ | Rs. |
|---|---|---|
| United Kingdom | 50 | 750 |
| United States | 72 | 1080 |
| Germany | 30 | 450 |
| Australia | 54 | 810 |
| Canada | 40 | 600 |
| Japan | 6 | 90 |
| India | 2.4 | 36 |

| Industrial Production per Capita. | Rs. |
|---|---|
| U. S. A. | 720 |
| Canada | 470 |
| United Kingdom | 410 |
| Japan | 158 |
| India | 20 |

| Bank Deposits per Capita. | Rs. |
|---|---|
| United Kingdom | 720 |
| Japan | 250 |
| India | 7 |

| Savings Bank Deposits per Capita. | Rs. |
|---|---|
| United Kingdom | 270 |
| France | 125 |
| Japan | 90 |
| India | 2 |

## Typical Crops of India.

Rice is the mainstay of the people of India, as also of the Orient generally. India is the largest producer and the largest exporter of rice in the world. The Value in normal times of its exports amounts to Rs. 3,77,000,000. The yearly output of wheat in India ranges between 8,000,000 and 10,000,000 tons.

The cultivation of cotton, and the manufacturing industry constitute one of the economic mainstays of India, with its population of approximately 3,65,000,000.

The average yield of the "wheat" lands in India is 605 lbs per acre compared with 1526 in Japan, 1530 in Egypt 1246 in Canada and 2202 in Great Britain.

For "Rice" the figures are as follows :—

India, 1295 lbs. Spain 5700 lbs, Italy 3300 lbs, Japan, 3040 lbs and Egypt 2783 lbs per acre.

The yield of cotton lint in India is 87 lbs. per acre, in America 158 lbs in Japan 181 lbs, and in Egypt 371 lbs.

WHILST FOR SUGAR THE FOLLOWING COMPARATIVE RETURNS ARE :-

India 2,400 lbs per acre, Japan 3,340 lbs, Egypt 3,378 lbs. Java 11,988 lbs and Hawaii 18,799 lbs.

These typical crops serve to show the low standard of cultivation prevalent in India as compared with other countries.

Food crops on the whole cover nearly 82% of the total cultivated land of the country, and in spite of their immense internal consumption they contribute from 13 to 14% of India's overseas trade.

Spices such as pepper, ginger, cardamom, and cinamon are exported to the value of Rs. 1,50,00,000 per annum.

## INDIA'S COTTON CROP.

In 1930–31 when the world's production of cotton was 27,000,000 bales, India's contribution rose to 19% (nearly 5,000,000 bales). But the progress made by India is not merely confined to the quantity produced; a real valuable improvement has, during the past few years, been made in the quality of the material, and this coupled with the increased production, has nearly doubled the value of India's crop in the past twenty years. In normal times India's output averages about 6,000,000 bales of the value of over Rs. 13,50,000,000.

Time was when certain objections were justly raised against Indian cotton, the principal one being the shortness of the staple.

During the past twenty years India has made such rapid strides in the production of improved cotton, however, that these objections no longer hold good. India now produces at least $1\frac{1}{2}$ million bales (or nearly one-third of total crop) which is of seven-eighth staple and above.

The Indian cotton crop for the season 1937–38 given below refers to the entire cotton area of India and deals with both the early and late crops of the season :—

| Trade Description | Area (thousand acres) | Yield (thousand bales of 400 lbs. each.) |
|---|---|---|
| Oomras | 10,676 | 1,802 |
| Bengal–Sind | 3,832 | 1,267 |
| Dholleras | 2,532 | 484 |
| Broach | 1,464 | 360 |
| American | 2,425 | 931 |
| Others | 4,654 | 819 |
| Total .. | 25,583 | 5,663 |

Indian cotton crop for the season 1938–39.

| Trade Description | Area (thousand acres) | Yield (thousand bales of 400 lbs. each.) |
|---|---|---|
| Oomras | 9,836 | 1,558 |
| Bengals | 3,402 | 1,032 |
| Dholleras | 2,254 | 344 |
| Broach | 1,419 | 399 |
| Americans | 2,444 | 1,031 |
| Others | 4,198 | 756 |
| All India | 23,553 | 5,120 |

Indian Cotton Crop for the season 1940–41

| TRADE DESCRIPTION | AREA (thousand acres) | YIELD (thousand bales of 400 lbs. each.) |
|---|---|---|
| Oomras | 6,595 | 1,410 |
| Bengals | 2,807 | 1,127 |
| Dholleras | 2,047 | 321 |
| Broach | 889 | 245 |
| American | 2,496 | 1,079 |
| Others | 7,287 | 1,290 |
| All India | 22,775 | 5,638 |

## Raw Cotton Markets.

**Below is a list of the world's principal raw cotton ports:—**

Belgium............................Antwerp.
China..............................Shanghai.
England ...........................Liverpool and Manchester.
Egypt .............................Alexandria.
France ............................Le Havre.
Germany ...........................Bremen.
Holland ...........................Amsterdam.
India .............................Bombay.
U. S. A............................ New York. Orleans. Houstan. Galveston. Charleś Town.

## Imports of Raw Cotton into India.

| Year (April to Mar.) | U. S. A. | | Egypt | | Kenya. | | Total. | |
|---|---|---|---|---|---|---|---|---|
| | Quantity Tons. | Value Rs. | Q. Tons. | Value Rs. | Q. Tons. | Value Rs. | Q. Tons. | Value Rs. |
| 1936–37 | 927 | 824 | 18,546 | 18,398 | 35,925 | 30,618 | 64,988 | 58,468 |
| 1937–38 | 29,186 | 22,101 | 28,404 | 28,349 | 47,702 | 42,361 | 134,451 | 121,287 |
| 1938–39 | 4,580 | 3,747 | 18,990 | 18,720 | 56,112 | 47,348 | 96,374 | 85,089 |

Value || in 000s of Rupees.

## Exports of Indian Raw Cotton to other Countries.

| Year (April to Mar.) | U. K. Quantity. Tons. | U. K. Value Rs. | Japan. Quantity Tons. | Japan. Value. Rs. | Total Quantity. Tons. | Total Value. Rs. |
|---|---|---|---|---|---|---|
| 1936–37 | 114,447 | 63,350 | 433,228 | 254,117 | 962,133 | 444,098 |
| 1937–38 | 70,554 | 42,756 | 242,695 | 147,802 | 487,764 | 290,297 |
| 1938–39 | 73,379x | 35,458 | 216,301 | 112,736 | 482,658 | 238,589 |

x Excluding Burma. Value in 000s of Rupees.

## Imports of Cotton Piece Goods to British India.

The value of the import of piece goods was Rs. 16 crores in 1935–36, Rs. 13 crores in 1936–37. Rs. 11 crores in 1937–38, and Rs. 10 crores in 1938–39.

## Exports of Cotton Piece Goods from India.

| Year | Value in Rupees. |
|---|---|
| 1935–36 | 2,02,94,908 |
| 1936–37 | 26,328,120 |
| 1937–38 | 650,032,288 |
| 1938–39 | 47,937,890 |

India used to have a large market for yarn in China and a considerable market for piece goods in Africa and other countries of the Near East. The Chinese market for yarn was lost during the great war and a large proportion of the market for piece goods was lost from 1918–1929. The chief reason for the loss of piece goods market was the incursion of Japan. But since 1933–34 India has been gaining her trade outside India.

## The Imports of Cotton Piece Goods to British India.

| | |
|---|---|
| 1933–34 | 796 million yards. |
| Value | 1349 lakhs. |
| Imports into Calcutta .................... | 208 million yards. |
| ,, ,, Bombay .................... | 266 ,, ,, |
| ,, ,, Karachi .................... | 171 ,, ,, |
| ,, ,, Madras .................... | 71 ,, ,, |
| ,, ,, Rangoon .................... | 80 ,, ,, |
| | 796 ,, ,, |
| Total exports of Indian Cotton piecegoods | 56 million yards. |
| ,, Re-exports | 25 ,, ,, |

Imports of cotton piecegoods (grey unbleached, white bleached coloured, printed or dyed, fents) into India and the share of each province during 1933–34.

| | Quantity (yards) | Value (Rs.) |
|---|---|---|
| Bengal | 2,07,985,624 | 32,230,834 |
| Bombay | 2,65,805,374 | 44,370,056 |
| Sind | 1,71,161,055 | 28,880,233 |
| Madras | 70,609,014 | 13,592,603 |
| Burma | 80,157,652 | 15,850,931 |
| Total .. | 7,95,718,719 | 1,34,924,657 |

Exports of Indian cotton piece-goods (grey unbleached, white bleached, coloured, printed or dyed) to foreign countries and the share of each province during 1933–34.

| | Quantity (yards.) | Value (Rs.) |
|---|---|---|
| Bengal | 134,727 | 52,810 |
| Bombay | 35,637,972 | 81,30,932 |
| Sind | 557,467 | 1,17,371 |
| Madras | 20,130,940 | 83,28,579 |
| Burma | 42 | 34 |
| Total .. | 56,461,148 | 166,29,726 |

Re:–exports of cotton piece goods foreign merchandise (grey unbleached, white bleached, coloured, sprinted or dyed and fents) from India to other countries and the share of each province during 1933–34.

| | Quantity (yards) | Value (Rs.) |
|---|---|---|
| Bengal | 64,425 | 21,220 |
| Bombay | 23,538,437 | 50,12,196 |
| Sind | 491,236 | 1,20,632 |
| Madras | 90,541 | 22,970 |
| Burma | 599,967 | 1,51,695 |
| Total | 24,784,606 | 53,28,713 |

## Chapter III.

## "SPINNING WHEEL AND HAND LOOM."

India has to its credit the discovery of the use of cotton as fabric and the invention of appliances to obtain the finished article such as the spinning wheel and the hand loom which was in use prior to the Christian Era, that is about 600 B.C. Cotton cloths and Corded twine have been found during recent excavations at Mohenjo Daro in the valley of the Indus in Sind about 200 miles from Karachi and Available Archaelogical evidence places this civilisation round about 3000 B.C. This and other evidence show that the birth place of cotton textile manufacture was India, where it was conducted with primitive instruments.

In addition about 1840 there was an import of American cotton seed (with American planters to grow it) from which seed some of the American Varieties now in this country have been derived. American varieties, since that time; also been imported directly or indirectly and tried with varying success, one of the successes being Cambodia cotton imported from the French territory of that name.

### The Original Method of Weaving.

The first textiles were produced by means of the distaff (a long stick) with its wisp of cotton, from which the left fingers of the ancients detached the tiny fibres and twisted them into thread or yarn. In this way the early Hindoos prepared their fine calicos which are not surpassed in qality even by the product of our modern mills. Their labour, however, was slow, and a single loin or dhoty cloth might be a long time in the making.

### Hand Spinning and Hand Weaving in India.

A substantial part of the world's total output is still produced by hand Spinners and hand weavers, especially in India, China, Japan and the near east.

There is an enormous number of hand Spinning machines in India distributed over the country, and it has been estimated that there must be more than two million hand looms of all types, which are used to a large extent by the Agricultural classes when they are not engaged in their usual occupation between the seasons and it is second only to agriculture in importance. The handloom industry has for years withstood the onslaughts of capitalist organisation and though in recent years the rise of cotton mill industry has perforce brought the handloom industry to its knees. But it still exists and on the basis that each loom represents a family of four members, the handloom industry in India may be deemed to provide sustenance in part for as many as ten million people.

There are also large numbers of small power loom installations with about 6 to 24 looms, run by electric power where this is available, or by a small oil engine in the out-of-the-way Villages.

In some districts where there are large number of hand looms and small power looms installations, schemes are on foot to provide small modern installation of machinery to serve as centres for the preparation and supply of sized beams to the weavers, in order to obviate very crude method of beaming and sizing usually adopted.

## The First Cotton Mill.

The greater number of mills are to be found in Bombay and Ahmedabad cities. Though the first Indian cotton mill was opened at Fort Gloster near Calcutta, yet the import of coal from England facilitated the starting of the first cotton mill in Bombay city in the year 1851 and it was known as the Bombay Spinning and Weaving Company. Between 1851 and 1870 ten mills were started with an aggregate strength of 3,00,000 spindles and 4000 looms. These mills spun coarse yarn up to 20s generally for the China market and thus India captured from England the large bulk of yarn exports to China. The cloth that was manufactured was consumed in India. Nearly half of the yarn production was exported. During the last 30 years India has lost the China market almost entirely to Japan. This reached its peak in 1915, and has since steadily declined.

Steady progress was made by the Textile Industry from 1870 to 1899 thereafter it received a great impetus owing to the Swadeshi movement all over India as a result of the partition of Bengal.

Japan finding that China was producing sufficient for her own market followed the example of India in developing their weaving industry. India being one of the most important consuming centres of piece-goods in the world, Japan entered into competition with India in India's home market.

## Progress of Cotton Mill-Pre-War Period.

In the pre-war year of 1913, the Indian industry had a complement of 237 mills with a total of over 6.5 million spindles and 94,000 looms as compared against 9.8 million Spindles and 2,00,000 looms in 1936. The output of the industry at the time was 688 million pounds of yarn and 422 million yards of cloth at the beginning of the century. Thus even the beginning of the war period found the Indian industry a substantial one with crores of capital, mainly Indian, invested therein and affording work to over 244,000 persons. It had shown remarkable expansion since its inception and had undergone in its later stages a change from one based on spinning to one embracing weaving both of home-produced and imported yarn. Whereas Spindles had increased by 39 per cent looms had increased by 142 per cent and the ratio of Spindles to looms had fallen from 119 in 1898–9 to 68 per cent in 1912–13.

**Progress of Cotton Mills**.—*Post-war period.*

Even more rapid was the progress of the industry during the great war when the decline in imports assisted the progress of the industry, though advance was hampered by the difficulty of obtaining plant and equipment from abroad. By August 1918, the number of mills increased to 252 with over 6.6 million Spindles and 116,000 looms consuming over 2,085,000 bales of cotton. The progress in the post-war period, though, highly chequered, has been rapid. At the end of 1937, the total number of mills rose to as many as 370, the production of the yarn at the end of 1936–37 was 1054 million pounds against 807 million pounds in 1926–27 and 966 million pounds in 1931–32, that is, at the end of the Great Depression. Production of woven goods of all descriptions from 350 million pounds in 1918–19 to 359 million pounds in 1926–27; 672 million pounds in 1931–32 and 782 million pounds in 1936–37. Production during the six months April to September 1938 stood at 456.5 million pounds against 415.5 million pounds and 384.1 million pounds respectively in the corresponding periods of 1936 and 1937. The capital invested in the industry comes to over a hundred crores of rupees of which Indian capital is by far the bigger share. It absorbs slightly more than half the total production of Indian cotton. It affords employment to half-a-million workers directly and many more indirectly.

To-day, India ranks 6th in spindle capacity, 7th in the loom capacity and 4th in capacity of cotton consumption in the world. India manufactures about 10 per cent of world output of cotton yarn and about 10.7 per cent of the total volume of cotton piece goods and grows about 17.1 per cent of cotton. India ranks second in the world and first in the British Empire, as a producer of cotton.

Bombay stands the first centre of the cotton mill industry, though Ahmedabad is the biggest mill centre in the Presidency.

Out of 380 mills in India, Bengal possesses 28 with 4.6 per cent. of the total Indian looms and 4.1 per cent of total spindles. In 1937–38 Bengal produced 16.6 crore yards of cotton piece goods as against 408.4 crore yard produced in British India.

## Cotton Spinning and Manufacturing Mills working as on 31st August 1938

| Mills Situation. | No. of Mills | Number of Spindles installed. | Number of Looms installed | Average number of hands employed | Bales of 3½ cwts. approximately consumed. |
|---|---|---|---|---|---|
| Bombay city and Island | 69 | 29,06,202 | 67,294 | 1,18,993 | 10,36,992 |
| Ahmedabad | 78 | 19,42,286 | 47,147 | 74,279 | 5,63,288 |
| Rest of Bombay Presidency including Sind | 61 | 12,57,704 | 26,381 | 65,207 | 4,46,780 |
| Total | 208 | 61,06,192 | 1,40,822 | 2,58,479 | 20,47,060 |
| Rajputana | 6 | 88,524 | 2,134 | 4,267 | 53,832 |
| Berar | 4 | 66,904 | 1,393 | 3,982 | 39,981 |
| Central Provinces | 8 | 3,23,118 | 5,739 | 18,792 | 1,24,606 |
| Bihar and Orisa | 2 | 27,500 | 300 | 288 | |
| Hyderabad (N. Dominions) | 6 | 1,24,140 | 2,132 | 6,597 | 64,422 |
| Central India | 15 | 3,77,573 | 10,432 | 23,937 | 2,56,122 |
| Bengal Presidency | 28 | 4,15,012 | 9,388 | 16,514 | 1,47,442 |
| Punjab | 7 | 94,942 | 2,114 | 3,366 | 43,476 |
| Delhi Province | 6 | 1,07,976 | 3,028 | 5,497 | 75,644 |
| United Provinces | 25 | 7,35,662 | 11,831 | 29,266 | 3,00,332 |
| Madras Presidency (including Cochin) | 34 | 13,02,960 | 6,707 | 51,516 | 4,51,844 |
| Travancore | 1 | 12,000 | 300 | 590 | 3,470 |
| Mysore | 7 | 1,51,216 | 2,587 | 9,082 | 61,412 |
| Pondichery | 3 | 86,556 | 1,879 | 5,535 | 23,066 |
| | 380 | 1,00,20,275 | 2,00,286 | 4,37,690 | 36,92,709 |

## DEVELOPMENT OF POWER-DRIVEN TEXTILE MACHINES.

All weaving was done by 'hand' until just about one hundred and twenty five years ago. Power-driven textile machinery developed very rapidly during the latter half of the eighteenth century.

Remarkable progress has been made during the last few years on the wide field of the textile industry. The old familiar types of machinery have been greatly improved, and their output has been increased accordingly. Specially close attention is being devoted to the construction of machines and apparatus for the treatment and exploitation of the latest classes of fibre, particularly the various types of artificial silk and cell wool, and new designs and constructions are being evolved for the purpose.

### Succssful Power Machinery Neccessitates.

(*a*) Abundant and cheap fuel—such as coal or oil or Electricity.

(*b*) Abundant of soft water for steam-raising purposes sizing, washing, bleaching and dyeing etc.

(*c*) Efficient lubrication—to reduce friction and wear and tear, to increase speed, and production.

A textile manufacturer who neglects to attend to these essentials is giving something away to his competitors.

### THE POWER LOOM.

Though the power loom was constructed in 1784, power weaving did not become a practical success until the dressing frame was invented in 1803. The first to attempt to construct a mechanical loom was Leonardo da Vinci, born 1452. He designed a weaving machine to be driven by water.

The first really practical attempt to solve this problem was the production of the ribbon loom.

Dr. Edmund Cartwright, the English Clergyman and Writer, applied for his first patent for a mechanical loom in 1785. It was intended to be driven by water or other suitable power. He belonged to an old and highly respected family, he studied Theology at Oxford, and after taking Holy Orders accepted a Curacy. He began to interest himself in technical questions when about 41 years of age, and concentrated on weaving. He established a weaving mill at Doncaster in 1785 and 19 mechanical looms were installed, while the power was supplied by a Capstan drawn by oxen, and later on by a steam engine. In spite of all his efforts, his hope were not realised and he lost almost his entire fortune. His inventions did little else but rouse the resentment and enmity of the weavers whose condition at the time was anything but enviable

As soon as the idea of a mechanical loom had gained a certain amount of acceptance,' it was not long before several improvements were introduced, all for the purpose of simplifying the Cartwright loom. The Picking Tappet, for example, was introduced by Miller and Printfield which was followed by effecting the movement of the slay by means of a Crank. In 1796, Miller of Glasgow invented the warp protector, a device for stopping the loom as soon as the shuttle was caught in the shed.

Numerous inventions have served to bring the loom to its present state, the most important of them perhaps being Northrup Automatic loom, invented by an Englishman named James Northrup, but taken up and developed by an American firm.

## The Machine.

We, to-day, live in a era of machinery. Everything is being speeded up, massive output, large turnover is the order of the day. Let us, however, remember that the rhythm and speed of the machine can be such that no human being can work up and accommodate themselves to such speed or rhythm. The rhythm and speed of any machine must not exceed the possible rhythm and speed of the worker. The worker must be speeded up to the highest capacity attainable, and be kept at a high standard thoughout his working day. This can only be done by working a reasonable number of hours, with well arranged rest periods, and the human rhythm and speed can be further greatly helped by the timely of playing some well-known tunes on a good gramophone, the music having a swinging rhythm in tune with the human and machine corhythm. This sudden addition of music at well-arranged periods during the working day has very definite psychological effect upon the worker,and braces him or her up, and brings them back again into the general rhythm, thereby increasing output, in quantity and quality. Music introduced into the mills would pay. The writer has seen mills on the continent where music was played at intervals particularly in the warehouse or Folding Department. It has a very good effect on both the workers and the work.

## The Supply of Mechanical Appliances and Technical Skill.

For years to come, India will have to depend on foreign countries for the supply of mechanical appliances and technical skill to develop her industries. The textile industry is not an exception to this. As a matter of historical truth, industrialization has been possible in India, only after it was successful in the West. The industrial revolution in the latter half of the nineteenth century practically divided the world into two parts—the producing countries and the consuming countries. The latter exchanged foodstuffs and raw materials with the former which supplied finished products to markets abroad. The existence of large and unexplored markets considerably facilitated the growth of large scale production, and the increasing application of machinery to industry. The manufacturing countries have a natural advantage of experience brought down from generation to generation, experience of mechanical inventions which might be out of date every year being replaced by new ones by the process of trial and error. It is not therefore, possible for a country which is launching a Scheme of industrialization to begin from the beginning. It must gain from the experience of others who are already advanced in the field. Russia and Japan have come to the fore not by merely relying in their own resources but by importing foreign machinery to the economic limit possible for them. They have industrialized by the means and method which have been already in use in the manufacturing countries of to-day. It is true, however, that industrialization was possible in these two countries because other conditions were favourable. Russia had a large internal market and Japan had the Chinese market, which were unexplored by the Western Civilization. The cause of India is not of a different type. There is a large internal market which can reasonably grow in extent with the increase in the standard of living.

## Machine-Made Civilization.

It is strange that those who are the most bitter about the moral atrophy of the mechanical age are those who have never used their hands either for handicraft or for machinery. Most of those whose products are now made in a fraction of the time taken formerly have found new employment and new leisure to enjoy the higher wages that they now earn. There was real "bondage" in work before the machine came. Men, women, and children had to work for twelve or fifteen hours every day in order to earn the remuneration necessary to procure the bare essentials of living. If there were ten in a family they all had to work to gain a livelihood. Hands were the principal tools, and the power was mainly muscle. There were no free hours, and no agreeable freedom in the home for wives and children. Physical burdens of crushing weight had to be carried by shoulders that could barely support them. Disease and suffering were everywhere.

## Bondage was almost complete.

Then came the machine. Working hours were reduced without reduction in output, and the cheaper price of the article caused the volume to grow to a point where as many operatives were required as formerly. Wages were stepped up by leaps and bounds so that one member of the family could earn enough to support his dependants. Generations of children were given the freedom of childhood. Mothers were left free to make a home and a pleasant surrounding for their men-folk and their children. The operative were interested in his work, for he realized that every saving of time made in production rendered it possible to lower the price of the article, and he wanted to be able to own an article of his own production. Of course, there were owners who employed sweated labour and who consistently refused to pass on to the employed the fruits of their own efforts to speed up production. But there were many other enlightened owners who realized that the market which they wished to encourage was just that represented by their own employees. They were content to make a modest profit and to acquire the goodwill of their men, so that volume should provide their economies and hence their profits. These are the men who have made big money fairly and honestly, and who have shared prosperity with their staffs and expected their men to stand by them in less good times.

Then there are those who speak of 'Complexity' of the machinage. They hold that "machine-made civilization" has complicated men's lives, so that they no longer know good from evil, and are content only if they live in a perpetual state of excitement. In the first place, we have no "machine-made Civilization" what we have is "Civilization-made machines." The more man masters his environment, the better he makes machines to ease his toil and improve the quality of his work. His rise in intelligence may be charted by the tools he has created. They did not make him, nor do they rule him. Civilization is not produced by the machine but the machine by civilization. This is not a complex thing at all.

It moves ever towards greater simplicity, for the better the machine, the more simple it is. The modern mass-production factory which, dazzles the visitor is merely a long series of very simple operations connected in sequence with each other for a single purpose. Life is more filled because we crowd together and do more. It is noisier, but it is not more complex, except perhaps to those whose mental equipment has not become adjusted to modern methods. We go steadily on our way from a sense of complexity born of ignorance and confusion, to a sense of simplicity born of knowledge and confidence.

It is somewhat strange that the Eastern races never invented anything to superside the rude appliances in the arts of Spinning and Weaving although they attained a high degree of skill in their use

In remote times amongst the extinct civilization of Egypt, the production of cloth, elaborate in texture and artistic in design, was quite common, yet nothing mechanical of these races appears to have advanced in succesive stages as, for example, may be traced in almost every branch of industry in the West.

## The Importance of the City of Bombay.

The city of Bombay owes its origin to its geographical position and to its magnificient harbour, which gradually became a collecting centre for other ports on the West coast and for the relatively small strip of land between Ghats and the Sea.

Bombay thus receives a large quantity of country products of all kinds, of which by far the most important is Cotton. It lacks the advantages which Calcutta possesses in its proximity to the coal fields and in the river system of Bengal. The Stony, arid Deccan uplands, where the precarious rainfall will scarcely allow the thrifty Maratha farmer to hope for a good harvest even in one year out of two afford a marked contrast to the rich alluvial plains in Bengal—a land that has little to fear from the seasons but occasional floods.

The canal zones of the Punjab, with their secure crops of wheat and oil seeds, are intermixed with the desert plains of the 'barh' that yield hardly more than a scanty pasturage for camels or Cattles. Only a very few miles away from large and prosperous ports or busy mining districts are wide stretches of jungles or sandy deserts.

Bombay is actually a few hundred miles smaller than Bengal, it is very much smaller than Madras, and again smaller than the Punjab or the United Provinces. Bombay is also the least populated of the provinces quoted.

## Assistance From Lancashire.

Had it not been for the early assistance at a vital time of Lancashire technicians in the pioneer mills of Bombay, started by illustrious Indians, matters would never have been smooth sailing for laying the foundation stone of the present—day industry. Even to-day machinery from England form the largest part of the technical equipment of Indian Mills.

## Patch Work is Unwise.

Successful management will always have one aim in view, namely to make the machinery last some time after its original cost has been wiped out by depreciation, and, in doing so will always, at the same time, as far as possible, keep that machinery abreast of the times by the adoption of efficient mechanism within its working parts and not patch work, which is very unwise to practice. But on the other hand if the machinery and method are too old for the pace of modern times, they must be discarded to make way for the improvements that keep plants young and officiency at maximum.

With new men, come always new methods and often new manners, and it has been found necessary by all who desire to keep abreast of the times that these new methods should be studied and adopted. There is no branch of manufacture of which the cost has not been materially reduced by labour-saving machinery.

It is very strange to say that there are some people who imagine that labour—saving machinery is meant to save their jobs and their wages as well, and others think that they cannot afford it or make it pay. A Scientific researcher has the peculiar quality that he must be sceptical of everything.

## CHAPTER IV.

## "OWNERSHIP OF INDIAN MILLS."

Almost all the mills in India are generally owned by joint stock companies managed by managing agents, as they are termed.

It may be pointed out here that the cotton industry in India is composed of different units which do not act together in any particular except in their demand for protection. There is no common labour policy or wage policy, nor even a common sales policy. Both men and methods differ in a striking way each centre has its own characteristics.

### Joint Stock Companies.

In this class of business the capital is provided by a number often a large number of persons who are called the Shareholders. The management of such business is vested in a board of directors to control the general policy on behalf of the shareholders, delegating to the managing staff the executive work and general routine business of the Company.

### Mill Planning.

A mill should be of the proper economic size say 500 looms and 17500 spindles. When a mill reaches in size to abant 42000 spindles and 1200 looms it should be considered as a good paying unit.

An example for the purpose of giving an idea as to the cost of building a mill of the size of 10000 Spindles and 300 Looms.

| Cost of Plant. * | Rs. |
|---|---|
| 300 Looms with preparatory processes. .. .. .. | 1,36,000 |
| 10000 Spindles .. .. .. .. .. .. | 3,05,000 |
| Building .. .. .. .. .. .. .. | 1,70,000 |
| Land .. .. .. .. .. .. .. | 60,000 |
| Motors and accessories .. .. .. .. .. | 61,000 |
| Stores etc. .. .. .. .. .. .. .. | 21,000 |
| | 7,60,000 |

* The cost of a plant and manufacturing cost will vary as circumstances vary.

**Production can be realised.**

750 lbs. of 50s weft.
1812 bs. of 40s warp.
1120 pairs of dhoties or Sarees taking an average of 280 working looms per day.

### Expenses per Day.

| | Rs. |
|---|---|
| 28 Maunds of cotton at Rs. 30/- per maund .. | 840 |
| Manufacturing cost of 200 lbs of yarn .. .. | 375 |
| ,, ,, ,, 1120 pairs of Dhoties or Sarees | 280 |
| Sizing .. .. .. .. .. .. | 35 |
| | 1530 |

Rs. 1530 × 25 days = Rs. 38250 per month.
Depreciation = Rs. 2200

40,450

### Earning.

| | |
|---|---|
| 1120 pairs of Dhoties or Sarees at Rs. 2/1/- per pair.. | Rs. |
| Rs. 2310 × 25 (days in a month) .. .. .. | 57,750 |
| Surplus yarn .. .. .. .. .. .. .. | 2,800 |
| Waste .. .. .. .. .. .. .. | 635 |
| | 61,185 |
| Less expenses.. .. .. .. .. .. .. | 40,450 |
| Profit per month .. .. .. .. .. .. | 20,635 |

Profit per year 20635 × 12 = Rs. 2,48,820.

### Disadvantages of a small Mill.

It is well to remember that competition, both internal and external, is very keen in the cotton industry.

(1) Too small a mill stands at a disadvantage for the following reasons :—

(*a*) The purchase of raw materials, stores, fuel, and sale of finished goods.

(*b*) Small mills are bound to be inefficient, as they cannot maintain a properly trained and highly paid technical staff whereas a big mill can afford to pay high price for brains, for it gets back many times more than it pays.

(2) A merely spinning or Weaving mill will not be a paying proposition. Because in the case of the former it has to depend on the demand for yarn from hand loom weavers and in the case of the latter it will be under a handicap of buying its yarns from outside and thus pays profits to others, which will increase the cost of production of the finished goods.

(3) In planning a mill, particular attention should be given to the following factors :—

(*a*) **Selection of Site.**

The first thing is the selection of a suitable site for the mill. The spot selected should be such that there should be a railway station as near as possible with good roads and transport facilities. If possible and finance permits a railway siding should be brought into the mill compound, otherwise motor lorries either driven by petrol or crude oil or bullock carts should be used.

(*b*) **Site should be selected where labourers are in abundance.**

In the selection of a site proximity to villages is a consideration of vital importance, otherwise a labour colony close to the mills will have to be established either connected with the mill or a separate investment concern for the sake of economical running of the mill.

(*c*) **Extent of Land Required.**

It is best to buy a little more land than less in case the mill is eventually required to be extended. If additional land is to be bought after building of the mill, the adjoining owners of land will demand a very high or fancy price for it. Thirty to forty acres of land for a mill of the size mentioned above including space for building godowns, workshop, stores, latrine accomodation, tiffin sheds for labourers, office for managing agents, manager and his staff, well for water-supply, etc., will be ample.

**(d) Mill buildings should be built in accordance to local requirements and the factory act.**

There are several types to be selected from. The type depends upon the finance that can be spared for it. As far as possible a building with roofs of corrugated sheets should be avoided. Experts should be consulted with regard to building of mills and the arrangement of the machinery.

**(e) Materials for Construction.**

This again depends on local conditions and finance. The experts will be in a position to advice in this connection. False economy in the long run will cost a great deal more.

**(f) The use of Electrical Power.**

If any kind of electricity is used, then the factory should be near the generating plant.

**(g) Supply of good soft water.**

The supply of good soft water is not only essential but necessary and, there should be an ample quantity available.

**(h) Transport Facilities.**

Easy and cheap inland and outward transport facilities are absolutely necessary if low cost is the principal object.

**(i) Low cost of Living.**

For this purpose every facility should be afforded to the labourers by way of supplying to them cheap grains etc.

**(j) Sanitation.**

Satisfactory sanitation is very important factor that must not be lost sight of.

**(k) Suitability of Climatic Conditions.**

Too hot or too cold a climate will not be conducive for the successful working of a cotton Spinning and Weaving Mills and secure the maximum production, and if it has to be started under such conditions then cooling apparatus and humidification plants for modifying the heat and giving the required humidity will have to be installed, and for too cold conditions, steam or electrical heating will have to be adopted.

Therefore, as far as possible, the climatic conditions should be suitable for the mill industry. A temperature of about 70 to 80 degrees and a humidity of 60 to 70 per cent are best suited for getting the maximum results.

(4) "Particular Attention Should be Given to the Character of the Market."

A mill will be at an advantage if it produces goods which are in wide demand. Market for goods which have a restricted or special demand will not be so steady. An extensive and ready market for the finished goods ought to be near by.

(5) Great care should be taken in selecting and appointing the right kind of men in charge of the departments. The officers should have both theoretical and practical knowledge and long-standing experience.

## Nature of Building of Mills and other Facilities.

To get the best from man, the building must be spacious, well ventilated, having air, well-lighted, and having all the window space possible for giving admittance to the sun rays. It must be properly heated and the contained air should not have less than 70 per cent humidity. There should be proper lavatory accommodation, and a room should be set aside, and fully equipped, for cases of accident. Besides this every department should be provided independently with a first-aid box according to the number of hands employed in each department. The first-aid box should be entrusted to a man who is capable of dealing with minor accidents quickly and efficiently. It is best to train a jobber from each department by the mill doctor. The far-seeing employer who erects such a mill with all necessary facilities will recoup all his extra expenditure in increased output.

The Mills in India are built in the open, occupying a large compound with a garden which is not unusual to be found in several of the mills as land can be had in abundance, and very cheap too.

The mills in India compare favourably, as regards building Construction, modern machinery and up-to-date labour saving devices, with the mills in Lancashire, with the exception that there will be found more operatives engaged in India than in Lancashire for indentically the same size of a mill, the difference is 3 to 1.

The Indian Mills have a decided advantage over the cotton mills of Lancashire, in as much as they are practically self-contained. The raw cotton goes in at one door as is turned out at another door ready for the market. The conditions prevailing in Lancashire are very much different. The raw cotton is sent to Liverpool; from there it is sent to the Spinning mills, and then it is taken to the weaving sheds to be woven. After that it has to be taken to the finisher and then back to the shipper. As a consequence of their system the Indian Mills can deal with larger quantities of cloth, and deal with it more economically, as labour is cheap.

All weaving mills spin their own yarn and sell any surplus production. Besides, they bleach and dye their own yarn and cloth. There are very limited number of mills depending on spinning mills for their supply of yarn.

The Mill agents do not specialize in certain classes of goods as in Lancashire. The Mill Agent tries to manufacture everything that is going and the number of different looms is astounding. They start at perhaps, 24in. width and increase by stages of 4 in. to 72in. and in some cases to 100in., all in one Mill. Not only is there a great variety in widths but in style too. They have about one-half dobbies or dobbies on every loom in most Mills and about 25 per cent of Drop box looms.

In some of the mills in India to imitate the English Cloths they dye black the cotton in the raw state and then mixed with the white cotton in proportion of one to three or one to six.

## PUBLIC COMPANIES.

In the case of Public Companies, the incorporation is secured by filing with the Registrar the following :—

(1) Memorandum of Association.

(2) The Articles of Association, if there be any.

(3) Notice of the situation of the Registered Office of the Company.

(4) Consent of the Directors in writing to act as such Directors and in the case of a Company limited by Guarantor and not having a share capital, every director shall have either signed the memorandum for a number of shares not less than his qualification shares (if any) or signed and filed with the Registrar a contract in writing to take from the Company and pay for his qualification shares (if any).

(5) A list of persons who have consented to be directors.

(6) A declaration by an advocate, Attorney or Pleader entitled to appear before a high court who is engaged in the formation of a Company, or by a person named in the articles as a director, manager, or secretary of the company, of compliance with all or any of the said requirements.

After the grant of the certificate of incorporation, which in law makes the company a body corporate by the name mentioned in the memorandum, the company proceeds to ask for the subscription of its share from the public. It shall not, however, commence business or exercise its borrowing powers, unless it obtains a further certificate from the Registrar declaring that the company is entitled to commence business. The certificate will be granted on the following further requirements being fulfilled.

(*a*) Shares held subject to the payment of the whole amount thereof in cash have been allotted to an amount not less than the minimum subscription.

(*b*) Every director has paid for on each of the shares taken or contracted to be taken by him, and for which he is liable to pay in cash, a proportion equal to the proportion payable on application and allotment on the shares offered for public subscription, or in the case of a Company which does not issue a prospectus inviting the public to subscribes for its shares on the shares payable in cash.

(*c*) There has been filed with the Registrar a duly verified declaration, by the Secretary or one of the directors in the prescribed form, that the aforesaid conditions have been complied with and

(*d*) In the case of a company which does not issue a prospectus inviting the public to subscribe for its shares, there has been filed with the Registrar a statement in lieu of prospectus.

## "THE MEMORANDUM OF ASSOCIATION."

(1) The name of the Company (with the word "Limited") if it is going to be a limited company.

(2) The place of business of the company,

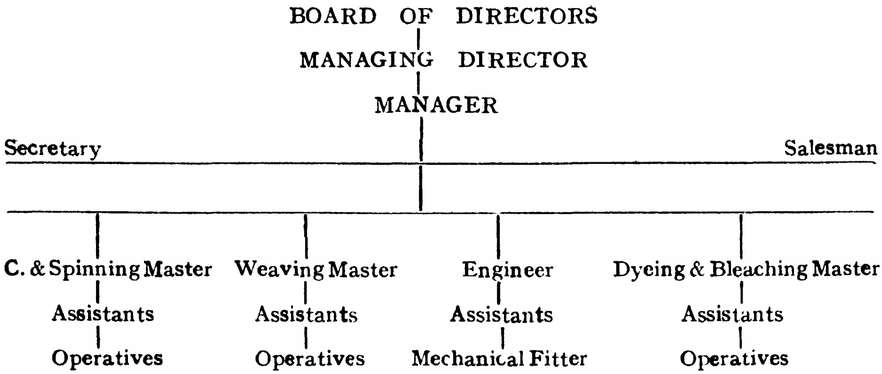
(3) The objects for which the company is formed—a clause which requires to be drafted with great care and ingenuity. This is because of all the documents one, which is the most difficult to be altered at Law, is the Memorandum of Association of a company and of all clauses of the Memorandum of Association, the clause which is the most difficult and inconvenient to be altered is this "objects" clause. This clause should include all the possible branches of business in which the company is likely to be engaged and these should be stated in all their details clearly and carefully, otherwise the Directors might find that they are unable to act on some important question because they have not the necessary power. In other words the action contemplated might be found to be ultra vires.

(4) The Company; whether the liability of the members is to be limited.

(5) The amount of Capital of the company, with its proposed division, if any into shares, classifying these shares under the headings of (*a*) cumulative Preference (*b*) Preference (*c*) Ordinary and (*d*) deferred and stating the amount which is to form the value of each of these shares. The Memorandum of Association has to be signed by at least seven members who are generally the directors of the company and each of these members has to state before his signature the number of shares he agrees to take up.

CHAPTER V.

# THE STAFF OF COTTON MILLS.




The board of Directors being the fountain head of the Company, and usually appointed by the body of shareholders, decides and controls its general policy and in its execution is assisted by one of its personnel, viz. the Managing Director. He in turn is indissolubly connected with his Works Manager and Departmental Heads. Their purpose is to ensure that production, quality and efficiency are maintained in accordance with the policy laid down by the board.

The commercial and statistical departments are usually under the control and responsibility of a secretary, assisted by a Head Clerk, Cashier, and Time-Keeper.

## The Proper Functions of Board of Directors.

(*a*) They should decide the general policy of the Company.

(*b*) They should decide the purpose and scope of the business.

(*c*) They should decide the form of organization and select the chief executives.

(*d*) They should study the progress of the company and judge the executives by results.

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 the knowledge is second hand and superficial. A wise board gives a free hand to a wise manager, and simply confines itself to the function of controlling the 'finance.'

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 knw.

## The Necessity for Organisation.

The constructive details of a sound manufacturing organisation begin from the laying of the first stone of the building, and reach to the delivery of the finished product. What are, therefore, the elements on which the successful prosecution of a manufacturing concern depend ?

(*a*) Does it depend on buying low and selling high ?

(*b*) Is it not a fact that greater profit, as a whole and lower cost per unit, bring greater business stability, because a lower selling price permits a wider market to be covered, and so lessen the effects of any local depression ?

(*c*) Is it not a fact that 'weak points' which demand immediate and closest attention, are to be found in every mill whether it is a new mill or old mill, or whether the former managers were clever or not ?

Now let us examine these questions and presume that the raw material was bought in the cheapest market, but it was not turned out in such a form as to be acceptable by those for whom it was turned out, in other words, by the consumer—for vogue, utility, quality, demand, and price. What is going to happen ? Why if the factory produces an article which is not in accordance with the liking or demand of the consumer both in quality and price, then of course, it stands to reason that the business instead of increasing it is bound to decrease and a "DECREASING BUSINESS" always needs a lot of "FINANCING." Therefore is it a wonder such a factory ending in a catastrophe ? Is it not clear as day light that it must either see a change or be closed down ? Similarly if any article is produced over and above the demand or requirement eventually it must depreciate. The prospect of a new sort must always be studied before it is undertaken to be manufactured on a very large scale. Bear in mind that every new sort has a period of demand and that period may be very limited too.

But on the other hand if a factory buys in the cheapest market and produces the articles in such a manner as to get to a system that will reduce production to a fine art by being conducted with a good management that does not only bring to bear on the whole but that every department is considered as a unit and is given in charge of capable hands who are thoroughly conversant with the practical details of the work of each department, that will enable them to trace the result of neglect, carelessness or bad workmanship and directly warn those who are responsible and thus be able to eliminate waste by bringing about an ECONOMY OF TIME, ENERGY and MONEY. It must be distinctly understood that the efficiency of the weaving depends on every item connected with it and it is exceedingly unfair to the operatives engaged in the actual weaving to expect them to attain the highest degree of efficiency when they receive unsuitable and very inferior materials from other departments. Therefore in the management of a cotton mill the main thing is to keep ahead with production and quality bearing in mind that both production and quality must be obtained with minimum cost.

The purpose of any industrial undertaking is to make a profit. The greater the profit the better the business can be insured against future contigencies. If no profit is made the shrinkage of capital involved must eventually force the cessation of activities. Capital, like labour, cannot afford to work without wages, and unless wages are forthcoming to all sections stoppage must ensue. Factory organisation, sales organisation buying organisation, the whole organisation of any business must be designed with the making of profit as the ultimate objective for the business as a unit. All divisional and sectional interests must be swept ruthlessly aside if full success for the undertaking is to be assured.

## Results Not Details.

The employer or the executive must be a strong and forceful man, as he has to direct the destiny of others and control their movements. To him the whole art of business should be one great game of skill and devotion, wholeheartedly honestly pursued. The personality of a mill agent or an employer or an executive is a part of his capital or asset and his chief possession. It can be his fortune or ruin, but one thing, it cannot do to play an indifferent part in his life. It must ever be the decisive factor.

The first and foremost principle the excecutive of a business concern should follow, is to divest himself of as much labour and responsibility for minor details as he possibly can. Because details of industry in their manipulative sense are well worth the study and attention of each one desirous of taking up the position of an executive or of managerial duties, to enable him to get a thorough grasp of the business and to realise the merits and demerits of the many problems which arise, but when once that position is attained he should endeavour, as far as possible, to carry the big things in his head and the petty details in his pocket.

(*a*) Each operative in the firm high or low, should have laid out before him a clearly defined job or task.

(*b*) The task as set out for each man should as far as practicable, call for a full day's work.

(*c*) The remuneration must be adequate for the needs of the worker and his family.

The man who makes his business his hobby as well as his work, who is always planning out the details of his business campaign or field, who in time of business peace (prosperity) is preparing for business war (adversity) is the man who must be successful ultimately. Success is usually a matter of being better informed than one's neighbour.

## The Managing Agent or Managing Director.

The Managing Agents amongst whom there may be found a good few that have not in their life-time before assuming the "Managing Directorship" been or seen or worked in a cotton mill and hence in many instances for want of proper qualifications on the part of the Managing Agents (with very few exceptions) are the main cause of failures or the inefficient working of a mill which if carried on for a long time must naturally end in closing down or change hands. Because they have no intimate knowledge of the inside working of the mill and yet they indulge in the practice of purely buying the raw materials and selling the manufactured goods, without first qualifying or acquiring the necessary knowledge of the art of buying and selling. They are undoubtedly fortunate enough being backed by their wealth which may have been acquired by legacy or through speculation to be able to hold or control more than 60 per cent of the shares or be in a position to advance the money for the running of the mills at a rate of interest ruling at the time in the bank, or as the case may be.

One feature of interest is practised by some of the mill agents is, to invite from their friends and relatives money to be deposited in the firm as fixed deposit for a period of three months, six months, nine months, or twelve months. This is chiefly resorted to whenever sufficient money cannot be obtained from the banks against stocks etc. or some of the agents that are in a position even go so far as to advance the money to the firms out of their private wealth at an enhanced rate of interest.

It is a well-known fact that those that are chiefly of the Banya or Marwari class will do all they can to invest their money wherever they can get even ½% more of interest and thus they are attracted or drawn in by the Mill Agents that are in need of money. But after depositing the money they take jolly good care to watch that firm like a cat watching a rat.

The writer was well acquainted with one of the mills that paid over one lakh of rupees every year in the shape of interests to the fixed depositors and to the banks on sums that were borrowed whether the firm itself needed it or not. This amount alone made a difference of about half an anna per pound in the cost of production of the yarn on the wrong side.

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 speculative element or inefficient management was responsible for the failure of the concern.

A mill agent in India, unlike his brother agents outside India, is more industrious and capable in as much as he is able to divide his activities in various commercial undertakings.

The outstanding characteristics particularly of the Ahmedabad mill owners is their capacity for work. Their ideal is—work, and nothing else but work. In season and out of season, on Bank

Holidays and on Sundays one will invariably find them attending the mills twice a day; early arrivals in the mornings and late departures in the evenings are the habit with them. Wherever they may be whether at home or in a club, their chief topic of conversation would always be commerce interlinked with or affecting their own trade.

He (the managing agent) may be, beside being a mill agent, a broker, a commission agent, an insurance agent, a merchant, a store supplier, a proprietor of ginning factories, founderies, etc. etc. In short he acts as a master and not as a servant of the shareholders.

Besides, some of the managing agents are overburdened with numerous directorships plus multifarious public duties with a result that they find very little time to devote to their duties even to hold the board meetings which at times are held once a month, or two or three times a year.

Red tape or departmental procedure is of very little consequence to some of the agents or directors owing to their inquisitive, restless, hasty and nagging nature, which may be considered to be natural characteristic of some of them particularly where money matters are concerned. There is no such a thing as impossible or refusing a manufacturing offer or order which if they think is of an advantage to them in some shape or form. They venture to undertake it and to execute it although at times it may be beyond their capacity. In other words they have a great deal of speculative pluck or spirit in them and hence they do not mind for the consequences.

Accuracy, methodical system, promptness, and fineness of art are more often than not overlooked by them. In fact some of them go so far as to ignore them in favour of false economy.

## Allowance Drawn by Management.

It is a usual rule for the managing agents to draw a definite sum monthly as office allowance and a percentage of profits as commission which altogether may amount to about Rs. 1,00,000 to 1,50,000 according to the size of the mill and business put through.

## The Necessity of Personal Efforts.

A managing agent who desires the mills under him to be successful and well organized must be the brains of the whole concern.

He must be the nerve centre of the entire mechanism, and so responsive in his organism that he shall instantly feel any weakness or failure in any outlying branch of his business.

Industrial life to-day is fraught with intense perplexities, and their orderly solution depends to a large degree on the quality of industrial management. Good management involves units of policy uniformity of procedure, and consistency of practice. It welcomes new ideas, and rationalized experiments, and through intelligent anticipation prevents rather corrects inefficiency.

The highest efficiency in modern competitive business is not attained by centralized authority, but by personal efforts in co-operative team work.

## Concentration.

The power of cncentration depends in part upon inheritance and in part upon training, there is no royal method of training in concentration. It is in the main developed by repeated acts of attention upon the subject in hand. Concentration is practically impossible when the brain is fagged or the bodily condition is far below the normal in any respect. Even though the health be perfect and the attitude of attention be sustained the will is unable to retain concentration by an effort for more than a few seconds at a time. Employers are finding it in their interest to make concentration easy for their employees by rendering their work interesting that is making the work seem worth while.

"BUSINESS MUST BE CONDUCTED WITH CARE AND IN A STRAIGHTFORWARD MANNER."

It is indeed, incumbent upon those engaged or responsible in a manufacturing concern, to conduct it with care and in a straight forward manner, with perseverence and economy in order to make it productive and to assure success so that the business would stand on a lasting or sound foundation. Success comes only to those who know how to organize and supervise with self-reliance, intelligence and initiative courage, by conbining their experience and capacity to make the wheels of that organization to go round smoothly—and they go round profitably.

Raw material must be bought and finished article sold . This is a tremendous field of mental activity in itself. The raw material is an annual product, and unexpected climatic conditions or speculative activities may upset the most predetermined schemes in the management.

In an industrial concern no one who is not capable of controlling labour should be allowed to have anything to do with it.

The Indian cotton industry has for its competitors trained and experienced manufacturers of Lancashire and no less trained but even more enterprising manufacturers from Japan, this tremendous diversity in the conditions in the industry cannot but lessen its competitive power. The first thing for the Indian industry to do would therefore be to try and put its house in order and attempt at as much uniformity as regards the conditions of production and sale as possible.

## CHARACTER AND PERSONALITY MUST BE BUILT UP.

(1) There is no disgrace in honest failure. Anticipate failure and you will get it. Cultivate optinism and you will achieve it. The worries will vanish, the work will be done.

Any man who settles down to a life of resignation and endurance, who accepts his troubles and does nothing to overcome them, is a fatalist.

He is acting exactly like an Arab, who says when disaster overwhelms him—It is the will of Allah. In other words the man who is discouraged by his mistakes and by opposition—he is dulled. And the man who learns from both Success and Failures—he is Sharpened.

(2) Failures should be analysed and studied in details for finding ways and means for the future guidance. Failure itself is an absolutely necessary thing for the building of true success. Failures are needed to fit you for your final success. Mount higher. Don't fall back to the point from which you started.

The great men of civilization were those who fought the obstacles in their way. When their enemies jeered and tried to hold them back, they were not discouraged but pressed onward to the goal they believed to be right. Intellectually, these men were not always exceptional, but they persisted in the face of difficulties. They had the habit of persistence when adverse conditions twarted them.

Learn to spend your time wisely; invest it carefully. The more you economise the time the more returns you will have. Do not spend your time in fretting but in doing. Work hard but very judiciously. Hard work will never kill you.

No branch of "Science" is more useful than the knowledge of 'men.' It is of the utmost importance to be able to decide wisely, not only whom you can trust, and whom you cannot, but how far, and in what you can trust them. This is by no means easy as each man has his own peculiarities. It is most important to choose well those who are to work with you, and under you, to put the square man in the square hole, and the round man in the round hole.

(3) Well conducted business enterprises cannot fail to return a profit, but profit must and inevitably come as a result or reward for good service. Work for success, and believe that you will achieve it and you will win.

(4) Buying and selling cash is a very good policy in business.

(5) Both a manufacturer, and an employee should entirely refrain from disastrous temptation of gambling and speculations.

(6) The temptation of buying too much ahead of immediate requirements results more often than not in more loss than profit. Because :—

(*a*) Consumption varies according to the price, quality, demand, and supply.

(*b*) Nobody knows or can figure out what future consumption will amount to, as it depends on the buying power that may be in force at the time, the life of which depends also on the purchasing power that may be in force at the time, whether the rise or fall is sentimental, speculative or natural, or due to unforseen circumstances.

(7) Wastage which is the outcome of indifference or lack of knowledge is one of the greatest items to be watched daily, very keenly too, throughout a business trade or factory.

Never waste anything, but above all, never waste time. To-day comes but once and never returns.

(8) The most important endowment of an executive is the power to analyse the fundamentals of any business, to weigh them accurately, correlate them properly and guide the activities of the

business on the proper basis. If he has facts without will-power, he will not go far; and if he has will-power without facts, he will go in the wrong direction. The prosperity of business chiefly depends on facts and will-power.

(9) There are many business people to-day who are busy and who are growing poor by it, merely because they have their eyes on the meagre credit and not on the expanding or growing debit side of the ledger.

(10) The basic motive of commerce is gain, the stimulus behind individual enterprise is profit. But keen competition with a view to outstrip, competitors and to overload the business with unnecessary and positively avoidable superfluous expenses will not arise for its master that happy smilling financial position.

Sit down and analyse your business periodically. Find out its faults. Be critical and harsh in your analysis and ask yourself the following questions :—

**Points for Analysis.**

(1) Does the trouble lie in my buying ?

(2) Does the trouble lie in my selling ?

(3) Does the trouble lie with any unnecessary expenditure or extravagance somewhere ?

(4) Have the overhead and selling expenses increased ?

(5) Do I know what is actually being done in my firm ?

(6) Do I control my firm or is it running along in a way of its own ?

There are two ways to learn—from the winners and from the losers. The winners teach us 'What to Do' and the losers teach us 'What Not to Do.'

**The "Main Function of a Business Executive."**

(1) Be thoroughly acquainted with, and personally handle, all possible details of the business.

(2) Be thoroughly acquainted with details, but entrust them to the assistants for attention.

(3) Establish general policies and plans and entrust the operations to subordinates.

(4) Establish policies and find out new methods and give them to subordinates for execution.

(5) Give each subordinate definite duties to perform and see that he carries them out efficiently.

## REASONS FOR BUSINESS LOSSES.

(1) Obsolete and defective equipment.

(2) Needless depreciation, or wear and tear.

(3) Ill-health, absentism and fatigue.

(4) Lack of co-operation, discipline, knowledge and experience.

## REASONS FOR FAILURE.

(1) Inadequate and unreliable statistics.

(2) Capital and labour wastage on insignificant matters.

(3) The undervaluing of effective leadership.

(4) The retention of out-of-date and inefficient plant and employees.

(5) Imperfect understanding of human element.

(6) The fear of spending capital.

(7) Poverty of ideas.

(8) Inadequate remuneration of employees.

(9) Lack of ambition.

(10) Periodical Depression in trade.

(11) Not complying with the requirements varying with the seasons.

(12) Restricted output and slow rate of working.

## "HOW TO TURN LOSS INTO PROFIT."

Turning of loss into profit is best done by cutting down some form of expense, which is an 'Evil'; that must be brought under control. If possible and certainly the right procedure to tackle the evil is to get the cost down by "Better Management", "Better Raw Materials" purchased in the cheapest market and up-to-date 'Labour-saving Machinery', so that it will enable the manufacturer to bring down the selling price to the buying power ruling at the time with the least possible expenditure of capital and minimum labour.

But also bear in mind that the commercial demand for a product, coupled with a shortage of same, invariably whets the inventive genious of a man to create by science or to discover new sources of supply.

Inventiveness cannot be stopped or stamped out by merely closing one's eyes to its presence in this as well as in other countries. There is no limit to what man's mind can device and accomplish to reduce human labour, to satisfy human needs, and in general to make more of this world's goods available to an ever greater proportion of the population, if man is left to work out his own destiny.

## Quality of Work Must Not Be Lowered.

The work of a textile man is made up of a multitude of small things and intricacies, therefore to build a great business those responsible for its destiny must have for its policy a love of the highest standard of craftsmanship. Such aspirations make it impossible for any one from the directors of the board to the youngest apprentice to do less than his best. There must be the courage to decline business offered at a price which if accepted, would result in the quality of work being lowered.

## Business Phrases.

In business one should never use such slack phrases as "very good", "very bad", "quite satisfactory", etc. The proper way to Communicate the condition of the business is to say that the production is five per cent up. The waste is two per cent down. Four machines have broken down. Two can be repaired and one cannot. The working cost in the weaving department has gone down by three per cent and so on. In this way one is able to create a standard for the purpose of comparison. To create a standard one must be in possession of Quick, Reliable, Complete and accurate records which must be fresh and not months old. Knowledge comes first and then Control. It is no use to exercise control without knowledge. A well-managed firm is governed by knowledge, rather than by authority. It must want to know the unpleasant facts and the wrong methods. No Managing Director should deceive himself or allow his Manager and employees to deceive him. The welfare of the firm—that must come above all else.

## A Man's word must be his Bond.

Commercial breach of promise is of daily occurrence amongst business people in India as they trust one another to a great extent and hence if there is any thing that has to be put down in black and white, it is done rather very cautiously and if possible they try to defer it for several days with an object to study its advantages and disadvantages before execution, and if executed, it is done very carefully in respect of the terms whether a loophole exists in them or not, which might enable them to get out of the bindings if they desired to do so.

On the contrary a man's word on "The Royal Exchange" (Manchester) is his bond. These contracts, purchasing and selling cloth averaging thousands of pounds per day, are all made by word of mouth, and yet there has never been a breach of this wonderful system, which can boldly be asserted.

## THINK WELL BEFORE MAKING A CHANGE.

The managing agents appoint a manager who is both responsible to the head office and the working of the mills and with his approval more often than not the other officers are appointed such as carding, spinning, weaving master for their respective departments under the control or supervision of the Manager.

Often enough many of the officers are combined and it may be found, the manager acting as carder and spinner with a weaving master and engineer, or a weaving master officiating as a manager as well as with the other officials separate.

The main principle to observe is that each person should have his authority and responsibility well defined, so that overlapping of duties does not occur. Provision has to be made for fullest co-ordination and liaison.

There must be a definite division of responsibility, so that in the event of any duties being improperly performed or neglected, there may be no uncertainty as to who is at fault.

In a cotton mill every workman is in a responsible position; intelligence must be exercised in the performance of their duties, and as a multitude of responsible units is created. For purposes of organisation and discipline this force is split up into section, 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.

All clerical work should, as soon as possible after its performance be checked by the head clerk or some such person particularly appointed for the purpose of checking the daily work before the close of each day.

From time to time–as far as possible, not at fixed intervals and not after previous notice–the duties of various members of the clerical staff should be changed, so that, if there are any irregularities in the books, they will in the absence of collusion, be discovered by the person succeeding to the duties of that department.

It is absolutely necessary that wisdom should be exercised in making appointments of officials whose character and abilities must be read correctly, so that the problem of getting the right man to do the right thing in the right manner may be solved in advance.

To be an accurate judge of character is a great asset. It is, of course, essential to secure the good-will of the staff generally, and while some men have this gift others antagonise those who should support them. It is almost inevitable that, however, efficient a manager may be–and sometimes because of it–he makes enemies, for in the course of reformation or development some one must suffer–some 'corns' must be trodden on–along the path to success.

*A good principle to bear in mind is that while it is easy to make changes it is not always easy to make improvements.*

## NEPOTISM.

The selection of the staff who start on a modest scale, should be made with care and impartially. Ability alone should be the guiding factor, and family influence as well as considerations based purely on racial or caste feelings should be strictly and rigidly avoided. Many a good business has been ruined when nepotism is resorted to. The old saying that "blood is thicker than water is really a potent destroyer of good business." It is a fact, blood is thicker than water. We love our relatives, we like our friends, and we are going to do the best we can for all of them, with the result that we put men in positions because they are the sons of our friends and the sons of our relatives rather than because they are fitted by nature or experience to assume responsibilities in the best possible way. Bear in mind that the potential qualities for success can only be developed by education and experience and that technical knowledge and business abilities are two distinct qualifications. The technical expert should strictly keep himself within the limits of factory management, whereas, the business specialist should be left a free hand in connection with his office work and finance. Both should however, co-operate by an exchange of views in order to bring about the most successful result.

*The best way to understand man's mind is to approach it through a study of what man does; the activities that we can observe or measure.*

## Point out a Mistake, When Necessary.

It doesn't matter if a mistake, a glaring mistake, has been made; notice it, mention it only if you have to; but in a way that encourages rather than discourages the person concerned. If you never criticise the action of another to him or her or anyone else, no matter how you may feel about it, then you are fairly certain of avoiding the making of very many enemies; you will save yourself much worry. Furthermore, not to do so, you will find is more "power to your elbow." Such reticence is significant of strength.

## Any Argument is a Curse.

Learn to play up to all and sundry whom you meet. Make careful preparation in your mind for every meeting; emphsise, by word and deed, his or her importance, and, in so far as you may be able, seek to avoid flattery. Never make a comparison unless it be to prove the superiority in a specific something of one with whom what they state is wide of the mark from the point of view of fact—agree to it: and if and when another should attempt to prove them wrong, still tactfully try to prevent them from clashing broadside on: prove them both right if you can. Life is too short to waste time on useless argument; what does it matter who is right?—any argument is a curse, so steer clear of it. Get into the habit of never stating anything as the fact: dont be absolutely convinced about anything, for in that way you are inciting others to argue with you; let your line be more that you were informed as it was so and so, rather than that you are certain it is. If what you hear at any time is contrary to fact, never give a flat contradiction to any statement made: You can find a way round it, if indeed you have to comment on it.

## The Value of Opinions.

Practically every man, no doubt, has a few valuable opinions. An old Shepherd's opinion about sheep would surely be worth knowing.

But his opinions about Industry and Finance would not be worth an Anna. An opinion can be formed wholly by prejudice, without any knowledge behind it at all. No matter how little a man know about a subject, you will notice that he always has an opinion on it, sometimes a very strong opinion. Ignorance creates more opinions than knowledge—that is a big fact to bear in mind.

*Opinions are created by fears, desires, dislikes, envy, laziness, imagination—by all manxer of causes.*

When a Scientist sets out to study a subject, he disregards all opinions. He looks for facts. So should everyone who holds a responsible position be it a Managing Director or a Manager should look for 'Facts' and not 'Opinions.'

To find out facts is not an easy matter. And when the facts are found they are usually not pleasant to know. Consequently, there is a vast amount of self-deception, and people are content to hold fast to opinions that have very little value.

Any business man who really wants to know how his business or the business under his control is progressing should now and then have a try-out.

He should, for instance, investigate thoroughly and independently on the amount of wastage in his business, and then perhaps he will be surprised at the results he obtains. The results may not please him but they are sure to help him to add to his profits.

## Officers Must Be Given a Fair Chance.

One of the most detrimental defects that will be found most prominent in some mills is that the propriertors have no confidence in the integrity of the manager or any departmental officer whom they may appoint to take charge of their mills particularly to bring about an improvément, to increase the efficiency and to reduce cost. They will not give him a free hand to do his business which he alone can understand than any explanation of them can possibly convey. They will keep so many men to watch him, and insist on his consulting them on even a very trifle matter though they themselves (barring very few) have very scanty knowledge of cotton manufacturing and even the manager may not derive any satisfaction by falling in within all their wishes, because when difficulties arise, he will be pushed from post to pillar, when he sees Mr. A, he will be referred to Mr. B., and Mr. B., Will ask him to consult Mr. C, and so on.

The results of the departments are mainly the concern of the executive. If they are not satisfactory the departmental details will provide the cause which can be removed. If they are satisfactory it is obviously sheer waste of time for an executive to doubt or worry the officer who is minding his duties to the best of his abilities.

Every executive must remember that 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.

## INDICATOR FOR DIRECTING THE OPERATION OF WORKPEOPLE.

It is the controlling force of the daily work of the plant that provides the indicator which enables the executive to keep in touch with the working of every section and show immediately when any details have gone wrong. Just as the Chief Engineer can stand at the switch-board of the huge electric power plant and direct with unerring accuracy the handling of tremendous amount of electrical energy over hundreds of square miles of territory, so the executive of the manufacturing business can sit at his desk and by means of his indicators must be able to direct the operation of thousands of workmen who have the handling of the operations of an enormous plant. It is also necessary that he should keep in touch at the same time personally with every important detail that may go wrong. Can ever a well organised and honest concern come to grief? Never.

On the other hand there is nothing to stop it from progressing and expanding. Presuming a question may arise thus; What about keen competition, trade depression etc.

The answer is........Remember, every depression in a trade is a warning to the manufacturer to put more brains into his business and find out the real cause of the issue and not allow himself to be misled by fictitious or unreliable reports or whims, and worse still tamper with wage reduction of the employees if not justified. An advance in wages can only be allowed if there is an equal increase in production or efficiency otherwise it cannot be maintained for a long time. Every payment that is going to be made to the piece worker should be tallied with the production and the payment to the fixed wage operatives should be compared monthly or fortnightly with the sanctioned scale.

## Slackness on the Part of the Manager Must be Watched.

When business prosperity is at its peak, jobs are plentiful and labourers are in demand. The workers soon realize that the manager is optimistic and will not demand the maximum limit of the worker's energies. Workmen also know that the discharged employee can obtain a job elsewhere. Labour, then, becomes less and less productive, until after the peak of the cycle is reached, after which, jobs become scarce and each worker must be exceptionally productive in order to hold the job.

## SPECIALISATION *Vs.* GENERAL KNOWLEDGE.

Specialisation within certain limits, and in certain branches of work, has no doubt proved to be the most advantageous from the point of view of efficiency, but there are other employments where the zeal for specialization may be carried too far.

"Specialization in any kind of pursuit has the tendency to limit the outlook in breadth while increasing it in depth."

In other words a specialist no doubt acquires a deep knowledge of his own branch of human activity, but outside its limits he is a mere child. The results is that the specialist can only be used as a component part of a large organisation, working and co-operating in that work with his brother specialists in other departments, but all of them have to be directed and guided by a master mind at the head of the organization who has acquired a sort of a "specialised" knowledge of general affairs."

The specialist efficiently assists the general Manager with the practical solution of the problems set before him, but he is incapable of creating ideas as far as the directing of the whole organization is concerned. This must be done by a mind well enough equipped with general knowledge of human affairs to construct with a sufficiently broad understanding of the relations of the different branches of human affairs, the plan upon which the operating problems are based. It is for this reason that many of the most successful merchants have been found among those who were not specialists in anything except the broad interests in humanity and buying and selling, but who because of this broad knowledge could direct the work of the specialists in any particular line so that the greatest efficiency could be secured out of the whole plan.

Commercial affairs of today dealing with enormous masses of employees with trade extending over the whole world, with activities of scores of sciences and inumerable details of practice, are demanding more and more not the detailed information along, single narrow lines possessed by the specialist, but the broad general information which permits of a view point properly proportioned with due consideration of the prospective."

*Dip into the future as far as human eye can see and construct a vision of the days to come and of conditions which are not yet Existent. The function of constructive Imagination is to Realise and Depict what is not present to the sight or the Outside World.*

## The Man who Hesitates is Lost.

'Will Power' is no mean equipment. It is not merely necessary for the successful management or manager to be able to make up his 'mind' as the saying goes; having made it up, it is equally important that he should be mentally strong enough to adhere to, and to carry out his decision. The adage, The "man who hesitates is lost," is more true in business life than in almost any other sphere. Decision and firmness should be twin qualities, and, in management, a decision should not be arrived at without due consideration of all the factors of the situation. When a decision has been given, it should be altered only when proved to be wrong by actual experience. It is better thus to buy experience once than to shake the confidence of the staff by constant changes of decision, reversals of policy, and the incessant alteration of arrangements before there has been a fair opportunity of testing what results will be brought forth.

'Adaptability' is a useful power in business life—not merely adaptability in dealing with one's fellows, but adaptability in connection with business methods. How often do we see men turn out business failures for no other reason than that they will not, or cannot adapt themselves to those with whom they are brought into business relationships, or will not change their methods to suit alterations made necessary by competition or other influences? Many fortunes have been made by men who have set out upon certain lines, and have adapted themselves or their business to some changed condition which they have been quick to notice and to fall in with.

## The Human Element in the Textile Industry.

Industrial efficiency is primarily dependent upon the selection of suitable operatives for different industrial tasks. Perfect work cannot be obtained from an imperfect machine, neither can an operative deficient in essential abilities be expected to attain a high standard of quantity and quality in his or her results. The necessity for selection is based upon the existence of individual differences in capacity and capabilities.

It is comparatively easy to determine the most suitable height, reach or degree of strength required by different machinery and to select the operatives on the basis of these considerations, but in the textile industry such simple, but important considerations are almost entirely ignored.

The selection of operatives assumes, of course, an excess of supply over demand, and since at present such a state of affairs does not exist in the textile industry, the possibilities of adopting this method are considerably reduced. It does not follow however, that a comprehensive process of selection will never be possible.

Having selected, whenever possible those workers who are likely to develop into efficient operatives the next step is obviously to train the selected operatives in the best methods of work.

## HOW TO STIMULATE BUSINESS.

Definite decision, initiative, wide vision, common sense, untiring energy, discipline, observation with concentration, experience, capacity, accuracy, patience, keen perception, foresight, honesty, tacts, reliable records and efficiency–all these go hand in hand to stimulate a business. It has to be borne in mind that the introduction of methods such as character of drives, air condition, light, power plant, arrangements of departments with regard to labour saving facilities etc. which will make the machinery already installed operate more efficiently is just as good as building a new mill.

But bear in mind that an old thing is not necessarily valuable because it is old. Neither is a new thing necessarily valuable because it is new. One must "prove all things"; hold fast that which is good. Every new or old idea and method must be studied and weighed and then it should be decided which should be used and which should be rejected.

A business is like a pond of water unless fresh water runs into it, it will eventually become stagnant and poisonous. A man may lose his life by drinking obsolete water, and he may lose his business by holding fast to obsolete ideas. There must be, at least every now and then, a new element in both water and thought. To always think the same thing is not to think at all. And to do always the same things in the same way is to be out of touch with the changing world of to-day. To be keen to learn, to remain simple and teachable, that is what pushes a man to the front in any trade or industry. Initiative is a priceless asset to any business or firm.

## "WHY AND WHEN TO INVEST ON NEW MACHINERY."

It is impossible to sell the manufactured goods at a competitive price if the machinery is old and inefficient, thus rendering production costs too high. Consequently the pioneer mills will not be able to compete with modern mills with better equipment, cheaper labour and lower taxes etc.

But bear in mind, however it may be desirable to make use of the most modern machinery to facilitate production and efficiency or economy in the textile mills, many factors must be carefully considered before installations can be made. It is necessary that the manufacturer should be convinced why and when it is profitable to invest on new plant and machinery.

## "A RESEARCH DEPARTMENT."

No progressive concern should ever be without a small department and a limited number of staff for the purpose of conducting or investigating a new idea with a view to put them into effect and thus be able to introduce, in the concern or works, improvements whether in materials, manufacturing processes or machinery.

Both men and equipment must be continually subjected to tests. When either is found lacking the necessary efficiency, to meet conditions they must and will be set aside for better models.

## "EXAMINE SCRAP BEFORE DESTRUCTION."

An executive, or director, or the manager should make it a regular habit of visiting the stores with a view to examine the quality and quantity of stores received, and the scraps should be kept under a strict supervision before they are destroyed. The scraps more often than not tell some good tales, which, if not taken notice of, may bring the firm within the reach of disastrous position.

A "System of Controlling Production."

Sales Dept Order

Buying Dept

Planning and Progress Dept

Store Room & Yarn Wherehouse — Work Distribution — Allocation to Machines, etc. — The Analysis and Costs

—Work Instructions

—Weft Warp. Winding Warping Healds and Reeds Beaming Weaving Dept.

Finishing Dept — Dyeing Dept — Caledering Dept — Inspecting and Wherehouse

## LOSS SUSTAINED BY A MANUFACTURER.

If a manufacturer were to spin yarn intended for weaving one count coarser than the nominal count then what will be the loss sustained in the weaving department? If 500 looms using 20's twisted weft at the rate of say 156,000 lbs per month and if each pound used is one count coarse, then the manufacturer is 156,000 hanks short, which is equal to 8,210 lbs. This at the rate of rupee one per pound means Rs. 8,210 clear loss per month. On the other hand, should the yarn be spun half a count finer, it will then be a clear gain of Rs. 8,805 per month. When the prices of commodities are falling throughout the world, competition becomes more and more keen, and, to maintain its trade, a manufacturing business must reduce its costs of production to a minimum. When demand is brisk and profits are more easily earned, this necessity is apt to be overlooked. But, whatever the state of trade, the manufacturer should seek the fullest reward of his enterprise, and this can be secured only by Vigilant control of all the expenses of production and selling waste and concealed losses must be eliminated, efficiency in every direction, must be developed. To achieve these ends, competent organisation, combined with an adequate system of control provided by efficient costing and cost accounts is imperative.

### HOW TO ELIMINATE WASTE.

Elimination of waste is particularly necessary in a weaving mill so that waste of EITHER TIME, LABOUR, MATERIAL AND CAPITAL may be reduced to a minimum, for whilst in some other trade a badly managed department only means a proportionate loss of profit; in cloth manufacture it may affect the whole for no single department is self-sustaining.

Today competion is much keener, accurate and precise costing methods have become a matter emphatically of great importance. To put it in a nut-shell, it amount to this that efficient organisation–"WORK" "WATCH" AND "SAVE"–is the switch-board of the business. Every bit of work must be analysed very carefully and supervised with as much strictness as possible. It is absolutely necessary to train and teach a worker the method of saving waste. Hence it is absolutely necessary to maintain a regular record of all kinds of wastage which must always be studied at a regular fixed period.

The writer has been in a weaving mill where the waste used to amount to over a lakh of rupees a year due to two factors, namely wrong type of shuttle tongue used and the weavers were not only not trained for the use of mule cops but they were constantly changing hands. By changing the shuttle tongues to the right sort and making the necessary adjustments in the loom, the waste was reduced by 50 per cent and the weavers were gradually trained for shuttling a cop in the right manner. Training of weavers must be persistent as it is not an easy job and the trainer must have a lot of patience.

### A Change is Inevitable.

A change in one form or other whether in ideas or methods or system or machinery is inevitable. It is essential for every executive to pay very close attention to all changes that take place from time to time. The executive that allows himself to be shut off from contact of new changes will one day find himself being overtaken unaware by a competitor who took notice very carefully and moved with the time and thus he may find himself at a great loss.

An executive may find it necessary to take action as follows :—

(*a*) Elimination of unprofitable lines.

(*b*) Study of market to discover probable demand or possibility of creating new uses for product.

(*c*) Consideration of a series of processes where such development is practicable.

(*d*) Research in respect of processes of manufacturing and distribution.

(*e*) Establishment of control of flow of work for the purpose of Co-ordinating all inter-related effort.

(*f*) Concentration as far as practicable.

## Experimental Changes Must be Made Judiciously.

Analysis naturally implies sectionalisation which must commence with a departmentalisation of the business. By separating the business into its main constituent parts, it is possible to watch clearly and closely the results of each of the section, and a close separation of main sections makes it possible to analyse the work of each thoroughly and efficiently treating each as a separate and distinct unit. All changes should be made very cautiously and should be well considered from all angles beforehand and analysed before they are introduced into the departments, and they must not be experimented on a large scale all at once, which may otherwise lead to a breakdown or dislocation of the operations of other or some of the departments or sections of a department. Experiments should not be allowed to interfere with the daily routine processes or work. They should be dealt with or handled quite independently and on their own merits.

## Mistakes Must be Paid for.

The manufacturer must so plan his records that they will keep him constantly informed of the progress in his business. Because these are as important as the practical part as incompetence in either division will often neutralise the best skill in the other. In the ordinary affairs of life one may be willing to admit that "to err is human.", but in business life to commit constant mistakes is to court disaster.

Many people fail to detect their own errors until they face the results. In every human being there are negative and positive qualities, and the only way to kill the negative elements is to so train the mind and care for the body that the human machine will turn out only good work.

All mistakes must be paid for by some one, and some mistakes mark the beginning of the end of many a man and many a firm. Not one of us can ever escape rewards and punishments. Sooner or later the consequences of what we do will overtake us. A man can do wrong or be foolish for a time and seem to profit by it. This will make him go too far, and then the consequences will catch him up.

## Dead or Excessive Stock.

Dead Stock, excessive Stock, Stock that has no Immediate use positively burden or add to the working cost which will enhance the cost price unnecessarily and thus retard the selling price which becomes exhorbitant from assuming a competitive position. Manufacturer should not commit nor tolerate the occurance of such mistakes which are certainly detrimental to the interest of the firm. Waste not, so there will be no cause for finding ways and means to get rid of it. Tons of money can be saved if the materials (such as stores, cotton, coal etc.) that enter the mills or factories as fresh purchases be subjected to a strict examination in regard to quantity and analysis for quality, suitability and adaptability etc., before they are allowed to be utilised in the departments. It is essential that each senior officer of every department should, with a keen interest, keep a clean record of the list of stores used in each of tha departments such as belting etc., and should submit a copy of his record with his remarks attached to it to his superior periodically.

The store room should be so systematised that the issues to the various departments should be made with the least possible delay. The jobber or the coolies should not be allowed to idle away their time in the store room.

The store-keeper must be an honest man. A monthly analysis of issues made to the various departments should be prepared monthly and also a comparative statement should be drawn up to enable the officers of the various departments and the Manager to mark out the items that were used in excess of the standard list.

The store stock must tally every month with the ledger and any shortage that may be found should be reported at once to the manager.

All articles that arrive in the mill premises must either be counted or weighed and should there be any shortage either in number or weight it must be reported immediately.

In order there should be less chance of loss by deterioration, breakage or other adverse factors, it is never advisable to buy more than it is actually required which can be done by purchasing a month or two months or even three months ahead according to the nature of the articles and facillities given by the suppliers so that the goods may arrive say a week or a fortnight before the complete exhaustion of the stock of its kind by written arrangement and a clause of penalty should be included in the agreement in case the goods are not supplied in time.

## Departmental Jealousy.

The habit of making the work secondary and the recognition primary is unfair to the work or industry. It encourages a peculiar kind of an ambition which is neither desirable nor productive. Opportunist subordinates should not be encouraged in their efforts to out do their brother officers. This sort of a game does not pay. It is absurd and should never be allowed. It may be an advantage for a short time. But eventually it will certainly do more harm than good. Friendliness and good feelings should be cultivated towards each other as far as possible. There is no element so destructive to efficiency and quality of goods as departmental jealousy.

The executive or the manager should resent a grovelling attitude on the part of an employee. Because there will be more time spent in walking, waiting and watching than working, and should this sort of a thing be of a daily occurrence then what time is left for looking after the work ?

The executive who conducts himself in an arbitrary and petty manner with his employees is likely to find that his employees will try to hide their dishonest or questionable acts far more than if he is open-minded and frank in his manner towards them.

## A Word of Warning.

Complaints at times received from few of the merchants when values have fallen, will not only be numerous but most exaggerated. The dealer will try his utmost to get some allowance to help to average his price. Really everything that can be wrong with the shipment of cloth will be wrong and the allowance asked for will be an astounding figure. But if one sticks up to them, it generally (unless, as sometimes is the case, their claim is genuine) boils down to such a trifle that it is obvious what they have been trying to do

## The Story of the Lad.

The reader might know the story of the little lad who after having been in the back-yard, went into the house and said: "Grandad, there's forty cats in our back-yard." "Nay" said his grandad "Not forty cats" Well there's thirty" said the lad "Nay not thirty" replied the old man. "Well, there's twenty", the lad. continued "Nay, not twenty" insisted grandad. "Well there's ten persisted the youngster. "Nay not ten," the old man still remarked. "Well, grandad, said the lad, there's our cat and another. "That tale, is a real example of boiling down" and if ever you are confronted with a tale or scandal, boil it down before you accept it or acknowledge it or act upon it.

## Practical Points for the Managing Director.

Too many Managers do not manage. They only issue orders. They neglect the first duty of a manager, which is to instruct. Routine must be built as carefully as a house is built.

The whole process in a factory or a mill or an office must be planned from above. Then the employees must be trained to do their jobs correctly. This is the only way whereby a right system can be established.

A Managing Director must create the right routine, but he in his daily work, should be as free from routine as possible.

Managing is never 'routine work'. It always means 'initiative'—'Constant improvements.'

In business, anyone may learn something from anybody. Authority alone does not take a man very far. A business man must ask questions. He must not be a "know–it–all." He must learn from books, from his own staff, and from other people.

A business is not as simple as most people think. It has as many parts as an engine. It fails often because of the breakdown of one part, just as an engine does. No one man has in his head all the abilities that are needed to make a business go.

The market value of a business depends upon the amount and the regularity of its profits. It is not the inventory that counts. It is the efficiency of the whole organization. It is the profit-making ability of the company.

The main duty of a Managing Director is to prove that he is one of the Efficient Few, who know how to make the business under his control pay reasonably well.

The managing Director is the pivot on which the whole Company turns. His responsibilities are tremendous. Thousands of Rupees are made or lost by his decisions. If the workers could only see the worries and difficulties that the Managing Agent has to face they would be much more reasonable. Also, if Shareholders could only be shown the daily problems of the Managing Director they would not be as unreasonable as they often are.

But Managing Directors must accept the responsibility for making dividends. They have the power and they must shoulder the blame when they fail. They cannot pass on the blame to the rank and file. Neither can they in most cases excuse themselves by pointing to bad trade conditions.

There may be big output and large sales and no profit at all. The Managing Agent must always think of the 'Efficiency' and the 'Percentage of Profit' he is making Monthly and it is also possible to find out roughly the profit that can be made each time a new quality is sold either based on pound, piece, or loom. Besides it is very wise and desirable to check periodically the profit that is made on the running sorts or qualities and thus this method of checking will enable the Managing Director to eliminate the losing quality or the one that is making the least profit and increase the manufacturing of qualities that are making reasonable profit within the average.

How much can be done in a year, in a month, in a day and what cost should be the constant points or factors in the mind of the Managing Director. A firm pays a certain price for 'time.' And the endless problem is to make a better use of this time.

The old way of increasing net profits was either to raise the prices or reduce the wages. But in the opinion of the writer that both of these ways are dangerous if there is no justification for them. If the prices are raised in absence of demand then the consumption is liable to fall. If the wages are reduced beyond reason the loyalty of the employees will be lost.

The right way is to employ able, aggressive and progressive officers and give them plenty of good materials and up to date machinery and leave them severely alone as long as the results are satisfactory. If ultimately it is found that the wages and salaries must be reduced then the right policy is to weed out the slackers.

A manager has a right to make his own mistakes. Perhaps he is right when he is said to be wrong. The test is the profit he makes each month and the total profit he makes at the end of the year.

Every manager should have complete authority, up to a point. He alone should deal with his work people. No one should give orders over his head. No person should be made subordinate to two or more persons.

Meddling with details is liable to bring a Managing Director and his firm into a state of nervous prostration. Managers and heads of departments should be allowed to manage their own groups as long as the results are good.

The administrator must survey the entire field of business. He must know the world; he must know men. To know the world he must study natural sciences. To know men he must study history and Government; philosophy and psychology; and the languages by which men express themselves, whether by word of mouth or by pen. Goethe, in a letter to friends said—what would have become of me, my dear children, had I not always consorted with wise competent people and learned from them ? Life is too short to learn much from one's own experiences. The Scientific way is first to learn what others have done and then to add to this knowledge by one's own experiences. It is not from books alone, but from living people that one must learn. Progress comes by going in advance of experience that is improving on passed experience.

Know-it-all does not go very far in the business world. He may know the old things, but he doesn't know the new things, and so he slips to the rear. Back of every great achievement in the business world, there have always been years of learning and experimenting.

Every business man should make tests once in a while, to see if his organization is as efficient as he believes it is. He believes for an instance that he has a good filing system, so he should call for three of last month's letters and see how long it takes to find them. He believes he has a safe stores system, so he should take Rs. 10

worth of stuff out of it and see if it is missed. He believes he is getting the best marketable price for his goods, so he should spend half a day in the market where his goods are sold noticing independently exactly what the merchants say and do with his goods. He should find out if the percentage of waste is decreasing.

Some employers surround themselves with "yes Sir" men. The main thing they require from their subordinates is obedience. They do not manage. They rule. They are well suited to be. Rajas and Maharajas; but they are not suited to be employers. If they say Blue is green, they expect their subordinates to say "yes." They regard contrary opinion as a personal insult. They control their firms by will-power, not by brains. Naturally, such men are not told the vital unpleasant facts. There is in their firm a process of hiding and covering up and making excuses. All down the line, there is a conspiracy of silence with regard to the things that go wrong.

Business is an obstacle to every ambitious man. Obstacles must be accepted as matter of course. A man cannot have confidence in himself until he has conquered at least a few of them. The more obstacles the less competition and the less competition, the more profits.

The practical way to solve a problem is to to disect it. It has known and unknown elements. There is always something that can be done at once. when part of the problem is solved, the rest becomes easier.

## Cause of Leaks and Losses.

(1) Is the contidion in your mill one of low costs (of materials) and high wages ? Or, Vice Versa ?

(2) (*a*) Are your employees, as a whole, contented ?

(*b*) Do they change hand very often ?

(*c*) The reason of constant changes.

(*d*) What are the grievances of the work people ?

(*e*) Who attends to grievances ?

(*f*) Who sees to Lighting, Ventilation, Meal—rooms, general comforts, etc.

(*g*) Do any of the conditions worry and harass the workers ?

(3) Do you, at intervals, find out and analyse for yourself the following and take such steps as to rectify the defects.

(a) Quality and cost of raw materials (b) who is responsible for the accuracy of testing the quality and the quantity received of raw materials.

(4) Method of stocking materials and percentage of wastage through pilfering, wrong weighment, and the time taken in issuing and carrying the articles to and from departments.

(5) Method of carrying materials to and from machinery and time wasted in doing so.

(6) The machine itself, its speed, arrangement, capacity and efficiency.

(7) Skill and Efficiency of operatives.

(8) Method of receiving, distributing to the various departments for executions and delivery of orders to the merchants and selling agents.

(9) Whether raw materials for the purpose of executing orders are available and sufficient to complete the orders in time. All accessaries, tools, etc. Should always be kept in readiness for the purpose of workers.

(10) (a) Is the work prearranged each day for the next 24 hours, and whether a next job is kept in readiness for each operation or gang? (b) Is due provision made against breakdowns of machinery?

(11) (a) Is there efficient contact between the employees and the management? (b) are the workers sufficiently encouraged to complain about anything that seems to be unreasonable?

(12) Are you satisfied with the output and quality?

(13) Are the workers trained in your mill for their jobs?

(14) Is the work of the operatives facilitated by their superiors?

(15) Do you get all of the available energy out of the fuel or power you buy?

(16) Are the various operations efficiently supervised in accordance to demand?

(17) (a) Are you manufacturing for stock or (b) against sale or (c) a combination of (a) and (b).

(18) Do the management issue orders direct to workers or through heads of the departments.

(19) How are the overhead charges distributed?

(20) Is idle time (of men or machines) ever included in overhead charges and what is the percentage of each department ?

(21) (*a*) How are the various departments divided up ? as regards sequence of operations ? (*b*) what is the nature of work and the number of operatives employed in each department (*c*) what is the productive capacity of each department ?
(*d*) what are the wages paid to them ? (*e*) How do the wages compare with the competitive mills ?

(22) (*a*) Do the officers think for themselves or do they rely on others ?

(*b*) Do the officers think deeply or quickly jump to conclusions

(*c*) Have they got progressive ideas ?

(*d*) Do they come forward with suggestions for improvements?

(23) (*a*) What are the basis of Costing ? (*b*) Are the cost reports prompt, reliable and comprehensive ? (*c*) what real use is made of cost statistics, and by whom ? (*d*) How about apportionment of establishment charges ? (*a*) Who looks after the establishment charges ?

(24) (*a*) Who is responsible for wastage and rejects both of raw materials and finished goods ? (*b*) Are the rejects examined now and again before they are delivered by a responsible officer to see whether they are really 100% rejects.

(25) (*a*) Who is responsible for the accuracy of deliveries and delay in deliveries ? (*b*) who is responsible for the condition of godowns and storage and handling of goods ? (*c*) who is responsible for complaints from customers ? (*d*) are the complaints recorded for future reference ? (*e*) Are samples for details of designs, texture, colour, finish etc. kept in readiness for reference ?

(26) How are the various phases of the selling policy decided upon, and by whom ?

(27) (*a*) Is the selling organization able to sell more than the mill can produce ? (*b*) Is the salesman competent enough for introducing new selling ideas (by way of designs, quality, finish etc. etc.) ?

(28) How is the efficiency of sales determined ?

*If a Mill Agent wishes to see his Balance Sheet always on the credit side then he must take care of three M's and three C's that is Machine. Material and Men. Cotton, Counts and Costings.*

*Bear in mind a machine is a very big tale tatler watch it Study it and it will take care of you.*

## Six Points or Rules for Successful Management.

(1) Pay good wages and salaries.

(2) Create a sense of security in the minds of employees.

(3) Train people or operatives to have more and more skill.

(4) Give praise when it is deserved.

(5) Reward initiative.

(6) Discourage politics while at work.

## Chapter VI.

## " THE OFFICERS."

Each officer is given one assistant or more. Experience has proved that in business as in most other departments of human activity, no man need be looked upon as indispensable. But a good and honest officer must be cared for and looked after. Here the writer desires to say a word or two for the benefit of the young Lancashire lads, novice to India, who come out whether out of ambition, curiosity or temptation for more money and thus enter into or take upon themselves a responsible office or post. The adverse weather and inconvenience that are met with in some shape or form are not to be lost sight of, and to avoid sickness, late nights must not be resorted to.

Prickly heat is a complaint that takes one a long time to get used to. Fever is another troublesome complaint, particularly when it becomes recurrent. Regularity of habits has a great deal to do with assuring good health. Also the food must be clean and fresh every day and the water boiled. Meals should be taken at regular intervals, with no unconsidered trifles in between—only a light meal should be eaten in the middle of the day and the heaviest meal in the cool of the evening. Certain precautions should be taken for the heat of the day. Firstly the eyes must always be protected by a pair of glare glasses. Secondly the head should be protected by a suitable hat. Thirdly the clothes should be reduced to a minimum. People probably require more sleep in the tropic than in temperate climates. Food and clothing can be got the same as can be got in England which is about 10,000 miles away.

### Keep Physically Fit.

Avoid alcohol and veneral diseases. Bodily infections seem to cause some mental illness. Fevers certainly do. Cocoanut water should be substituted for alcholic drinks particularly in hot weather. It may not have a Kick in it but it is delightfully cool and refreshing. Hot tea is good for hot days.

### Admit your defects.

Bear in mind that your impulses and conduct are the results of natural causes, even though your associates consider you ignorant, or guilty of poor judgement. Do not expect yourself to be perfect. You should have a real good friend to whom you can tell your most incriminating acts and impulses.

### Associate with people who are Successful and Happy.

We all need certain contacts to give us new points of view, new thoughts, and new hopes. Living within one's self alone is dangerous. Attend a social affair once a week or month. Visit your neighbours. Meet friends at the club. Play cards, or dance, or sing, or play golf, when you do associate with others, do not consider the associates as superiors. Let your motto be: "All men are my equals, but no man is my superior." Try to learn from those who are experts in other fields, but do not envy them of their money or position. Happiness does not lie in wealth, fame, or personal beauty. It is achieved through work and a balanced view of life.

### Realize that you are not an Exception.

You are just about the same kind of person as the rest of the human race. Every human being has the same basic impulses and feelings. Just be yourself and do not brag about a relative who is a very big man or a Raja.

### Have a Hobby.

Your hobby should be one that gives you contacts with new people and new Worlds. It should be a hobby for its own sake—just because it appeals to you. It should be a hobby that requires physical effort rather than mutual effort.

### Have a Plan for Your Life.

Make a list of the things on paper that you would like to accomplish this year or at a near future or even next year or year after. Have some fixed objects that can be achieved with ease. Whenever you accomplish one item, cross it off, and throw out your chest once in a while when you gain a point as the results of your endeavours.

### Change your environment occassionally.

Take a Vocation when it is due. Meet some new people. If possible leave your wife and children at home or send them to some other place when you take a vocation as a new surrounding occassionally is beneficial in all respects where the health of a person is concerned or when one has mental worries.

## Officers Must Possess a Wealth of Patience.

The officers in India, unlike Lancashire where one man is to one job, are expected to be one man for all the jobs whether it may be within or outside the stipulated duties. He must be experienced, tactful, resourceful and never complain of being overburdened with multifarious duties. He must possess a wealth of patience, and indefatiguable energy to keep the efficiency of all the departments up to the highest practicable standard in a business like, fair and square manner.

As a rule most of the ideas for improving the machinery, emanate from the brains of the man who helps to make the machine, the man who runs it, or the man who has charge of both the operatives and the machine. Such a workman should always be in demand or sought for if the success of the industry is the main object.

## Qualifications of a Mill Manager.

(1) An officer must be honourable.

(2) Should be able to command the respect and confidence of his associates in business and of the men he comes in contact with in business relations.

(3) Must be well educated and well trained.

(4) Must know and understand Human nature.

(5) Attention to business.

(6) Must have intuition—a quick grasp of details knowing what is going on and what people are doing or about to do.

A mill manager must be able to eliminate or 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.

(7) A general knowledge of machinery and the theory of cotton spinning and weaving.

(8) A good knowledge of Mechanics and Drawing.

(9) Sound judgment in raw cotton, spun yarn and manufactured cloth.

(10) A just knowledge of dealing with workpeople.

(11) Ability in choosing officials so that they may carry out his instructions.

(12) Commonsense and tact.

(13) A good knowledge of costing yarn and cloth.

(14) Must have poise.

(15) Must be Thoughtful of the welfare of others.

(16) A mill manager must recognise his full responsibility for all that happens in a mill, otherwise chaos is likely to result, discipline and organisation will disappear, and such results will ultimately affect the products of the mill.

## Qualifications of a Carder and Spinner.

(1) A thorough knowledge of selecting and blending Cotton for the purpose of laying down an appropriate mixing for the counts to be spun.

(2) A thorough knowledge of all preparatory processes.

(3) Ability to produce yarn exactly to specifications or demand.

(4) A capacity for maintaining production at its highest point.

(5) A thorough knowledge of all calculations and costings pertaining to Carding and Spinning.

(6) Ability for controlling labour.

(7) The Carder and Spinner are responsible to the manager. If a carder be engaged he will be expected to do or to know the duties of the card room, the fly-frames and the spinning room. He must be well acquainted with all the process work, the calculations, the fitting work and must be conversant with each and everything connected with or pertaining to carding and spinning. Also he must possess a general knowledge of account-keeping.

In fact if he possesses inventive or extraordinary abilities and ideas they are welcome without any further considerations, though he may deserve it, over and above his duties. "He should not be impatient or get discouraged."

## Better work and More Production.

A carder and spinner must keep a note book in which he should enter all details pertaining to his department such as 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 thousands of rupees of materials may be spoiled in price before the fault is discovered. Actual times and facts are necessary, and these afford much information to a carder and spinner.

Drafts in the fly frames, that cause stretching between rollers and flyers, for instance, are bound to produce bad, uneven yarn. Perfect cleanliness are absolutely necessary such as 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 character of the cotton.

It is a very bad practice for a carder or Spinner for his own selfish object to tamper with the change pinion or speed of the frame in order to show a big production. If the tampering exceed its limits the results are bound to be detrimental to the Weaving department. Officers that continuously and without justification indulge in bad practice should not be allowed to remain at their posts and should be got rid of as soon as possible.

## Qualification of A Weaving Master.

(1) A thorough knowledge of all preparatory processes.

(2) Ability to produce cloth exactly to specification or demand.

(3) A thorough knowledge of the technicalities of weaving and of the loom.

(4) A capacity for maintaining production at its highest point.

(5) A thorough knowledge of calculations and costings.

(6) Ability for controlling labour.

(7) Ability for minimising waste.

(8) A thorough knowledge of Sizing and Size Mixing.

(9) A thorough knowledge of the finishing processes.

(10) The weaving master is responsible to the manager.

If an officer undertakes the post of a weaving master, he is expected to know all about sizing, size mixing, calendering, finishing, calculations, fittings, etc. pertaining to weaving and the preparatory processes. If he is particularly inefficient in sizing and size mixing though he may not be a very clever weaver, it will certainly be advisable not to take up the risk without acquiring for himself to a certain extent the practical knowledge in sizing and size mixing before proceeding to it; because the remarkable number of different width of looms working on various qualities or class of goods that are found in many mills is a great disadvantage to the weaving master, for he has to keep such a variety of beams and so many other necessary things that his job becomes complicated.

If an inefficient officer happens to drop on a mill managed by Europeans, he may or may not be shielded or assisted to pull on, as a lot depends upon circumstances, such as where he comes from, what are his talents, to what extent can he entertain a company of brother officers and above all the satellites of the agents.

If a Lancashire lad is altogether a stranger to India and if he has no pals in the place where he is proceeding to, he is well advised to leave his family behind (if he has one) until he can be sure of his job.

Woe be to an officer who is discovered by the workers as wanting and failing in his duties. They will soon whisper it around the mills and outside the mills too, and worse still, the news will soon reach through appointed spies to the managing agents or the proprietor, some of whom encourage it and welcome such reports and very often act upon such tidings very seriously, may it be genuine or not. An officer, be he a manager or weaving master, is not free from attacks by means of anonymous letters and back-bitings.

It is very strange to say that a Lancashire man can be found unable to converse beyond few words put together in an incomplete sentence in the local language, and that too perhaps after several years of efforts and experience in India.

The reason may be a personal abhorrence or taste of the language or just because there are to be found several assistants ready to interpret for them and thus save them the trouble of learning it. Whatever may be the reason, it is certainly to say the least a very unwise attitude adopted as undoubtedly it places those that neglect to learn the language of the land at a very great disadvantage.

To acquire knowledge of the language of the land, the best way is to employ a servant who can speak the English language as well as the language of the land. A half-an-hour's daily practice with the servant or a teacher will soon help him to grasp the language quicker.

## Officers must be Cautious before introducing a New System.

Officers with exceptional abilities and experience must go about their business very cautiously and carefully. They must not be slow to exhibit their talents whenever an opportunity presents itself, and also they should take good care that it is done through the right channel otherwise unpleasantness is sure to follow. One cannot start in at a new place and expect to have every thing well in hand the first day or to change the system over to his own ideas at the start. When you go to take the charge say of weaving department that has been running under a management of different ideas to your own there is usually a system already in force, it is according to that system the force is organized and it is in accordance with that system that you must for the time being work. It would be very bad policy to upset a long established system suddenly and without first getting familiar with its details. You may see one hundred things that are not right, that may be positively wrong, but if you were to work and change them over too fast you would quickly find two hundred other things out of harmony and fast and before a week had gone by, your work would be on top of you so that you could not stir. One can never be considered doing too much in India; the more you do the more will you be expected or required to do. Therefore whatever you may do it should be done cautiously, and gradually.

## Observations to be made when joining a Mill.

(1) Who is the manager ?

(2) What are his personal qualities or pecularities ?

(3) What are the standing orders ?

(4) Is the manager really a manager or one of those that justifies his existence by bullying his juniors ?

(5) Has he any private connections with the managing agent apart from his mill duties ?

(6) (*a*) What are the counts of yarn being spun ? (*b*) Could they be minimised ?

(7) Is the cotton suitable for the counts of yarn spun ?

(8) Are the cotton mixings regularly given and fairly of a good standard ?

(9) (*a*) What are the efficiencies of the productions of the various departments ? (*b*) Can they be further improved ?

(10) Are the conditions of the machinery good or satisfactory ?

(11) Are the number of the machinery sufficient to cope with the demand of the succeeding or following departments ?

(12) Are there sufficient spare parts available ?

(13) What are the facilities for the supply of spare parts and Stores ?

(14) Are there spare rollers ready at hand for replacing the worn out ones, such as calender bowls, copper rollers, tin rollers, etc.

(15) Is there a welding plant on the premises to facilitate the welding of broken parts ?

(16) (*a*) What sort of assistants have you got ? (*b*) Are they really good assistants or spies ? (*c*) Do they carry out their routine work in a good order (*d*) Do they take interest in their work ?

(17) Issue all your orders in writing and be very careful when you do so.

(18) (*a*) "In your heart" trust nobody until you get sufficient opportunities to test all those that you have to deal with (*b*) Never stab a brother officer in the back and never utter an unkind word behind his back.

(19) (*a*) Have you sufficient orders to keep all the departments going ? (*b*) Always prepare or issue orders for the next day's work in advance.

(20) Keep a record of all your important doings daily.

## AN OFFICER MUST BE STRAIGHTFORWARD.

Beside the Jamadar, who is the prime minister in disguise, there is also the secretary to contend with. At some of the mills he is a man in majority of cases without any technical qualifications, knowledge or experience, but he certainly knows how to bully an officer and burden his work rather than facilitate it for him, more often than not he is very impolite both in his speech and letter writing. In short, he grows too big for his shoes very quickly. He walks or acts as if to-morrow instead of today will do where he is concerned, but the case becomes the reverse where an officer is concerned. He is very fond of questioning the clerks behind the back of the officers and goes so far as to invite them at his residence or at the head office. A secretary out here is generally entrusted with store buying. It is far better for an officer to be straightforward and undaunted in dealing with stores. In accepting inferior articles to please somebody will eventually bring upon himself unnecessary worry and displeasure.

## Illegal Commission.

All types of men are found in India or anywhere else, and it is very difficult to say what a man may do where imminent temptation presents itself. It is best for a good man to keep out of the way and he can do it if he has a strong will power. He should, persevere, and show the world that honesty is something worth struggling for.

## Creation of Misunderstanding.

In some mill it is a common knowledge for the proprietor to create a misunderstanding or friction amongst the officers so that he may get to know their secrets by lending their ears to the tales that may be carried by an officer against his brother officer. So far the proprietor's interest is not affected he will listen to all stories and will take no notice of them. But as soon as he finds that the rupees are getting affected he takes action very quickly.

The mill that adopts such practices is bound to be the sufferer, as it stands to reason that a house divided against itself cannot stand.

## An Officer should always keep His Head Cool.

It is better not to worry, it is better to keep a sense of humour, and in all circumstances, if nature were kind, to keep your hair on.

For success in life "tact" is more important than talent. Always remember that men are more easily led than driven, and that in any case it is better to guide than to coerce. Be wary and keep cool. A cool head is as necessary as a warm heart. In any negotiations steadiness and coolness are invaluable, while they often carry you in safety through times of danger and difficulty.

If an officer is foolish enough to adopt tactics from hearsay, for it may be natural to him in resorting to kicking, or hitting or cursing the operatives, he must therefore beyond all doubts meet with the consequences and thus perhaps ruin all his future prospects. Avoid most carefully all harshness and brutality—they are apt to give rise to cruelty, hatred and deceit give a mild answer to an angry man, for it is like water on a fire, it will abate his heat, and from an enemy he will become a friend.

When it is necessary to correct a serious fault, or note with appropriate emphasis a glaring mistake or error, the following points should always be borne in mind.

(*a*) Be sure to have the facts of the case set out right, and further be sure that the reason for the complaint is fully explained and grasped by the aggressor at the outset.

(*b*) Never, on any account whatever, correct a superior member of the staff in the presence or hearing of an inferior.

(*c*) Take plenty of time before deciding how to act, or pronouncing a verdict.

(*d*) It is necessary to dominate the interview and to be severe, and even angry at times, but one must always be just.

(*e*) Where punishment or disciplinary action is necessary, on no account let it be of such a nature as to lower the self–respect of the individual concerned.

## All Important work must be Supervised Personally.

An officer is well advised to be clean in his habits, and appearance. He must endeavour to uplift the young people under his charge in every way that he can by his own high grade of education.

It is absolutely necessary that the officer-in-charge should supervise personally all the important work and concentrate on it. The operatives should be trained for doing clean, good and quick work. They must also be trained to understand that maximum production will bring higher wages for them.

It is also a good idea to divide the work among the assistants and make each one responsible for one particular work, thus the work may be facilitated. Bear in mind that if a workman is to exercise his judgement as to what is to be done on the method of doing it, he should be thoroughly informed on all points in advance clearly and distinctly, more than once if necessary. It is not a good policy of being able to point out only errors but it will be much better if the operatives are shewn how to rectify the errors.

## Questions the Manager must ask himself.

The manager must ask himself now and again. "Do I get the most work out of my machinery ? What is the difference between their capacity and their output ? Have I selected the right men as heads of departments ? Have I trained them ? Do I keep my stores as carefully as I keep my petty cash ! Is my mill an orderly place or is it a mess ? Have I planned my process and studied how to prevent the waste of time and materials ? Do I pay by results ? Do I keep my best men ? Do I promote by merit ? Do I encourage intelligence and inventiveness and ambition ? Do I encourage the operatives to excel their own records of previous month ? Do I encourage competition between men in the same department ? Do I reward the efficient workmen ? "

A manager may often learn much more from a casual walk through the carding, or spinning departments or the weaving shed at meal times, when the machinery are stopped. At such times many details are noticed that would be missed when the machinery are in motion. Spent cops or bobbins and waste do not always reach the manager, and when the latter finds evidences of concealment he should deal with the matter firmly but tactfully. Excessive wastage is a serious matter, but admonition couched in courteous language is much more likely to check it than any other means, since it enables the manager to maintain his prestige and at the same time gain the confidence of the operatives to the mutual benefit of both. All waste, of whatever description, must be placed in waste tins, and not thrown carelessly on the floor. The manager should also note any defect that he may be able to correct.

*The essence of good Managment is to make the best possible use of employees and equipment.*

## Root Causes of Low Production and Output.

One of the causes of inefficient labour and low production which in this country has received nothing like the attention it deserves, is that the actual method of working is too often left entirely to the worker himself, on the traditional "go as you please" day work plan; and he is often so poorly equipped on the technical side that he cannot plan out the most efficient way of doing his own work. It is the management who should take interest in each individual worker's result and issue complete instructions to the workers instead of relying too much on jobbers and head jobbers and leaving important matters to be decided by them.

## How to Obtain Maximum Efficiency.

(1) Take interest in your work—keenly and faithfully.

(2) Be kind—Utter no unkind word to your subordinate or business associate.

(3) Place efficient workmen where they may be imitated or observed by the less efficient workmen. Encourage competition between individuals and one section or department may compete with another.

(4) Help or arrange for your efficient operatives to visit better than theirs or highly efficient factories or mills if it is not possible in their own district they may be sent out of their district. Educational trips to other mills will help to stimulate mental alertness and the instinct of imitation in the workmen and officers.

(5) From time to time draw the attention of your staff and workmen explaining to them by way of an example the lives of successful men and the work of successful mills.

(6) Bring frequently to the attention of your operatives model methods of work.

(7) Take pride in the quality and quantity of your output.

(8) Do not be afraid to do more than you are paid to do.

(9) Aim to accomplish 5 per cent more and 5 per cent better work than any of your associates do. Perseverance will help you to succeed.

(10) Co-operate with both your superiors and Co-workers—Shoulder responsibilities with a smile.

(11) Keep physically fit.

(12) Have confidence in yourself and your ability.

(13) Cultivate a will to win.

(14) The achievement of success to a great extent depends on the courage and confidence that one develops in himself.

*The increase of efficiency depends upon continued efforts of will, therefore variations are inevitable. Voluntary attention cannot be sustained for a long period.*

**It is a well known fact to an experienced officer, that, in a mill there will always be found some operatives who are incompetent, careless, thoughtless, mean and ignorant. It is with these that the officer's concentrated skill of management is most needed.**

If an officer uses some discretion and shows some kindness to the operatives, he can soon convert them to his side and his business creed or method, and if successful they will serve him faithfully. The nature of kindness should not be shown such as to be misunderstood for weakness. Sympathy goes a long way with them if it is shown to them in a true spirit which they will not only appreciate, but not forget it.

Various devices may be adopted for keeping the weaver's work up to a high standard of quality such as graded price lists, fines, etc. Weavers whose work is usually below the average must be dealt with more severely than those whose work is usually above the average. Judgment should be used in imposing fines etc. Excessive fine will always create trouble leading more often than not to strike, etc. Although no matter how excellent may be the system or vigilantly the work is being looked after, defects in the cloth will come along to some extent. But good supervision will help to a great extent to put down the defects in the cloth to a minimum figure. It is absolutely necessary that rules for the employees in every department and among all groups should be established and insisted upon under disciplinary penalties. There are plenty of operatives who consciously or unconsciously waste their time. In this connection both the management and the employees are to blame for it. Unless there is an adequate supervision on the part of the management, some kind of laxity is bound to creep in somewhere.

If adequate instruction is given to the operatives, efficiency can be achieved in a very short time, without it, may not be obtained for years.

*Men who know how to get maximum results out of machines are common; the power to get the maximum of work out of subordinates or out of yourself is a much rarer possession.*

## Low cost depends on Efficiency.

To get the maximum efficiency is to realise the greatest amount of the highest quality cloth in a given time, with the least cost and the greatest degree of comfort to the operative concerned. The cost of outturn depends very largely on production, which is one of the most important factors in the cotton industry, and the factors that directly affect production are first of all the yarns. A great amount of yarn used in the cotton industry is not exactly suitable for the purposes for which it is required or it is very badly carded. In many instances it is certain that unsuitable yarn to a large extent accounts for reduced production. Because it is impossible to deal effectively and satisfactorily with badly prepared or inferior yarns especially warp yarns, and there are probably very few mill managers who have not at some time or other been forced to utilise such yarns for purposes other than those for which the yarns were originally intended.

There are also various defects that occur in the winding, warping and sizing operations which may help to make a beam of warp unsatisfactory, and probably the greatest proportion of these defects is directly traceable to the formation of the warper's beams and to the transferance of the yarns from these beams to the loom or weavers beam. Nevertheless, there are several other defects that may appear in the yarns before the latter leave the winding department, and such defect may be grouped into two main classes :—

(*a*) those on the yarns themselves due to large knots or imperfectly made knots and (*b*) those present on the warping bobbins, cheeses or cones.

It must be borne in mind that a large knot or slub cannot pass easily through the mail or–the ordinary eye of the heald, or even through the dent or split of the reed unless several threads are in one dent, nor can the knot resist for any great length of time the repeated chafing and scraping of the reed wires, especially if the knot appears on a thread at or near the selvedges of the cloth without causing some damage, such as a decrease in the earnings of the weaver, the creation of second quality fabrics or fents etc. It is very essential that all knots made by winders, warpers etc. should be of the smallest possible dimensions, for the failure of a knot to pass unbroken through the reed clearly results in duplication of labour.

The system in general use for testing yarns are not so sound as they ought to be, and many of the tests are not reliable at all.

To improve production and quality of the cloth the weavers work in starting and stopping the loom must be reduced.

In India, owing to the dryness of the climate artificial humidity has to be resorted to and unless there is a good system employed the production suffers.

Waste of time cannot be too severely dealt with in any progressive concern. Also bear in mind that an increase in production with an increase in waste tends to lower efficiency and increase the cost of production.

Similarly an increase in production with a decrease in waste but increase in wages and stores tends to lower the efficiency and thus add to the cost of production.

It is very essential that efficiency should be measured by the ratios of the output to the human efforts and working capacity of the machinery in use.

It is also very essential that in the business of cloth production irrespective of the type of yarns or fabrics involved, that ideal conditions should be kept constantly in mind with a view to all persons concerned working towards the realization of the ideals. Even though the absolute attainment of such ideals as may be formulated is never actually reached, the striving to reach a particular goal is certain to improve the individual and the organization as well as the product. The improvement so gained is bound to result in the formulation of new ideals of an even more advanced type, and so the struggle towards perfection proceeds.

*Progress in trade, industry and agriculture means, more and more Efficiency.*

## Hints to Officers.

(1) Keep your mouth shut and eyes open. Attend carefully to the details of your work. Be prompt in all things.

(2) Your ears should be lent as little as possible to tales that concerns others. See things for yourself before you arrive at any conclusion. Consider well, then decide positively. Never let your attention be distracted from your job.

(3) Adhere very carefully to factory acts and Rules and Regulations of the firm. Always read and pay attention to any notices displayed. They are put up for your guidance, and safety. It is foolish to try to perform an unfamiliar job without instruction. Dare to do right and fear to do wrong. Endure patiently and fight your battles, manfully.

(4) Stand at the gate or entrance and watch the operatives come in first thing in the morning and after the interval hour. Each time an operative enters the gate he or she must insert his or her ticket in the time-keeper's box.

(5) Time-keeper should be instructed to come before the starting time to take down the numbers of late comers. He must report within an hour after starting the number of absentees in each department. Check daily the attendance book and initial it.

(6) Also jobbers, head jobbers and clerks should be ordered to be in their respective places no sooner the engine starts. The head jobbers and jobbers should see daily that all guards are replaced before starting and everything is clear before starting up a machine. A machine should never be left unattended while in motion. All machinery should be stopped before oiling, adjusting, inspecting, or repairing it. Every jobber and head jobber should carry a tape, a scissor and a pick counting glass. Every new beam gaited should be examined first for width and picks and then for length.

The head jobber should also make it a point of checking the picks of newly gaited beams as soon as it is started.

(7) All departments should be inspected inside and outside very carefully and minutely. Take note of all defects that you may come across and keep a regular diary of daily occurrences. All places in the departments must be kept clean. All oily waste, rubbish, or papers should be placed in the containers provided for the purpose. Do not allow things to be left about for others to trip over. All exacavations, open manholes and other places where persons might fall should be suitably protected. The floors should be kept free from oil slippery substances likely to cause falls. Serious spinal injuries have resulted from slipping on grease, a small bobbin, a rivet and even a screw or nails in an upturned planks, etc. should be withdrawn or turned down.

(8) Any stoppages or accident must be reported at once and recorded on daily reports.

(9) Prepare yarn requirements daily whether yarn or stores and report them to the right quarters or departments and see that they are carried out.

(10) Store keeper, wrapping clerk, spinning clerk, winding clerk, weft clerk, sizing clerk and weaving clerk should present their reports promptly each morning at a fixed time showing the working requirements (that is stock of yarn or sized beams whether there is sufficient orders on hand or not and there is no machine likely to remain idle for want of it) which must be studied very carefully by all officers concerned.

(11) Drawing jobber should check the reed space of each beam as he receives them from the sizing department and before it is sent

to the weaving shed in order to avoid any mistake (shortage in width) to pass unnoticed due to an oversight on the part of the sizing master or sizing jobber who are at times apt to put a wrong warper's beam of either more or less ends.

(12) Check or get it checked all your official business particularly figuring work. Always keep an instruction book for orders to be given to the subordinates regarding work to be carried out.

(13) Go through the production reports, for the purpose of criticising those that are behind with their work. Those that cannot improve or does not improve must be dealt with severely or dispensed with as soon as possible.

(14) Inspect daily waste, cover of cloth on working looms. Take the wrappings of the yarn as often as possible or necessary and check weight of yarn received from the spinning department and cloth from the loom shed as often as possible. Examine cloth very carefully in the warehouse, for width and length, reed and pick, for texture, calendering, borders (if dhoty borders) finishing, dyeing, bleaching, fold, stamping, packing, etc. First piece book must be kept upto date.

(15) Attend to Head Office correspondence very carefully and answer them promptly. Never fail to carry out the orders given to you by the Head Office with the least possible delay. All difficulties must be reported at once and all changes must be recorded with great care. Think twice before accepting and manufacturing orders and before doing so you must analyse your position with regard to standing orders.

(16) Never trust a salesman particularly if he is the brother-in-law or father-in-law or a relative of the Managing Agent. Never accept any presents from him or under any circumstances be bound to him by obligations. Always attend to his complaints and see that they are rectified immediately and as far as possible see that they are not repeated again. Never worry about his complaints which should always be received very calmly. All instructions from the salesman should be received in writing and reported to the Head Quarters or Manager with the least possible delay for confirmation. Beware of the sweet tongue of a salesman or a broker.

(17) No cloth should be sold without first finding out its cost. Every type of cloth should be costed out and never rely on rule of three or salesman's rule of tricks. All cloths before they are sold should be compared with previous selling rates.

## USEFUL MAXIMS.

It will not only pay a manager but also every officer in a mill to bear in mind the following six points :—

( i ) Thou shalt not complain of the weather.
(ii) Thou shalt not criticise thy neighbour.
(iii) Thou shalt not worry over thyself or thy friends.
(iv) Thou shalt not polute the morning with doleful face.
(v) Thou shalt not be in bondage to weakness or doubt.
(vi Thou shalt not be afraid to go where duty calls.

Whether you are in an office or a factory or wherever you are stationed, aim at neatness and orderliness, for they tend to become automatic, pay well through saving time and energy, induce a feeling of surety and contentment, and help others by setting for them a good example. Improvement in business technique is always possible. To understand your work thoroughly you must know much besides. Every extra bit of knowledge may come in useful. Look closely at everything analyse it, and see whether the purpose meant to be served could be better dealt with in some other way. Something you know "that you need not have known" may suggest improvements to you. You will see the solution of one problem through another. It is a useful plan to have a note book by one's side to jot down any particular point that strikes one about one's work, but which one cannot deal with just at that time. When you have noted down a thing do not lose sight of it.

At least an hour a day should be strickly set aside for the study of some special subject, such as facilitating or systematizing work and thereby increasing efficiency etc. or affecting such improvements that will cut down cost, reduce waste and stoppages for stores etc. and increase the comforts of the workpeople.

Every precaution should be taken to safeguard the health of the operatives in the mill, by providing facilities for preventing insanitary conditions. In the case of infectious diseases, as when scourges such as plague, smallpox or influenza are prevalent, the whole mill should periodically be sprinkled with disinfectant, even though the operatives may not be affected at the time.

## THE REALLY EFFICIENT MANAGER.

Business is an excellent training ground for developing self-control, good temper, quickness, versality and other characteristics.

There is also a great fun in business. It is a wonderful adventure with an unending source of amusement and interest.

The successful manager must cultivate self-control. Coolness quietness of demeanour and utterance, firmness of manner, and uniform command of temper are certain to ensure obedience and respect.

As an operative or a jobber starts when the whistle goes, a manager must start when he gets out of bed.

The manager must go to his work as though it was a pleasure, not a drudgery, he must make the work people feel that it is a daily pleasure to meet them, that the relationship between them is not antagonistic, but sympathetic, and this subtle difference is achieved not so much by words as by demeanour, and thus the outward appearance of the manager is a matter of prime importance. If he is punctual, the work-people will be punctual, if he is cheerful, the work-people will be cheerful, if he is obliging, intelligent and interesting so the work-people.

Shouting, blustering and bullying may appear to have a temporary effect, but continued indulgence will soon be recognized as a sign of weakness, and induce contempt and perhaps even hatred in the minds of subordinates. For a like reason sarcasm is generally to be avoided.

The really efficient manager should be thoroughly familiar with all the production processes, their methods and cost of working.

It is well to remember that whatever aspect he is enagged on at any time, all the other sections are going on in the normal course of events. Therefore, if all round contact is to be established and exercised even the smallest business will require some record of what is going on, all the time, in all the functions.

He must also give all facilities to the workpeople and arrange for their comforts whether ill or not. All the places to which the workpeople have an excess must be kept perfectly clean and tidy in every respect. Remember the happy employee is the efficient employee.

Cultivate a spirit of fellowship in the staff, take an interest in their doings, and let them feel that they are not regarded as machines but as brains whose active and sympathetic co-operation in the progress of the undertaking will be welcome, whose interest is invited and whose welfare will be safeguarded.

The provision of proper and up-to-date machinery, and the necessity for keeping it up-to-date, the efficient layout of the mill or factory to get a good work flow, the provision of proper equipment for lifting and transport. correct lighting and ventilation; all these factors are essential for obtaining the best results.

In addition, the management must have a thorough knowledge of obtaining correct raw material at the right time; they should see that there is the right balance of stocks of cotton, stores, yarn (both in quality and counts), colour or dyes, and they should lay down the minimum economic manufacturing qualities, and endeavour to regulate their orders to suit, particularly bearing in mind the necessity to absorb warps completely and thus prevent producing in excess to requirements or orders which if not sold in time might lead to wastage and unnecessary loss to the firm.

The manager should periodically if not daily investigate defective and spoiled work and the volume of waste, not solely to allocate blame, but to establish the causes and so prevent repetition. The manager should also ascertain and maintain the correctness of both cotton and size mixings used, and the accuracy of the machine settings. He should watch or ascertain that the speed of the machinery are such that the maximum capacity is being achieved. On the services side, he should see to the efficiency of the steam and power used, the maintaining of boiler pressures so as to ensure the maximum use of them, and to make careful observation of the power transmission losses. The manager should also have a training in all the business departments, be a good organiser, and naturally have keen commercial instincts.

Upon the managers rest to a very considerable extent, the responsibility for the present efficiency of the industry and for its future welfare. Efficiency with economy should be the main aim throughout bearing in mind, however, that what appears cheap is often dear. The mere fact that a firm is large does not necessarily make it efficient, nor is a small firm necessarily inefficient, nor Vice Versa.

On the other hand if there are sufficient facilities available such as raw materials, machinery, labour and 'brains' in a big or a small factory there is no reason whatsoever why maximum efficiency should not be obtained.

The efficient manager should have his finger on the pulse of establishments, so to speak; should watch closely every detail of expense, remembering that while there is only one source of income "SALES"—there are a hundred and one items of "Expenditure."

*THERE IS A TECHNIQUE OF MANAGING PEOPLE AS WELL AS ONE OF MANAGING MACHINE.*

## Practical Suggestions.

(1) Think twice before committing yourself in black and white. But let your instructions from your superiors and to your subordinates be on paper. Make your own decision for yourself. Don't be deceived by others.

(2) A good name and a good will are very important assets in life.

(*a*) Go not in the society of vicious.
(*b*) Hold integrity secret.
(*c*) Injure not another's reputation or business.
(*d*) Join hands only with the virtuous.
(*e*) Keep off your mind from evil thoughts.
(*f*) Make few intimate acquaintances.
(*g*) Never try to appear what you are not.
(*h*) Observe good manners.
(*i*) Pay your debts promptly.
(*j*) Question not the veracity of a friend.
(*k*) Sacrifice money rather than principal.
(*l*) Touch not, taste not, handle not, intoxicating drinks.
(*m*) Use your leisure for improvement.
(*n*) Venture not upon the thresh-hold of wrong.
(*o*) Watch carefully over your desires.
(*p*) Extend to every one a kindly salutation.
(*q*) Yield not to discouragement.
(*r*) Zealously labour for the right and success is certain.

(3) It is not work that kills a person. Work is healthful. But a manual labourer must have a limit on his hours otherwise he will wear himself out very quickly. Far more illness develop from

under work than overwork, and any reasonably healthy person is capable of eight to ten hours' work out of 24. Such a person can do this without the slightest risk of injury.

## Matters for Noting Down.

(4) (*a*) Things or subjects requiring immediate attention.

(*b*) Matters or work remaining in abeyance.

(*c*) Matters requiring periodical attention. Every few days do something (no matter what) because of its difficulty or because you would rather not do it. Link together every possible idea in connection with some simple everyday occurrence. Be too far apart enthusiastic about your scheme, plan, or objective. Instead of saying to yourself "I will do that", say, I will do it in this particular way." Put your mental efforts upon the "how" of the proposition.

(*d*) Always acknowledge or confirm a transaction with the least possible delay.

(*e*) Lost time can never come back, when you feel you must let go, just hang on all the harder. Make your motto "Do it now."

(*f*) Brooding over a wrong done to you or a wrong you have done is madness. And who wants madness to-day ? There is plenty about without individuals encouraging it. Most of the things that a man is afraid of, simply do not happen. The imagination creates dangers, often, when there are none. Bear in mind that every possible danger, seen in the future by the imagination, seems vastly larger than when you come up to it and see it with your eyes.

It doesn't pay to waste time over regrets, losses, or disappointments. Be grateful for present opportunities and privileges. Bend your mind and energies to the work that now lies before you. The remedy for worry, anxiety, and fear is to assume new interests and responsibilities.

To-day offers you ample pursuits, pleasures, and problems to engage your best powers. Take all reasonable measures to avoid repetition of past mistakes, plan intelligently, and be hopeful of the best results.

Be a sensible optimist, realize your immense resources, carry yourself confidently, work industriously, and be assured all will be well with you. Keep your mind open to truth. Right thinking always yields a harvest of right results. The things that we worry about—almost all of them are trifles; and they can be overcome by initiative and efficiency.

Work is as necessary for peace of mind as for health of body. A day of worry is more exhausting than a week of work. Worry upsets our whole system, work keeps it in health and order. Exercise of the muscles keeps the body in health and exercise of the brain brings peace of mind.

Do your best and leave the rest
What's the use of worry ?
Firm endeavour stands the test
More than haste or hurry.
Rich rewards will come to him,
Who works on with smiling vim.

(5) It is better to check your work and better still to get it checked. But it must be done efficiently with all the necessary concentration. Economic analysis is essential to govern the operations. The application of any principle can only be effective if one investigates into it before starting it.

Make a list of the things which you use or do in your daily work. Find out how to improve these things which you use or do. Perform your daily work according to the improved methods which you have discovered or found advisable.

Check all productions daily whether be it in pounds, yards or hanks and always compare the results with the standard weights or calculated yards or hanks.

'Speeds' of all machinery should be checked periodically be it a spinning or weaving machinery. The speed of the engine should be checked daily and if necessary more than once during the day as variations in the speed of the engine are bound to make a difference in the production of both the spinning and weaving departments.

'All kinds of wastes' should not only be checked, but examined minutely and the sources of wastage should carefully be watched daily and compared with the results of previous days or months.

'Heavy and Light' whether in the case of yarn or cloth should be recorded and rectified at once otherwise it means a dead loss to the company and if allowed to go too far then disaster must follow.

All changes whatever made in any process or machine in the mill should be recorded, and eventually 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 systematized, such a book will tend to considerable economy in mill management, and it will have a far greater value for the manager than for any one else in the mill.

(6) The man who has the largest capacity for work and thought is the man bound to succeed.

Make an inventory of your mental assets. Take stock of yourself and know precisely what you are doing with your thought, time, talents, and every energy. Put your mind in order. Thought rules the world. Everything that is wrought out in material form is first constructed in the mind. As you think, so you build. Store your mind daily with great thoughts of great thinkers.

Contact with master minds will elevate your taste and enlarge your intellectual outlook. Realize your responsibility to maintain a constantly high standard of thought. Thoroughly discipline your desires, habits, and efforts.

To succeed in life you must have an ambition. Foster it muster it against all odds and it will produce mighty results. It will bring about the realisation of life's dearest ideals. The man who wishes to accomplish anything worthwhile must have a will to win. In any field of human activity success is never won without absolute constancy of endeavour. Discard all non-essentials and focus your mind upon the object of your ambition with steadfast intensity. Do not have a tramp mind. It wanders aimlessly from one thing to another. Whatever, you do, do thoroughly and never hurriedly.

(7) He never fails who never gives up. Comprehensive reasoning and sound judgement are of paramount importance to the attainments of ends magnitude; success attained, self-confidence and perseverence are thereby increased. Self-confidence is no doubt useful, but it would be more correct to say that what was wanted was firstly perseverance, secondly perseverence and thirdly perseverence.

Above all remember a person's success does not depend upon the amount of knowledge which he possesses, but upon the use he makes of it. It is not wisdom but the force behind it which counts.

(8) One cannot become skilled by mere wishing good intentions coupled with well thought out working designs; if put into practice with enthusiasm and perseverence it can be made to succeed. To relax your efforts simply means that you will slip back and your past exertions will have been in vain. To be successful you must cultivate success.

The highest attainments are still incomplete. "Genius is nothing more than a capacity for hard work." Work hard and rise above average level of mankind. Achieve your own success, and realise the highest potentialities of individual life. Your dream of today is tomorrow's reality. By constant exercise one develops the power of imagination, will concentration, observation and perseverence which are indeed the creators of the greatest achievements, success and worth while life. No man has ever succeeded in life without a struggle.

(9) Keep mostly your eyes and ears open. Suggest an improvement by all means but not unless you have thought over it more than once. In methodical suggestion one has an instrument which when used aright, gives certainty and speed to one's endeavour.

Be a good listener for thereby you make money, friends, and if you keep the right company, you are certain to learn a good deal from those with whom you converse. Avoid becoming heated in an argument. It is apt to place you in bad light and perhaps always at a disadvantage. A spoken word can never come back.

(10) The successful persons depend largely for their happiness on their faithful obscure friends. So be sure that the barrier between you and them is not put by your hands; keep your own secrets and the secrets of others within thyself. Confide or trust no one who is in the same firm as yourself. In other words your colleagues should be treated as strangers both inside and outside the mills until you have tried them, but render help whenever necessary.

(11) Never force an operative to do a thing which you cannot do yourself–a title is often injurious to the wearer. There is perhaps no greater single source of personal dissatisfaction amongst operatives than the fact that the title bearers are not always the real leaders. Every thing acknowledges a real leader....a man who is fit to plan and command.

Be frank, and yet reserved. Do not talk much about yourself: Neither of yourself, for yourself nor against yourself.

(12) To prevent waste, one must realise that waste is occurring. Mills can no longer be operated haphazardly with a great percentage of faulty output and greater wastage of material, time, etc.

(13) An operative should not be hurried in his work....he must have every minute necessary but not a single unnecessary minute. It is necessary that the executive of every factory or mill should study the questions of individual fatigue under their charge.

Words of encouragement or appreciation are as good as gold to an operative. Keep your eyes open and you will find that life is full of opportunities to spread a little happiness by way of encouragement.

If you are kind and sympathetic your advice will be often sought, and you will have the satisfaction of feeling that you have been a help and comfort to many in times of anxiety and distress.

(14) The sooner an operative is discovered swelling out with authority, he must go. An unjust authority should not be exercised by subordinate or assistants over the operatives. Unwilling operatives should not be retained.

(15) No one should ever consider himself an expert if he really knows his job. One that knows his job sees so much more to be done than he has done.

(16) Willingness will carry one further than obstinancy.

(17) To fall in the clutches of drink and undesired company is a curse.

(18) Listen to everybody, but judge for yourself. Other men may be wiser than you, but they may be more interested in hindering than in helping you.

If a comparative stranger protests and promises too much, do not place implicit confidence in what he says. Even if he is not insincere, he probably says more than he means, or perhaps wants something himself from you. Do not therefore believe that every one is a friend, merely because he professes to be so, nor assume too lightly that any one is an enemy.

(19) Visit every nook and corner of your departments at least twice a day with a view to discover or to find fault with the sole

object of making improvements. When a fault is found, rectify it and if not possible at once, then return to it, and do not allow it to slip your memory.

(2) Many men occupy inferior positions all their lives because they have not the courage to aspire higher. They are continually on the look out for opportunities of a kind that rarely, if ever, come. These persons must rely upon themselves before they can reasonably expect others to rely upon them.

(21) Unless you can manage one business well, you are scarely able to manage two or three simultaneously. To succeed in one's work, one must be so well-equipped as to compete successfully with others. Concentrate your energies. It is an exceptional plant that does not contain a surprising number of opportunities for worth-while improvements in mechanical transmission details, opportunities for improved application of electric power, and so on. More often than is realised savings can be accomplished with little or no expenditure beyond the cost of investigation necessary to locate the leaks.

It is as essential to overhaul an organization periodically as it is to overhaul a motor car or a gramophone.

(22) The cotton industry or any other industry or business is not one either for 'inefficient man or inefficient organization.'

KEEP YOUR OWN COUNSEL AND DO NOT MAKE YOUR PLANS KNOWN UNTIL THEY ARE IN OPERATION.

If you do not keep it for yourself, you cannot expect others to keep it for you. "The mouth of a wise man is in his heart, the heart of a fool is in his mouth, for what he knoweth or thinketh he uttereth."

## Practical Points for a Manager.

The Manager's job is not a desk job which is of a book-keeper or a clerk. He should be here and there, all over the place, wherever his authority extends.

The manager is not a part of the routine. He is the inspector of the routine and the creater of new and better routine and thus helps to facilitate the work of labour. Much of his time should be spent in breaking up routine that has gone stale that is those that are non-progressive.

The manager must see for himself. He should create improvement. He is to learn and teach. He must stop what is wrong and start what is right.

Every manager must be a man among men. He should take more pleasure in learning new methods than in giving orders. He should not have the delusion that dignity is an asset. It is not. If his people dislike him, he will not go far. The danger to be avoided in creating any organization upon a scientific basis is that the organization must not be looked upon as a machine; as an artificial sort of thing that recognizes such realities as order, system, discipline, skill, and ability, but has no place anywhere in it for the "spirit" of anything. When all has been said, it must be remembered that every organization is concerned with human beings; and here we come at once to the human element in industry. Any organization, however apparently perfect, is yet imperfect if there is no espirit de corps.

The task of a manager is to build up an organization and a policy. His employees themselves cannot do this. If he is merely a co-worker, then there is no management at all. As some do to cover up their main weakness. A definite responsibility must be put upon every employee. There must be division of labour. The workers must be fitted to the jobs. This in itself is a big job that is never finished.

The manager must stand outside the organization that he creates. He should take a very close observing or watching position while it is operating for the purpose of perfecting the weak points. He can never make it a 100 per cent organization. But he can steadily and patiently keep on improving it. He must study the daily reports and compare them with the previous results. He must judge every department by the percentage of results until each department reaches its maximum and then every effort should be exercised to maintain it and not left alone to depreciate for want of attention etc. The aim should always be how to make improvements better in every way and everyday. Plenty of us know how to work, but few know how to organize. And it is organization that builds up a business and makes the profits. It is certainly true that the ablest workers cannot do their best if the work is not planned—if the stores are not sufficient—if the yarn is of an inferior quality—if the machinery are in bad order—if there is no system of efficient production.

The question always is not how hard a man is working, but what are his results. The main thing is not to slog,, but to work intelligently. If a worker is doing a certain job with two or three operations instead of one, that is not efficiency. If he wastes ten rupees worth of time over a rupee mistake that is not efficiency. The main thing in efficiency is, what you get and what you pay for it.

The aim of a good organizer is to get rid of work—to put every possible job on some one under him. This sets him free to think, observe, plan and start something new and investigate wastes and create new sources of profit.

There are many officers that work with their nose to the grind-stone—that is they work twelve hours a day and they seem to effect praise or pity. But in the opinion of the writer they deserve neither if their efforts are not sensible, they should put an end to their nose—grinding as soon as they can. They should learn how to organize.

Creative work is not at all like routine work. It must be done under the best conditions, else the brain will refuse to work efficiently. There must be a feeling of pleasure and enthusiasm, if the work is to be done well.

*Concentration means working with the whole brain. It means working without having one eye on the door or the clock.*

Although a manager may be able to undertake personally any of the duties in the mill, and to correct any faults that may arise, it is not wise for him to do any work for which others are employed, excepting, of course, when the person whose duty it is fails to accomplish what is required. When this occurs the manager has an opportunity for giving a useful object—lesson, and his prestige is increased thereby. All cases of inefficiency, idleness, etc. should be dealt with firmly but courteously. Even the best workers are liable to errors of judgement, and a friendly reproof will generally be accepted in the right spirit. whereas a severe or harsh reproof will naturally be resented. An important thing to guard against is 'overstaffing the departments with odd men.'

It is a well-known fact that cloths having a very low Reed and Picks, are more often than not a cause of low earning Capacity. Because the materials that are produced are not in conformity with the materials that are required by the public in as much as the feel, weight, designs, colours, etc. etc. or not attractive or pleasing to the eye and hence they fetch very low price compared to finer counts to such an extent at times that they leave a very little or perhaps no margin for profit.

## CHAPTER VII.

## "THE COMMISSION AGENT."

It is a rule in majority of the mills in India to appoint Commission Agent for the sale of yarn and cloth, in other words, the commission agent or the salesman is a broker on behalf of the mill.

The commission agent or salesman is a servant of the firm which employs him. An ordinary commission agent is paid a commission for his services but he is not responsible for the payment of accounts, nor is he on the other hand responsible for the correct execution of orders given to him. Still, an ordinary agent may assume extra responsibilities by guaranteeing to pay his customers accounts if they themselves fail to do so. In such a case he usually receives an extra commission known as "del credere". The commission agent in India who is required to deposit by way of security a sum of money from 50,000 to 5,00,000 of Rupees as the case may be, depending upon the size of the mill and the extent of the credit to be given to him, has a shop in the cloth market or bazar where all the packed bales are despatched from the mill and thence distributed to the buyers or dealers, on receipt of full or part payments from the commission agent for the goods that are to be delivered to the merchants for which the head quarters issue a delivery order or note that is required to be presented to the mill manager, for the purpose of effecting delivery.

The goods are generally delivered at the sight of 14 days or as the case may be to the dealers for which the commission agent is solely responsible. The commission agent draws on the money that he deposits in the firm interest at a fixed rate; besides he receives (according to the system in force) 1 per cent on grey cloth and 1½ per cent on the fancy cloth etc. on the value of the bales or goods sold by him. Thus the deposit unreservedly be involved or utilised at the discretion of the managing agent say in buying cotton, stores, etc.

### Sales on Indent Basis.

An indent is a definite order so that when it is booked the exporter or the manufacturer knows exactly what price he will get for his goods, irrespective of market fluctuations, provided only that his customer will pay up in due course.

### Sales on Consignment Basis.

Shipment on consignment, however, involves a considerable amount of speculation. In this case, the exporter or manufacturer ships the goods which he thinks will be saleable, but for which he has no definite order. He runs the risk of fluctuations in fundamental values at his side and also of variations of the market which may arise on the other side, due to the depreciation of local currency, excessive foreign supplies etc.

### Method of Selling Cloth in India.

The method of costing and selling cloth is peculiar in India. Cloth is sold by weight, and the majority of the natives go in for the heavier and coarser yarns, and shun the finer and much lighter materials. Such a method makes it a funny business to adjust the ruling price in the market, and also makes the payment of weavers a difficult matter, seeing that they, too, are paid by weight of cloth produced, and not at so much per piece. Though there are few mills where the weavers are paid so much per piece based on production in yards converted into pieces.

Some mills pay to the weavers on the total weight manufactured that is weight of yarn plus size, others pay only on the net weight of the yarn, (size excluded) composed in the manufactured piece. It will be much better for all concerned if the weavers are paid on length or pieces they produce rather than on weight.

### Direct Selling of Goods.

Branded goods such as Viyella, Tricoline, etc. sells in large quantities direct from the manufacturer or producer to dealers due to advertising in various papers, periodicals etc.

But in India advertisement method has very little effect chiefly due to the most of the population being unable to read and it is not always possible to convey in pictorial form the idea of branded line. Direct sales is based essentially on creating a demand for the articles from the general public.

### Sales through Agents.

Business is practically transacted in all the parts of the world by this method. The resident agent, or traveller as the case may be, is supplied with ranges of the exporter's or manufacturer's qualities, and any orders he obtains he submits to the exporter or manufacturer that he represents for confirmation.

## Qualifictions of a Commission Agent or Salesman.

(1) Personality.

(2) Adaptability.

(3) Courtesy.

(3) Tact and Common Sense.

(5) Insight into human character.

(6) Regard for the goods he is selling.

(7) Quickness of obervation—a man quick to seize opportunities and gauge the future.

(8) Eagerness to make something new as often as possible.

(9) Desire for action and deeds—a detective for searching out the weak and strong points in one's client.

(10) Power to analyse—Have a keen business scent and be incessantly on the track; and have a very clear idea of what can be done or not done for the firm or by the firm.

(11) Capacity to find the cost of a piece of cloth.

(12) Self-trust.

(13) Daring by way of foresight.

(14) Power of Expression.

(15) Robust in health.

(16) Personal appearance.

(17) Resourcefulness by way of finance etc. for the purpose of security or deposit etc.

(18) Enthusiasm (in the real sense of the word, there should be no jealousy and spitefulness).

(19) Willing to listen and explain politely and also with interest.

(20) Love of mingling with people for the sake of deriving the bazar informations.

(21) The unnecessary nagging habit of a salesman should never be entertained.

(22) The salesman should always willingly co-operate with the weaving master and not interfere with his duties.

(23) The salesman should never be given the liberty of access to record books of the company which do not concern him.

## Duty of a Commission Agent.

The chief duty of a commission agent is to deliver the commodity at the exact time of demand. In this way there is no need to overstock the godowns and thus incur unnecessary loss for the mills that he is working for.

The question of creating a demand for a particular article is one of 'Salesmanship,' that is, a salesman must have the capacity of organising the production of a mill in the right time and in the right manner.

Demand determines value, and the art of salesmanship consists in the creation and direction of this demand to the particular article on sale.

It is the duty of a salesman to interest a buyer in the goods that he is selling and convince him in such a manner that he will be tempted to buy the goods.

*'Business building' rests upon attracting and keeping the customers.*

If a person attempts to sell something, about the qualities and limitations of which he is ignorant, then he is a bad salesman. Such a man may sell a quantity of his goods once to the credulous, but he will not succeed in establishing a sound repeating business. A commission agent or salesman must remember above all that he must get rid of the mentality of lowering the standard of goods for effecting an easy sale or in competition against other mills without considering the detrimental consequence that is bound to follow.

The getting down of prices on manufactured articles by taking out picks or weight and making up with size or filling, or by cutting down sizes to skimpy proportions is an easy–too easy–method of getting down prices. It is a short-sighted policy for it has inevitable reactions on the ultimate consumer and his or her attitude towards the article or make in question. Moreover, it should not be confused with the real getting down of cost by improving efficiency.

The salesman must not encourage the merchants with whom they might be dealing to stamp wrong widths and wrong length on the piece of cloth (whether dhoties or otherwise). By doing so both the merchant and the mills stand to lose and perhaps lose very heavily too not only their business but their prestige will be at stake.

Textile materials can be seen as daily necessaries of a semi-durable character only, and as an excessive consumption in one year dimimishes the level of stocks, these must be replenished.

Again, stoppage of looms or reduction in production will help to reduce stocks and thus form a huge potential demand which will produce excessive buying the moment it is felt that prices are right. There is no royal road except close application to one's business and that too by educating the user of your product to desire more of it, teach the consumer to have a liking for more cloths or whatever the product might be. Keep the range of selling prices as low as might be reasonably possible to make them attractive.

## Helping the Manufacturer.

In many cases when a manufacturer received an order for a cloth he was only given bare instructions, the merchant refusing to give any detailed information about the cloth and what it was to be used for. How could a manufacturer put his best into a cloth, if he did not know for what purpose it was intended ? If he had this information he would be able to make it suitable for its particular purpose. The cloth might appear in order while in the grey state, but it was in subsequent stages of finishing that faults would show up. If perfect goods were to be produced at minimum costs, there had to be complete co-operation between every branch of the trade from the cotton broker to the merchant.

## Determining Unremunerative Lines.

There are many selling agent or salesman today, and I am afraid many principals who have not the means of knowing which lines are remunerative and which are not. Frequently on analysing a line which has been supposed to be remuneratives on real investigation to be the contrary. The dangers of "averages" are more real than is generally appreciated in the textile industry.

In some types of business the manufacture is only carried out when the order is received. In other types of business, future demands must be forecast and goods manufactured so that sales can be made from stock. In business where fashion enters into the calculations, a very close study must be made of the trend of events. It is safe to say that on no side of the business is information so necessary to management as on the sales side, although this point is not so frequently appreciated.

## Design Creates the Demand.

The designer is the worker who creates the demand especially if he is, continually striving to produce something novel that will catch the public taste.

The continual production of new effects in textile fabrics may be very costly, but it is the inevitable precursor of progress and manufacturers must carry on with it or go out of business.

The managing agent as well as the head salesman or selling agent must have the means of knowing the cost and profit on processes or products, so that he can determine which lines are most remunerative and should be pushed, and which are the least remunerative which should be stopped or reduced. Before withdrawing unremunerative lines it must be ascertained from the market whether some change in the design to cheapen production may not be possible, otherwise the managing agent or his manager should study the manufacturing processes to see if efficiency can be improved with a view of lowering the cost of production.

No salesman should be trusted with the actual cost of the various processes unless he is very honest and reliable and worthy of being taken into confidence of the secrets of the mills.

## Varieties should be Limited.

Always endeavour to limit the number of varieties or sorts and concentrate on bulk standard production. If the customers are convinced that certain dimensions only can be obtained, but obtained much cheaper, they will adapt themselves easily to the situation.

## Colours used in Dhoty or Saree Borders.

Green and Blue—all the year round in proportion of 16 and 8 per cent respectively.

Red Borders—The red borders are in great demand during the months of January, February, March and April.

The width of borders of various qualities are $\frac{1}{8}''$ to 2″ generally. Borders up to 5″ are manufactured particularly in fine counts on a limited scale. Dhoties and sarees are manufactured throughout the year.

The months during which Dhoties and Sarees should be manufactured in readiness for Doorga Pooja, Devali and Dasra holidays are—August, September and October. Sarees woven with borders in artistic designs whether cotton or artificial silk and with fine counts of yarn are greatly in demand in the Bengal Presidency.

Heavy sorts or coarse cloth including Blankets and Chaddars are manufactured during the months of—November and December that is particularly during the cold season. Durries are often in demand.

Satens, Longcloth and grey cloth for Dying purposes should be manufactured as demand arises.

Drills and Twills should be manufactured in accordance to the bazar demand.

For shirtings etc. follow the market or watch the demand for qualities and designs.

The cloth market is generally slack during the month of May, June and July.

## Points for making a change in cloth Contracts.

(1) "Weight" or "Length" against weight or length must be considered (if sold by weight or length).

(2) If 'widths' vary, square inches (Length × Width) against square inches must be made the basis of change or transfer.

(3) If coloured goods are under consideration for making a change or transfer then consider the difference in cost and the profits that would have been made if the transfer were not allowed. Always bear in mind while making a change, cost, loss in production, loss in profit and loss in carrying unnecessary stock of Colours, Chemicals, etc. as the result of the change.

(4) In coloured or dyed goods not more than 3 or 4 shades or patterns in the case of fancy designs should be allowed per bale unless the merchant is willing to pay extra for wastage and loss of production that will result due to change of patterns etc.

(5) At times a very clever merchant may come forward with an enquiry for manufacturing say a 2″ Border Saree the dimension of which is 44″×10 yards and after obtaining the selling price for this width he would then ask to quote for 28×5 yards and 31″×6 yards on the basis or in proportion of 44″×10 yards by doing so the mill will be the loser. The basis of selling price should not be the proportion but actual cost price worked out individually as the case may be.

(6) Manufacturing instructions from a salesman must always be received officially in writing.

(7) Be careful to insert every detail while making a contract for instance a merchant may buy 101 bales of Dyed Susi in 4 colours namely, black, red, blue and green without stipulating the number of pieces of each colour to be packed in each bale. Because he might tactfully attempt to fix the price of all the four coloured

pieces on the basis of an average say for an example the cost is 2 annas for Black, 3 annas for Red, four annas for Blue and eleven annas for green then the average will work out to be (20 annas $\div$ 4) $=$5 Annas as the dyeing charges per piece. Now here where the catch lies—after taking delivery of few bales of the right proportions of colours he will in a clever way try to get round the weaving master to give him two colours in the bale only namely blue and green and he would suggest that the price has already been fixed at 5 Annas per piece for dyeing so there is no harm in packing two colours only in a bale. In such a case it is for the manager to refuse it and make it clear to him that the change from four colours to two colours will entail a higher cost that is 7½ annas and not 5 annas per piece.

## Helpful Suggestions to a Salesman.

(1) Study in advance the position and needs of your new customer very carefully before you call on him. Remember that there are busy and dull seasons in every business.

(2) Be prepared to suggest ways and means to him as how he could make profit from the business you have to offer him. Most people are poor judges of value.

(3) Find out the education, the family position, business history, clubs and recreations that your new customer is interested in.

(4) Pass any helpful information to your new customer should you come to know about it.

(5) Do not discuss the price of the goods before you explain the good features of your production. Price is not generally the deciding point in sales; persuading buyers to want the article is the most important factor.

(6) Do not discuss politics or any other topic which does not concern your business.

(7) Never gossip about your Competitors.

(8) You may pass informations about the money—making constructive activities in the same line of business.

(9) Never persuade your firm to lower the quality of goods to spite Competitors.

(10) Never persuade your firm to cut down the prices when you know the prices are fair. A low price will not of itself, create a demand for an article.

(11) To compete with others you must adopt their methods in every respect.

(12) Concentrate either on selling the cheapest goods only or superior goods only. Preparing articles in a more attractive or more convenient form will cause a demand, even at higher prices.

(13) The stocking of too many varieties is disastrous. It leads to debts and dead stock.

(14) It is more profitable to sell goods in two weeks and make one rupee profit on one sort than to keep that sort for one year in the hope of making two rupees profit. It may be added here that it is a wise policy at times to sell the stock at a small loss than by keeping the stock and pay interest to the bank on the borrowed money against it hoping for a better time to come which might be a great deal worse when it does come.

## The Point of View of the Buyer.

(1) If I want the article and cannot do without it any longer —Public Demand.

(2) If I have the money to pay for it and I can afford it— Spending Power of the Public particularly the Agriculturist.

(3) If it is offered at a less price than I can buy it elsewhere —A Fair Price.

(4) If it is of sound quality, and looks nice—Make up or the tempting Attractiveness of the goods.

*Severe Competition necessitates an army of salesmen and buyers, all acting as keen advertisers of their employers' goods.*

## CHAPTER VIII.

## "CONSUMPTION OF COTTON."

The consumption of cotton per 1000 spindles per day in India is about 6,224 candies of 784 pounds or 15 bales of 392 lbs employing 418,000 work people with a total paid up capital amounting to Rs. 40,55 lakhs, whereas in Great Britain it is about 9¼ bales. In Lancashire there are operating 17,000,000 fine spindles out of 23,000,000 in the whole of Europe and out of 25,870,000 in the whole world.

### Spindles in the World.

Out of a total of about 180 Millions of Spindles in 1938 all over the world, Great Britain has 38,000,000 whereas in India there are about 9¾ Millions and hence India stands fifth in Textile World.

Japan in 1937 had 13,474,102 spindles and the United States of America 27,000,000 during the same year. The latest American census figures show that out of a total of 27,676, 805 cotton spindles there are 313,056 mule Spindles.

### Looms in India Compared with England and other Countries.

Out of the total number of 471,258 looms in Great Britain there are about 2,00,000 (automatic looms—about 5 per cent).

Whereas the total number of looms in India is about 1,97,810 during the year of 1937.

### The Cotton Mill Industry.

An average cotton mill is divided into five departments—General establishment, Spinning department, Weaving department-ment, Dyeing and Bleaching departments. There is also to be found in some of the mills a Printing department.

The mill industry is well distributed over the country with the main centres in Bombay Island and Ahmedabad. Bombay Island leads with over 2,889,509 Spindles and 66,758 looms in 69 mills; and Ahmedabad follows with approximately 19,76,370 spindles and 48833 looms in 81 mills in the year of 1937. Then come the other centres such as the United Provinces, Calcutta, Punjab, Delhi, Central India, Madras Presidency including Cochin etc.

### Cotton Mills in British India for the year 1936-37.

| No. of Mills | Paid up Capital Rs. | No. of Spindles. | No. of Looms. |
|---|---|---|---|
| 303 | 31,62,31,669 | 8,054,088 | 1,63,175 |

### Cotton Mills in Indian States for the year 1936-37.

| No. of Mills. | Paid up Capital Rs. | No. of Spindles. | No. of Looms. |
|---|---|---|---|
| 64 | 6,24,45,059 | 1,260,501 | 27,890 |

### Cotton Mills in other centres—during the year 1937.

| | No. of Mills. | Spindles | Looms. |
|---|---|---|---|
| United Provinces. .. .. .. | 25 | 7,41,051 | 11,245 |
| Bengal Presidency .. .. .. | 26 | 3,52,368 | 8,545 |
| Punjab .. .. .. .. .. | 7 | 94,314 | 1,853 |
| Central Provinces .. .. .. | 8 | 3,22,926 | 5,739 |
| Delhi Province .. .. .. .. | 6 | 1,04,376 | 3,028 |
| Central India .. .. .. .. | 15 | 3,69,834 | 9,967 |
| Madras Presidency including Cochin .. | 47 | 11,50,886 | 6,169 |
| Mysore .. .. .. .. .. | 7 | 1,27,816 | 2,334 |

Bombay and Ahmedabad now appear to have reached saturation point as regards their present numbers of mills, and there is a definite tendency for new mills to be erected adjacent to the cotton producing districts, and within easy reach of consumers. Not only do they save transport costs, but they also have an advantage in labour costs; and the initial benefits of cheaper land, buildings, etc.

The chief centres of development at the present time are the Coimbatore district, where the number of mills has increased with the last six or eight years from about 5 to 25 and Bengal district, which has hitherto been very backward in attempting to cater for its own large consumption of yarn and cloth, can now claim about 80 mills to its credit that are working and in the course of erection.

Now is the turn of Bengal to make a special effort to grow more cotton so that it will not only supply adequately to the existing mills but also there should be a surplus for mills that may be built in the future if the extra burden of cost of importing cotton is to be saved.

## The Average Counts Spun in India.

In India the average counts is about 20s owing to coarser average counts produced, the consequence, therefore is higher production than in Lancashire or Europe, as the working hours, which is longer in India, should also be taken into consideration. Night work formerly was not so usual in India. But recently practically all the mills in India have made up their mind to work their mills in two shifts. India grows about 26 per cent of the world's cotton, which can be spun only what is known in Lancashire as coarse counts, that is to say up to 40s. The change from lower counts to higher counts of yarn and from coarse cotton goods to the finer varieties has been achieved with remarkable expedition particularly in Ahmedabad. Formerly a good deal of American Cotton was imported, but the most favoured cottons at the present time are Uganda for counts about 40's to 60s and Egyptian for counts up to about 120s.

During the last few years there has been a marked tendency to depart from the old standard of $20^s$ to $30^s$ counts, and at the present time a large number of mills are concentrationg on $30^s$ to $40^s$ and $40^s$ to $60^s$ whilst a number of mills are producing up to $100^s$ to $120^s$. This tendency towards finer counts is the result of severe internal competition between Indian Mills on the lower counts, and this tendency will no doubt be maintained. A number of mills are also experimenting with the spinning of staple fibre, and it would appear that this is a side of the industry which will extend in the near future. Yarn spun in India could be divided as coarse, medium and fine, taking up to 14s as coarse from 15s to 29s as medium, and from 30s to 60s as fine counts. Whereas in England up to 40s is considered as coarse upto 90s is considered as medium and above 90s is considered fine counts.

## Fluctuation in Cotton Price.

The price of Indian cotton fluctuates in sympathy with American Cotton prices. In India a spinner buys his cotton and if the market goes up he gains on his stock, should the market fall he stands to lose as he has to reduce his yarn prices to the prevailing market prices. Because he has not got a regular system of covering sales, that is, he does not buy futures to cover yarn sales.

## Cotton used and Counts Spun.

Presumably for counts upto 20s, Indian Mills output approaches 50 per cent upto 30s as much as 85 per cent. While about 10 per cent go to make up for counts 31 to 40 only 5 per cent mark the limit above 40s.

Owing to the competition from artificial silk, the higher standard of living and the spread of civilization, there has been an ever–increasing demand in the world for fabrics possessing better finish and appearance. This has often necessitated the spinning of textile materials, such as cotton, into finer counts. The same tendency has been in evidence in the Indian Cotton mills statistics which show that in 1926–27 these mills spun 515,000,000 lbs of yarn under 20s counts and only 39,000,000 lbs of yarns above 30s counts. Within the brief period of ten years, in 1936-37 these figures stood at 592,000,000 lbs. for yarns under 20s counts and 185,000,000 lbs. for yarns above 30's counts.

Thus the production of yarn below 20's counts showed an increase of only 15 oer cent. Whereas the production of yarn above 30's counts registered an increase of 370 per cent.

This enormous increase in the relative proportion of the finer counts was made possible partly by the importation of foreign long staple growths, partly by the steady improvement in the quality of Indian Cotton Crop and partly by the adoption of such mechanical aids as better opening and cleaning, high draft system of spinning and the use of combing machines.

For ordinary grey shirtings, Long cloth, etc.—Punjab American or Karangani cotton is used, very often, other inferior qualities of cotton are also blended with it.

## Loss per cent in Spinning.

General percentage of Waste loss in Spinning =20%
Percentage of Waste in Spinning in Bolton =8.57%
" " " " " " Oldham =8.89%
" " " " " " Bombay =10.23%
" " " " " " Ahmedabad=9.82%

## Turn per Inch and Test of yarn.

Average Strength of 20s Ring Twist Yarn =65 to 70lbs. per lea.
Turns per Inch of 30s Spun yarn from Indian Cotton=27
" " " " 30s " " " Uganda Cotton =21

| | |
|---|---|
| The highest counts spun out of Indian Cotton | =40's |
| The Standard warp twist in U.S.A. for 20s | =21.24 |
| The turns per inch in U.S.A. for 20s weft | =14.53to15.65 |
| In England warp twist for 20's | =18.00 |
| The Standard warp twist in U.S.A. for 36s | =28.00 |
| In England warp twist for 26s | =24.00 |

The difference in the turns per inch must be taken into consideration in the costing, because it means 16 to 20 per cent greater outlay to buildings, machinery power and upkeep.

For spinning 30s to 40s—1" to 1¼" staple cotton is used.

Although in U.S.A. yarns are spun commercially up to 300s, and even occasionally up to 400s, few American mills spin over 125's or 150's and most mills do not spin over 120s weft and 100's warp yarn, relying on the English mule spun yarns for the finer numbers.

A considerable amount of combing is done even in the coarser counts, which are generally used in the hosiery trade.

The combed yarns are usually made from cotton of $1\frac{1}{16}$" or longer staple, two of the growths of cotton used being Upland Peeler $1\frac{1}{16}$" to $1\frac{5}{16}$" Sea Island 1½" to 2½" Staple, and 1¼" to 1⅝" Pima.

The counts in the ordinary grey shirtings are 18s warp and 20s weft although there are some qualities that are woven from 20s and 30s twist and 30s and 40s' weft etc.

Dhoties and Sarees of an ordinary quality woven from 22s warp and 24s weft and there are also Dhoties and Sarees that are woven from 20s twist and 30s weft or 30s T. and 40s W. or 40s T. and 60s W.

"Approximate tests per one full Lea for Reeled yarn."

| | | | | | |
|---|---|---|---|---|---|
| 6s | =105 | lbs. | 20s | =58 | lbs. |
| 6½s | =100 | ,, | 20½s | =55 | ,, |
| 7s | =95 | ,, | 21s | =52 | ,, |
| 10s | =90 | ,, | 21½s | =50 | ,, |
| 10½s | =85 | ,, | 30s | =40 | ,, |
| 11s | =80 | ,, | 40s | =34 | ,, |
| 19½s | =62 | ,, | | | |

## Packing.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6½s | = | 18 | Knots per bundle in Red and White tie. | | | | |
| 10½s | = | 21 | ,, | ,, | ,, | ,, | Red tie. |
| 20½s | = | 20½ | ,, | ,, | ,, | ,, | Red ,, |
| 40s | = | 40 | ,, | ,, | ,, | ,, | White ,, |

## Ring Frame Production and Efficiency.

Average production of 20's warp — 6.50 to 7 ozs. per Spindle per day of 9 hours.

Ring warp Average production of 30s worp — 3.25 ozs. per Spindle per day of 9 hours.

Ring warp average production of 42s warp — 2.75 ozs. per. Spindle per day of 9 hours.

Number of doffings per day on 20s = 7 of 1¼ to 2 minutes each Spinning Efficiency = 90 to 92 per cent per day of 9 hours of 24s counts of yarn.

Breakages per 1000 Spindles should be 20 to 30 per hour for medium counts. The writer has an experience of some mills where the breakages per 1000 spindles per hour used to be from 80 to 100 due to the inferior quality of cotton. In England and the continent of Europe it is a common practice for one operative to mind considerably more than 1000 spindles, whilst in America, where wages are still higher, one operative will tend upwards of 1200 spindles, whereas in India one operative looks after one side about 300 spindles.

The number of spindles which can be efficiently tended by one operative is largely determined by the quality of the spinning, and under this head the most important single item is end breakages. If breakages can be improved by improving the quality of cotton mixings for counts spun, the atmospheric conditions, gauging, ring, lift, drafting unit. etc. then one operative can easily be trained to mind at least 600 spindles.

## Size in Indian Cloth.

Average amount of size in Indian cloth is generally about 10 to 40 per cent. Although there are some mills that weave cloth with about 100 per cent or even more than that.

## Weaving Efficiency.

Weaving efficiency is 75 to 80 per cent in most upto date mills per 9 hours but can be increased to about 85 per cent if all the loom are working on plain weave cloth, and if there is strict and efficient supervision in the mill. The yarn must be good and the weavers efficient in their work.

The best modern mills manufacturing plains, twills, Sateens poplins, and fancy dobby cloth in the grey, do not exceed an efficiency of 75 per cent. In the coloured trade an efficiency of 60 to 65 per cent is considered good. On the other hand mills having Northrop looms have an efficiency of 98 per cent for grey and 85 per cent for coloured goods.

Average waste of the weaving departments varies from 1 to 3 per cent. The percentage of fents and rejected pieces should not exceed three per cent.

Efficiency may be calculated as follows :—

(*a*) By taking the theoretical revolutions of all machinery as running with no allowance for any kind of stoppages.

(*b*) By taking the calculated R. P. M. of various widths of looms and allowing 3 to 7 per cent for slippage and also a reasonable number of looms say (5 per cent.) are to be considered as stopped for delay for replenishing or waiting for beams etc.

(*c*) Bear in mind that the chief factors that influences the work in a weaving shed are as follows :—

*Machine*—the lay out, the kind of machine, Makers and condition of machine.

*Material*—Counts and quality of yarn and the condition in which it is delivered from one process to another process.

*Men*—Ability and training of each individual operative, the help or supervision that he receives from his superiors and the facilities that he receives by way of material and help towards his health.

*Other Factors*—Climatic conditions, construction of shed labour control, surroundings and psychology of the working people.

(*d*) Efficiency is a necessity. It is a way to prosperity. It throws light upon the amount of energy lost, through carelessness of all concerned.

(*e*) A machine cannot lie. It is the best tale tatler. It tells the truth about everything. Watch it with keen interest if maximum efficiency is desired.

## Consumption of Cotton cloth per Head per Year.

Cotton is the chief material worn, though the better class wear also silk and woollen garments. The consumption of cotton cloth per head per year was about 17 yards in the year 1938 or about 6 lbs, whereas the consumption per head in U.S.A. is about 24 lbs. (which may include what is utilised in motor industry etc.), whilst in England it is 15 lbs. and in Germany it is about 12 lbs.

In 1931–32 the per capita consumption of cloth in India was about 14.28 yards while it was about 13.29 yards in 1913–14.

The poverty of the Indian people is so great that for some years to come there is little prospect of an appreciable rise in the per capita consumption of cotton cloth.

## Foreign Supply of Cloth.

India was dependent for foreign supply for about 65 per cent. of its cloth consumption whereas England could clothe the whole world without growing any cotton.

## Cost of Production (Ahmedabad).

The cost of production in Ahmedabad is lower than that in Bombay. Because the Ahmedabad mill owner buys the latest machinery that gives the maximum production with the least cost. It must be admitted that Ahmedabad Mills have improved wonderfully in producing good quality of cloth which is manufactured according to public taste and demand.

## Ahmedabad vs. Bombay.

During the last ten years the Ahmedabad mills thrived and those of Bombay have deteriorated. As compared with 1926–27, the number of mills in Bombay decreased from 83 to 69 in 1936–37 and the number of spindles and looms also decreased from 34,66,426 and 74,545 to 28,89,509 and 66,753 respectively.

In Ahmedabad there has been a notable increase, the number of mills increased from 66 to 81, Spindles and looms increased from 1,402,948 and 30,721 to 1,976,37 and 48,833 respectively.

Out of a total of 370 mills in the whole of India, Ahmedabad possesses 81 mills and the mill workers number about 80,000.

Up to the end of the great war Bombay held an unchallenged position and dominated the textile industry in India. In the post–war period, however Ahmedabad forged ahead to expand and develop its industry, in a manner and to an extent which simply left Bombay gasping.

It is important to point out that Bombay's share of the total number of mills in India fell from 32.9 per cent in 1919 to 18.6 per cent in 1937, while Ahmedabad increased its share from 19.8 per cent to 21.9 per cent in the same period. The share of the rest of India also went up from 47.3 to 59.5 Likewise in the production of yarn Bombay's share fell from 49.7 in 1918–19 to 26.3 in 1936–37, while Ahmedabad's share increased from 11.9 to 15.5 and that of the rest of India from 38.4 to 58.2. The corresponding figures for woven goods are 50.6 and 32.1 in the case of Bombay, 20.3 and 21.7 in the case of Ahmedabad and 29.1 and 46.2 in the case of the rest of India.

## Chapter IX.

## WORKING HOURS OF THE MILLS.

The textile mills have a fifty-four working week of nine hours per day for six days–both summer and winter alike. Although the engine works nine hours a day with a break of one hour's interval after first five working hours, yet the operatives do not work continually the whole of the day, or the full nine hours. The majority of the operatives take complete rest during the dinner or interval hour, which is also used as an opportunity for oiling the engine, etc.

Whereas in Bengal, there are the same nine hours but with a break of two hours interval. During working hours the operatives spend a good portion of time in taking their meals behind the looms or machinery and go out at their discretion for drinking water, washing, or smoking or for prayers (chiefly Mahomedans) or for settling their home differences, etc. Their best meeting place is the lavatory in the factories. In some of the mills they are allowed to smoke near the boilers, the blacksmith's shop or at a place which is intentionally set apart for the purpose. They at times take too much advantage of this liberty, and, hence it affects the production to an appreciable degree.

The meals of the workers are generally brought to them by either a member of their family or the person with whom they may be boarding. It is wonderful to see a woman carrying the food of about 10 persons on her head put together in separate brass boxes on a copper or brass tray. It is very amusing to see a woman dodging about from place to place to prevent everybody who does not belong to the same cast as her own from touching her. If an outcast touches her it means a starvation for her husband and a thrashing for her, if, her husband happens to be a wicked man.

The writer has on more than one occasion seen a woman standing in the pouring rain in the compound of the mills in one of the corners waiting with the food of her husband in her hand for him to come out. It might be mentioned here that in India the wife of a labourer is strictly prohibited from carrying an umbrella in her hand or even put any shoes or chapals as they are called, on her feet. Is not that a pity for a woman to be treated in such a manner? There are few women who are now daring in going against the old customs. Some of the mills have tea-shop as well as sweetmeat shop inside the mill compound. Should a worker feel hungry at any time of the day he can proceed to the shop and obtain what he wants on credit. The shop affords the idle operatives an opportunity of idling away their time.

The labourers go out oftener in summer than in winter as it is fresher and cooler in the open than inside the mill. They are given a kind of token (cast iron) which cannot be easily stolen or destroyed, which they carry in their hands, and the guard or door-keeper posted at each exit does not stop any one that passes him with one of the tokens in his hand. One or two tokens are provided in each section of a department, that is 15 to 20 operatives. Eighty percent of the textile hands are men or boys. Women or girls are also employed in winding, reeling and spinning room. The employment of women is limited owing to reasons of caste, early marriage, family custom, etc. etc. There are some mills where only men and boys are employed. The women start work an hour later than the men and leave half an hour earlier. They are admitted into the Mills on presentation at the main entrance of a ticket made of tin bearing their numbers etc. Although this practice is not in vogue so much outside Bombay.

## THE ENGAGEMENT OF LABOUR.

When a worker is engaged, all desired information concerning him is entered on a labour engagement Pass Book. The rules of the company is then read out to the operative and his or her thumb impression taken as a proof that the rules were explained to him or her.

The practice, which is almost universal, is to allot to each worker a number, by which he or she is identified, and which is used for reference in the records and accounts pertaining to the Time-Keeper's office or department. This number is known as his or her ticket number. Where there is a large number of employees, it is useful to reserve a block of numbers for each type of labour, or for each Department, e.g. 1 to 100 Engineering Department, 101 to 200 for the Mixing, Blow room and carding Department and so on.

### "Method of Checking Tickets."

Tin discs bearing the worker's numbers are placed on hooks on a board at the entrance of the mill. The worker, on entering, the mill gate places his or her ticket on a hook bearing a corresponding number to his or her number on the ticket. The late comers are required to place their tickets in a box which is known as the 'late' comers box. The tickets enable the time-keeper to enter up the Attendance Register after which the tickets are handed back to the workers by a boy who goes round the departments. The checking of attendance is done twice a day both in the morning and the afternoon.

### "The Prevention of Fraud and Irregularities in the Muster-Roll."

Frauds in connection with the payment of wages are liable to occur provided sufficient precautions are taken by means of independent checking and counter-checking.

The following points may be adopted to ensure against fictitious names being entered and irregular payments paid out.

(1) The Time-keeper should see that each worker while entering the gate places only one ticket either on the board or in the box provided for the purpose of checking and every ticket must bear a number and the name of the department for an example the letter "S" for spinning and "W" for weaving and so on in which an operative is employed. The numbers on the ticket must be very strictly in a consequtive order from the beginning to end. No gaps should be allowed under any circumstances.

(2) The attendance book or the muster-roll should be checked daily by a responsible officer of the mill initialled each day. No erasing should be allowed in the muster-roll.

(3) Fixed wage muster-roll and piece-work records or muster-roll must be checked both at the mills and counter checked by the Head Office.

(4) Overtime should be sanctioned in advance, and an overtime slip should be made out and signed by the Departmental Officer and countersigned by the Manager.

(5) Operatives leaving the mill during the working hours should present pass out slips, duly signed, by the departmental officer, stating reason. The gate-keeper should hand over such passes daily to the time-keeper for varification.

(6) The actual paying-out to the workers should not be done by the time-keepers who prepare the pay-sheets. Pay envelopes which must be counter checked, should be the style of making payments.

(7) The Head-jobber of each department should be present during the paying-out of wages to see that the payments are distributed correctly, and to identify the recipients. Each operative must hand over his or her indentification ticket to the pay master and at the same time call out his or her name.

(8) A substitute should be paid at a lower scale of wages than the fixed man and the practice of taking advantage of paying a substitute at a much higher wage than the sanctioned or standard wage must be carefully watched or rather checked monthly if possible. This practice is generally adopted particularly in the Engineering department. All substitutes should be given a token either with a particular mark or Colour for distinguishing it from the permanent ones.

## Textile Workers in India.

### Factors that affect the Workers.

(1) Hours and conditions.
(2) Remuneration.
(3) Efficiency methods.
(4) Fatigue study.
(5) Time and Motion Study.
(6) External and Internal organization
(7) Housing facitilies with plenty of air, light and also particularly sanitation.
(8) Recreation.
(9) Education particularly free education to the children of the workers.

## "Qualities that a worker should possess."

(1) Carefulness.
(2) Punctuality.
(3) Obedience.
(4) Honesty.
(5) Industrious.
(6) Good memory.
(7) Patience.

(8) Sobriety.
(9) Reliability.
(10) Loyalty.
(11) Spirit of Co-operation with brother workers.

"How Intelligent are the Employees."

The usual practice in most business is to fit the majority of their employees into jobs which suits them, by a method of trial and error. The employee is assumed capable until he proves incapable, and he is then moved into a simpler job, and thence perhaps, to a still simpler one, until at least he is either found one suited to his abilities or dismissed.

## "Money lost."'

It is not generally realized how much money is lost as a result of this hit or miss method by reason of lowered production and faulty work.

There is as much variation in intelligence as there is in height, and the variation is similar in character. There is an average height, from which individuals differ more or less considerably, being either taller or shorter. There is also an average intelligence, from which individuals similarly differ, but for obvious reasons, deviations from average intelligence are more difficult to perceive and to measure.

## The Mill Hands.

When the mill hands first migrate to the big industrial centres, they are known as Dehatis. In the vast majority of cases their wives and children are left in the village home, and the married man finds himself bereft of home ties at a time when their steadying influence is most needed. The village home, a poor thing enough, was, nevertheless, his own and that of his family. Moreover the mud wall of the compound gave him the privacy so dear to all Indians. They may be clad very poorly if not in rags and give one the impression that they are ignorant and very humble, and when they first see a white man or an officer for a job they bow to the earth before him.

They have certainly advanced and very fast too in the art of both spinning and weaving. Some of them are so good in their knowledge both practically and theoretically, it may without any prejudice be said as good as a Lancashire man. They are not slow in picking up or noticing a new thing no matter how difficult it may be, they endeavour very zealously, persistently and patiently to do it, if not master it.

There are good few of the operatives that invest their money in landed property or agricultural lands, and hence some of these do not fail to manifest defying attitude at times to their superiors due to the fact of their independency. On the whole they are willing, hard working and ready to do any sort of work if they are shewn how to do it. It is very seldom when they are asked to do an extra bit of work that they turn their back on you or decline to do it, whether they are paid extra for it or not, more often than not they do not receive anything for it. The majority of them are faithful unless they are ill-treated.

The Indians are at heart agriculturist. They willingly return either to their families or relatives in their village and tend the paddy fields or the cotton fields without suffering any loss, as they will be provided with food as long as they wish to stay and hence they have very little ambition of improving themselves. Undoubtedly the custom for the worker to go back to his village occasionally has its advantages inasmuch as in case of ill-health, it gives him a place to retire and recover to his former health by a means that he has his faith in.

The bulk of the labour may be considered permanent in the sense that the workers return to the same mill when they get fed up of their indolent design for a change.

## Operatives Mode of Living.

The majority say 90% of the textile operatives live in houses containing several rooms the size of which is about 10ft × 10ft in densely populated areas with bad sanitation. Some of the rooms are so dark that even at midday to see a face at no more than an arm's length one has to have a light. Because they have a tendency to close up their rooms and stop light and fresh air from coming in. This habit of over—crowding is responsible in a large way for loss of efficiency, sickness and heavy infant mortality.

Their mode of living is simple but no better than pig style. It is appalling how poorly some of the cheap labourers take care of themselves. Some of them go several weeks without taking a bath. Others that do take a bath use no soap and put on again the same dirty clothes that they take off before getting under the tap or in a tank. The writer has witnessed several times operatives taking their bath under a tap or in a tank with their clothes on so that, their clothes and body be washed at the same time. Also by this way it serves the purpose of moral decency, as they take their bath generally in a public place. When they finish somehow or other they manage to dry their clothes (those that are very poor by standing out in the sun) to put them on again.

Six to ten persons occupy the same room. Whether they may be the members of the same family or be temporary lodgers it is a most common thing to be met with. If one were to pay them a visit it will be found that, besides themselves, they may have a cow or a goat or fowls to participate in their dwellings. In fact they are forced to live a most miserable life and it is shocking to see them in such a miserable state which they tolerate patiently.

Unfortunately they have to pay a heavy toll whenever an infectious disease, such as smallpox, cholera or plague breaks out amongst them. The effects of plague etc. have an ever-recurring factor in the problem of the industrial labour supply.

A common skin disease to be found amongst their children women and men alike, is eczema or some such sort of infectious skin diseases. The majority of them are never free from it. Nature is certainly kind to them and bestows upon them plenty of sunshine, and even then the death rate is generally appalling.

## Cost of Living.

This element also plays a significant part both in the determination of the standard of an adequate "living wage" for workmen and the building up of their physique. It is no doubt to the interest of efficiency of the industries concerned that the necessaries of daily life, particularly articles of food and clothing, should be procurable by working classes at the most advantageous rates. It is hardly necessary to state that well-fed properly clothed and adequately housed labour is generally able to maintain its standard of efficiency at a uniformly high standard. If therefore, these necessaries are procured at rates which are most advantageous from the point of view of labour, the wages of labour are also likely to be cheaper.

*An atmosphere of "Plenty" is good because it is stimulating. An atmosphere of "Want" is bad because it is depressing.*

## Co-operative Societies.

The employers can also help to lighten the heavy burden of indebtedness of the working classes through Co-operative societies of men under their employment. These societies would not only help the workmen to borrow at lower rate of interest, but they would also help in the redemption of debt and in fostering and encouraging the habit of thrift.

## Factory Labour is Inadequate.

The position of the operatives is greatly strengthened by the fact that the supply of factory labour undoubtedly is, and has been inadequate and there is, and has been the keenest competition among employers to secure full labour supply. This all militates against efficient labour as very few of the employees are truly and thoroughly skilled. Some of the best of so-called skilled operatives show no conscience in their work as their sole aim is due to lack of education, poor nourishment and plenty of liquors etc. to pull through life with the minimum amount of work as long as he and his family obtain their daily rice, dal and chapati. They also dodge the money-lenders or their creditors (Bania, Marwari, or Pathans) into whose clutches they easily fall victims due to the heavy expenses incurred on marriages, funerals, death ceremonies, birth of sons, periodical religious and feast days. They see very little of a real life and they understand very little about it. They are knotted very badly, in religious matters, caste distinctions, jealousy, etc., which somehow or other tend to interfere to some extent with their progress. Some of them fall victim to dishonesty driven to it either due to the influence of drinks or temptations of other vices, but the dishonesties chiefly of the Mistries and Jobbers are not betrayed very easily partly due to a sense of gratitude on the part of the operatives for having been given to them or rather having obtained a living through their mistries who very often resort to might and may even go to the extent of murdering those that they suspect for their betrayal.

## The Faculty of Indian Labourers.

An Indian operative is in general independent of the factory work to the extent that he does not rely exclusively upon factory employment in order to obtain a livelihood. At most seasons he can command wages sufficient to keep him going probably on a somewhat lower scale of comfort by working at the docks as a coolie etc.

One must admire them also for the perseverence and abilities of adapting themselves to all sorts of work. They possess a remarkable faculty of changing their situations in the mills, an operative may be a piecer one month in the spinning room and may be next month developing into a sizer or weaver, due to the temptation of getting more money. The barrier of illiteracy is insurmountable. The most intelligent worker can only look to a jobber's post. Amongst the jobbers one can hardly come across men who can read or write English and in some cases even in his own language.

*One of the main factors in production is labour, and when referred to in an economic sense, labour means exertion. It is obvious that labour or exertion will be required to extract from Nature her gifts.*

*A peculiarity about labour, which enables it to stand out from the other factors of production, is that it is individualistic, that is, it is vested in the individual. In the earlier stages of civilization man was the producer and consumer combined. To-day he is the same, only in a more ordered fashion, for he must labour to produce, in order to gain the means whereby he may consume.*

Whenever the condition of the work and living are such as to cause a considerable amount of bodily discomfort and discontent, human nature as strong in the working man as in any one else, is stirred into a state of improductive restlessness. From this it is obvious that there are two distinct phasses of this subject to consider —the place to work and the worker's place to live in.

The first deals directly with production because light, ventilation, sanitation and other condition of work have a very pronounced influence on both quality and quantity.

The second has just as important and active—effect on production, if they are forced to live in surroundings of inconvenience and discomfort. He may willingly put up personally with reasonable discomfort, but his family's discomfort will worry him terribly and naturally they will reflect that state of mind in his working by lessened production, by lost time, looking for a less unsatisfactory dwelling place. The highest degree of unrest is to be found among non-owners of home and those that move from district to district without their family and thus find a temporary home with others. Many large employers have overlooked the obvious reflex of human nature and have neglected the opportunity afforded by it to create stability, contentment and interest in their workers, by providing them with homes at reasonable rentals and other necessities of life such as grains, rice etc., at a reasonable price thus deriving the following advantages :—

(*a*) A better class of operatives (*b*) More contented, efficient and sufficient workers (*c*) Better control of labour situation with greater facility (*d*) If a labourer feels that his day's work is not only supplying his basic need but is also giving him a margin of comfort and his children their opportunity in education, and his wife some pleasure in life, then his job looks good to him, and he is free to give his best for it. (*e*) Every enlightened employer must recognize the justice and necessity of paying wages enough to maintain a certain "Standard of Life."

It may be added here that efforts are being made by the mill owners on a large scale to erect dwellings on or near the mill premises for a proportion of their labourers.

## Monotonous work Dulls—Change Develops Brain Capacity.

Today we are witnessing the triumph of the machine, and this triumph meant that a great deal of the monotonous, exacting toil of the past has been superseded. It has given us more leisure and we must find new interest for that leisure. The mechinization of the world must mean a drastic reconstruction of industry. The worker will be rationed with fewer hours of labour and this enforced leisure time will have to be filled up with new employments and new interests. The machine, if we make it our slave, instead of making ourselves slaves to it may end this monotonous toil by performing the part that slave labourer did in the old Greek world, and give every one of us a richer and fuller life. We are all human beings and we should get satisfaction out of life as well as a living.

The employer should provide for the employees some sort of recreations which must be looked upon and conducted with interest so that they may be fed with something elso besides gloom.

Some of the mills have introduced cinema shows for the operatives who are entertained once a week. It is one of the best means of educating them besides being a sort of recreation for them. Here the mill owners could take the opportunity to educate their employees for their work, their home and health.

It would be a good thing if the cinema could be used for the purpose of showing the various processes involved in the manufacture of cotton goods. This would enable the operatives to observe any defects in their work etc.

*To understand how pleasure heightens the suggestibility of the individual it is but necessary to consider the well-known effects which pleasure has on the various bodily and mental process.*

*With pleasure the lungs are filled with air from deepened breathing; the volume of the limbs is increased by the increased flow of the blood. Pleasure thus actually makes us larger and displeasure smaller.*

The American employer believes in high efficiency in production, and knows that in order to obtain this he must see that his worker's health is maintained.

## Education and Training of Labour.

Education enables workman through improved intelligence, to do his work intelligently, using his brain as well as his hands, and at the same time it makes it very easy for his superiors who have to guide him as to his daily work.

Education enables him to read and understand books dealing with technicalities of the work he is engaged in, and in case he happens to be a genius, his chances of bringing his natural faculties in full play are vastly increased, thus paving the way to some important invention which may radically affect fortunes of the industry concerned.

*Labour must be shaped and developed like raw material, as there is very little of skilled labour to be found all at once on a large scale. In every industry there is a mob of untaught workers, spoiling good material, half—using machinery etc.*

Labour means more than physical exertion. It means the energy and skill of body and brain as applied to the doing of a piece of work. It means the doing of all manner of jobs efficiently. Labour is mental as well as physical.

Cheap labour or, workers are practically worthless. Because (1) they are destructive (2) they reduce the output, (3) they make so many errors, (4) they are quarrelsome.

The first thing in any industry is skilled labour. It can seldom be bought. It has to be made by training and supervision.

There are great differences in workers. A suitable worker must be engaged for each job. No two workers are alike. They have different aptitudes. In every case they must be studied and trained.

## How to develop the young men of a firm.

(1) They can be organized into a club. Membership should be voluntary. This club should have weekly meetings and discuss practical business subjects. Now and then it should have an address from an outside lecturer or from one of the executives of the company. Facilities for demonstration should be given.

(2) There can be a Company Library, free to all the employees of the firm. A firm can afford to buy a hundred books full of information that its employees ought to know.

(3) As soon as a young man shows signs that he is fit for a vacant higher position, it should be given to him. He should not be told that his youth is a handicap. The young are more dynamic. Invariably the young are more likely to make changes, which, as Nature tells us, must constantly be made.

(4) Bear in mind that formal instruction is out of place with the workers, they do not like the idea of going to school again, but they want to learn by lectures or debates or by other methods than that of the set class. It is no use forcing education or instructions of any kind on the worker—unless the initiative comes from him.

## The Ability of Labour.

Many an executive or manager walks by some of his employees every working day for years and never thinks of their specific characteristics. If an employee commits a serious error, the executive or manager may then hear of the matter and gauge the employee by a single dramatic incident. In most cases, the dramatic incident is an isolated defect of the employee's conduct, because his good qualities are taken for granted. Too many executives are negative—minded toward their employees. They can recite their weaknesses or failures, but are unable to test their positive points.

The writer can confidently state that if the operatives were educated and looked after in the right manner and spirit and trained up zealously without any sort of prejudice, the majority of them could be made into efficient and skilled labourers that could stand test against their brothers in the trade anywhere. Their faults should be brought home to them with some pains and enthusiastically and not in a loathsome manner. The biggest difficulty is to get each man to do only his own job, as, instead of that, each weaver or operative tries to be his own jobber or mistry or tackler, with the result that the looms or machinery are adjusted n all manner of ways.

The executive or manager should keep a record of all good men in their employ and give them special training, extra compensation and opportunities for additional responsibilities and duties. The employee will thus learn the particular qualities that he should develop for the benefit of the concern or Company.

## The Mental Quality of Labour.

A curiosity or rather a peculiarity in an Indian lad of the town is, so far he is about 14 years of age, he is very active and keen at learning and picking up something new. No sooner has the age of 18 exceeded then the mental deterioration begins to set in more often than not due to perhaps early marriage, immorality, lack of ambition and education etc. An Indian lad at the age of fourteen needs some wise grown-up person to whom he can talk freely—some one who will guide him and advise him on his further career and when he becomes interested in his own posibilities and opportunities then he sets out to become more intelligent and efficient.

Whenever we see a young man studying his job—trying to learn all he can about it, we can be sure that he will go far. His feet are on the ladder of promotion. The two duties of every ambitious young man are to read and save. The two things he needs most are knowledge and money. The average age of the Indians is about 27 years.

## Gain of Practical Knowledge.

The practical knowledge gained in the years from 16 to 21 or from 18 to 21 more than outweights the adventage of an academically trained mind which has to begin industrial or commercial practice at 21 or 22 or 24, especially when it is realised that under present conditions close practical knowledge is a sine quo non on the part of an executive.

## Physical Growth.

Physical growth is gradual from infancy to 15 years, rapid and directed from 15 to 25 years, and at 25 years we all become muscle bound. Man, therefore is at his best as a physical being between the ages of 20 and 40 years. Mentally things are different. Intellectual infancy is from 15 to 25 years. Intellectual youth from 25 to 40 years. Young manhood from 40 to 48 and then full manhood. Man is mentally at his best from 45 to 65 years of age. "Too old at 40" is physical man, but mental man is only becoming too old at 60 if he has kept up an active mental life. This process of growth is fitting, it serves man well during his physical fittest period he works hard and aids mental development in storing experience and training himself in every way to rise from a worker to become a Commander of practical experience and increase in mental value. He will then open out mentally and have breadth of vision. Physical fitness is a way to efficiency, health and happiness in life.

In comparison with the other creatures of the earth, man has one distinct advantage. He has intelligence. The biologist tell us that man has not changed in brain capacity for twenty thousand years. Man did not have to change structually in order to meet the vigours of his environment. He used his 'head.' Survival did not depend entirely upon the chance strength of muscle or the length of arm, but also upon ability to cope with conditions by thinking, when man's environment does not fit, he changes it, if he does not, he perishes. If a man recognizes the potent biological forces that govern the world and man's relation to his world, he can prepare to meet the changes in modern life and business, and survive in the business struggle for existence.

## Construction and Physique of Workmen.

The items that play an important part in relation to the physique of a nation are (1) climate, (2) care of women and children and their mode of life, (3) Education and care taken of the average youth during his school life (4) Quality of diet and the mode of its preparation, and (5) observance of the laws of hygiene.

## Atmospheric Conditions.

The human body is a mechanism which is constantly producing and losing heat. Under normal conditions of existence the healthy body is maintained at a fairly uniform temperature (97.7 deg. fah) which means that the rate of heat production is balanced by the rate of heat loss. Heat is lost from the body by the process of radiation, convection and evaporation, consequently anything which interferes with the functioning of these processes will obstruct the flow of heat from the body. Further the preservation of a suitable body temperature will depend upon the rate of air movement and the kind and amount of clothing worn. Finally in cases of increased activity, the greater amount of heat produced in the body necessitates a greater rate of heat loss by one or more of the processes mentioned above.

## The Average Worker is Naturally Lazy.

The labourers are almost entirely uneducated. But both in Madras and Bengal there can be found good few weavers or operatives that are fairly well educated in the English language. After they are employed as soon as they become settled down and in a position to save few rupees, they either utilize it in drinks, or cultivate laziness and thus begin to absent themselves from their work. The women are much more hard worker than the men, and if they are married, they are forced to go to work when they accompany their husbands to the town. The husband invariably impose on their wives their own work, and while their wives are at work they indulge in earthly pleasures (or take their work easy) that they would better be without, consequently, they gradually turn just the contrary in their manners and begin to show signs of restlessness. Because in the town a new comer particularly if he is not accompanied with his family finds himself one of a vast army of human beings unrelated by ties of life-long contact. He shares with strangers one small airless room in a congested and insanitary quarter where privacy is unknown and unprocurable. The simple amenities of the village—music, the song, the story-telling between groups of friends and caste men—are gone and in their place are to be found the pitiful few and only too often insidious relaxations of the illiterate *town–man–drink–drugs and the red light district.* Hence the Indian labour in organized industries is much less efficient than the corresponding classes of labour in western countries. In many cases it does not produce as cheaply as western labour in spite of the lower wages. In majority of cases the Indian labour is content with a very low standard of comfort.

In most countries, those people transplanted from an agricultural to a factory life, remain settled in their newly found occupation. In India it would appear that factory life has not the same lasting attraction, and there is a constant cross migration from one mode of life to another, in other words from the jungle to the cotton mill, and vice versa. No industry can ever hope to attain the peak of efficiency under such circumstances. What can therefore be expected of emaciated Indian labour steeped in indebtedness and vice, whose minds are in abject misery, although they are inside the mills or factory. It is therefore absolutely necessary that the labour psychology must be studied and the employer or their representative should co-operate in all directions towards making the operative a higher producing unit. Systematic work increases efficiency and reduces cost of production.

## The Labour in Bengal.

The majority of Bengali workers owing to their coming in possession of their ancestral property have cultivated laziness. The average Bengali does not like to work in a factory but he would not mind being a clerk and hence most of the labourers are from Madras, Behar, Orissa, U. P. or C. P.

Both the men and women particularly the latter, clad themselves very insufficiently. By nature with a very few exceptions they are not so bold in going forward in their work, and if they will only make up their mind to apply themselves to the mill industry they will prove themselves to be as good as any other fellow workers in India. Three-fourths of Bengalees are engaged in agriculture. Therefore the prosperity of the presidency is dependent more on agriculture than on manufacturing.

Bengal is the largest province in India, and in area it occupies the ninth place amongst the provinces of India. The average density of population in Bengal is greater than that of the other provinces of India. The average holding for an agricultural worker is a little above 2½ acres of land. The pressure of population on the soil is so great in some of the Eastern Bengal districts that it is being relieved somewhat by emigration to Assam and Burma.

## Indian Labour Maintains a Family Unity.

There is a sort of family unity amongst them. Practically the whole of the earnings of the sons or daughters are handed over to their parents who assume responsibility for the maintenance of all their household, and when they are grown up they get them married perhaps at the age of 5 or 6 or more or less.

The system of joint family presents rather a difficult situation while fixing a living wage. If the family as a unit is to be considered the difficulty will be whether the same should be calculated on the joint family basis or that of the separate family of each of the workman concerned. For an example: if each workman were to be taken separately with his wife and children constituting a family for the purpose of wage calculation, another difficulty arises in the case of some families the workman of which may have more than one wife, one looks after the house, whereas the rest are earning units. In case of children, sons and even daughters may be earning units and living with the father jointly sharing the expenditure. n such cases a joint family budget naturally runs into larger figures and to give such workmen the same wage on the footing of a single separate family calculation wage would be highly unfair to the industry concerned and is sure to be opposed by the workman with a single separate non-earning family.

There are in India various locations at which industry is planted and naturally the wage must differ with the varying conditions of the centre under review. Again the cost of living in itself at each centre is a varying factor with the rise or fall of prices of commodities and necessity of life. For this purpose each location must have some organisation which is empowered to fix a correct wage standard from time to time.

## Causes of Discontent Among Employers and Operatives.

The power of recruitment and dismissal gives enough scope to favouritiosm and harrassment. This has increased the inefficiency in the industry and is often a cause of discontent among employers and operatives.

The mistries, as a source of income, hire or buy a plot of land and gradually build very cheap cottages which they rent to the operatives that work under them. This practice also helps them to make their position stronger by having the men under them together to obey or carry out orders whenever it is necessary either during a strike or at a time of their dismissal from the mills.

## Causes of Industrial Unrest.

One of the chief causes of industrial upheavals is undoubtedly the lack of understanding between employer and employee, which usually means an absence of common interest or of any attempt at co-operation. Each is content to work along his own narrow lines without attempting to appreciate the other's point of view or to combine forces for the betterment of all concerned. Active contact of the proprietors, or even of the management should be encouraged with the rank and file in a proper manner. It is the rank and file who are primarily responsible for the out-turn. A domineering or even intolerant, employer or manager—and there are many of them—can very easily supply the spark necessary for an imbroglio. Individual employees are too prone to regard themselves as mere cogs in the industrial gear. This sense of isolation can be aroused to a sense of irritation should a grievance regarding working conditions become manifest. Worse still, professional labour agitators, with false notions in respect to the relationship between Capital and Labour, can cloud the real issues, magnify the sense of injury, and plant the germ of contention.

*Some of the agitators are actuated by the highest motives, others, reactionaries with half—baked socialogical theories to foist, and a political axe to grind, are moulding labour opinion to their own ulterior purposes and ends.*

## Workers are Oppressed by Money Lenders.

Ninety per cent of the workers are in debt and pay exhorbitant rate of interest to money-lenders. Most of the essentials of life are purchased on credit system at enhanced prices. Some of them are in the habit of gambling besides being addicted to the drink evil. When the operatives receive their wages before they can know where they are the creditors take their due even by using force as they wait for them at the exit door. If they are not paid in full they receive part of it and carry the remaining part for next month charging interest as they please more often than not the amount that is the principal is doubled consequently the operatives have hardly anything left in their hands by the time they reach home, and when they get there they try to evade the Land-Lord's share of rent. If they are compelled to pay the rent they might pay half or a part of their rent or even go to the extent of leaving their cooking utensils (brass or copper) behind and rent another room somewhere else or lodge in a boarding house. They take jolly good care to save a little money for their strong drink which is the only thing that they cannot get on credit. They go to the extent of either selling their belongings (generally ornaments and brass utensils) or pawning them with the Marwaris if they fail to raise the money for it. They may starve themselves of their food but they will not miss their drink. So it goes on month after month, year in and year out.

## How the Employers are Misled.

Through the jobber the spinners or weavers come to know of the decisions of the employer and through him the employer derivese his information regarding the needs and desires of workers. In the circumstances and in view of the fact that the jobber is an illiterate person (in majority of cases) it is not surprising that there are many occasions when he misleads both the employer and the employee.

The best way to avoid a misunderstanding is to acquaint the operatives by means of notices put up in all the departments written in local languages rather than through the jobbers. All orders should be given by means of notices exhibited in all the prominent places.

## Why do the Jobbers Prey upon those that are Beneath them.

Nearly every jobber maintains in some shape or form, a small band of followers to come to their aid or rescue whenever required. The strength of their followers depends on how much and to what extent the jobbers can entertain them for drinks (liquor) etc., and this is manifested daily on their way to the mills and their return journey from the mills to their homes or the liquor shop. The followers generally carry a long soild bamboo with iron knobs at both the ends. Outlaying one another is almost of a daily occurrence in India amongst the mill hands, whether men or women, chiefly due more or less to misunderstanding of the disputed facts and their revengeful nature. Domestic affairs which are taken ill of very seriously by them are also one of the chief and most irritating incidents of serious consequences amongst them. The women are generally at the bottom or the cause of the troubles. If one at all dares to expose the jobbers, it is done by means of anonymous letters to the firm which is of a common occurrence in India chiefly when the jobbers become too avaricious and thus deprive the operatives too much of their livelihood. It may be due to the fact that they (jobbers) become conscious that the post of a jobber is a life-long post and thus they cannot look upwards at all, and are therefore, inevitably driven to prey upon those beneath them who alone are within their easy reach.

The Indian textile workers undoubtedly lack the skill, stability and stamina of the Lancashire operatives. But they certainly make a successful attempt in trying to learn to write and read the English language besides their own.

Few of the Indian officers, also the head jobbers, are hard working and willing though others are very indolent who need a lot of watching. One cannot totally rely on some of them, no matter how small or how easy the task may be, as they are apt to forget, and never get tired of being told or goaded for the same thing over and over again. But bear in mind that human nature is such that if allowed to become stagnant will deteriorate in efficiency.

Unfortunately, one of the most serious difficulties arising in the employment of labour is the reluctance of the majority of employees to work to the best of their ability. Because they feel that by turning out their work in a shorter space of time they may be establishing a basis for a lower rate of pay. Unfortunately it is true that there is some foundation for this fear as the managements of some of the mills have over done it by taking advantage of a man's exceptional efforts and reduced the scale of payment. The false economies and the false moral theories upon which the policy of restricting output is based, have done and are doing in some places incalculable harm to the cotton industry.

## General Considerations.

The cost of labour is a factor which requires most careful thought. It provides problems of major importance, and on the solution of these, success of any enterprise must largely depend. Whatever system of payment is adopted it should be readily understood by the workers, otherwise the fullest advantage will not be secured.

The attitude of the workers is of great importance towards obtaining efficiency and good work.

## Factory Discipline.

It is very essential that the discipline inside the factory should be very severe in nature. The operatives should be trained to cultivate a high sense of duty. Loitering should never be allowed. The practice of a weaver or an operative leaving his machine and going to another operative for a chat etc. should never be permitted. The offenders should be punished severely. The operatives should be trained to look after their machinery with a view to minimise the breakage of parts. The operatives should be trained for the work they are going to be entrusted with.

### MODE OF PAYMENT OF WAGES.

The wages are paid to the workers fortnightly or monthly, and in each case a fortnight's wages is held over by the firm to be paid in the next fortnight and so on. If an operative begins work in a mill on the first of the month, he would not get paid until the 5th or the 6th of the following month and hence this is in a sense an evil from which the operatives suffer, in as much as to keep alive they are obliged to fall victims in the hands of the money-lenders.

The cotton mills in Bengal pay the carding and Spinning departments once a week but the engineering and weaving departments in the 3rd week of each month, thus retaining in the company three weeks' wages.

The idea of retaining a fortnight's wages in the company is to get the operatives to stick to their work and not leave at their own will, that is without a month's notice. This does not produce the desired result to an appreciable mark. Absenteeism ranges from 7 to 10%. The wages in the Indian cotton mills vary from mill to mill inasmuch as for instance some mill pay on poundage and others on yardage to the weavers. The workers in Bombay get on an average of about one and a half rupee per day. Woman workers get about 12 annas per day, of course including war allowance or bonus.

Some mills do not pay war allowance. The writer has a mill in view where the weavers are paid on poundage, but on the net weight of yarn composed in the piece. For example if the warp weight of a piece is 2 lbs and the weft weight is 1 lb and the weight of the size is 8 oz and when all the three items are added together will go to make the nominal weight of the piece as 3½ lbs. The weavers are paid on 3 lbs that is the weight of warp and weft only.

## Wages as a means of increasing Human Efficiency.

Almost without exception the interest of workers centres in the wage that he earns. If they could retain their accustomed wage with less effort, they would do so. If the retention and increase depend on individual production, they will respond to the compulsion. Success or failure in business is caused more by mental attitude than by mental capacity. When wages are based on commission, piece rate, or a bonus system, the stimulus to action is constantly present. whereas the worker with a fixed salary or wage does not feel as continuously the good of his wage. It is less in mind and does not control his attitude toward his work. The man on a fixed salary therefore, will not produce so much. An efficient and contented employee has a positive money value to any employer. To hold him and keep him efficient, his personal comfort and needs should be considered in every way not detrimental to Company's interests.

## What the Manager can do.

If every worker could be impressed with the importance of every stage of manufacture of a cloth or yarn, and shown what a necessary part of the machinery of the industry he or the she was, the result would be a larger or more satisfactory output. If there had to be cohesion of employer and employed, it was in the hands of the managers to bring about a better feeling between those above and below them.

No set of rules, however well devised, can control a man's action or his desires; human nature demands latitude and room for development in directions outside the fixed boundaries of set of 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 over weening 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 expression to his workmen of his intention to abide by these conditions.

## EMPLOYER & EMPLOYEE MUST CO-OPERATE.

There is a national duty imposed on each person with an industry. Therefore the wisest course for both the employer and employee is to Co-operate and to do his or her share to make the industry safe and paying so that both can live confortably. Undoubtedly no business can last very long if the expenditure exceeds the income. Because no business can pay to its employees say rupees 50,000 per month if its income is Rs. 20,000 per month. It is the product that pays the wages and it is the management that arranges the production so that the product may pay the wages. It is extremely unwise on the part of an operative to look to his own side only viz., that he must get as much money as he can from his employer and is not in the least concerned as to whether the industry is paying or is likely to continue to pay such a wage under competition of other industrial concern both local and foreign which are competing on the same market on which the employer's manufactured goods have to be sold.

The American mill man believes in Co-operation of ideas and exchange of policies, and to further these efforts regular conferences are arranged at which technical matters are discussed.

In some mills the managers have started "suggestions" scheme whereby the operatives are asked to write out any suggestions for improvements in the method of production and conditions of work. These suggestions are brought before the management at regular intervals and are considered. By this means many valuable ideas have been put into operation which ordinarily would not have been brought forward.

Capital and labour have not, like the proverbial 'lion and lamb,' yet lain down together; but they have learnt to co-operate with each other in many ways.

More work and more pay,
Thinker 'Creates'
A worker 'Delivers the Goods'
Both are necessary to each other.

Some Labour Leaders think that wages can be raised and that the extra cost can be added to the selling price.

If the price is raised 10 per cent, then the sales will probably fall off 10 per cent, and there will be no net gain. This fact should be taught to wage-workers.

## How To Stimulate Profit.

The two men in any industrial company who can do most to help towards raising of wages, are the salesman and the Manager with the Co-operation of the operatives.

(1) By skill and energy of the salesman, who will increase the volume of profitable sales.

(2) By greater efficiency on the part of the Manager and Workers, thus reducing the production costs thereby increasing the profit.

(3) Profits come first, because without good profits there cannot be good wages, whoever attacks profits attacks wages.

(4) Strikes and lockouts are self-destructive. It does not help either the employer or the employee.

Higher and still higher wages can be paid only if funds are available. In other words, operatives cannot expect more money for their labour unless they help the employers to increase margins between buying and selling.

But should there arise a misunderstanding or financial difficulty in the industry whereby either side present a stubborn attitude towards the solution of the position, it must be said that there is no such a thing as a waiting period. Because if one centre or country ceases to meet a demand, be it temporary or otherwise, the trade is sure to find a fresh centre or country or city to welcome its demands which will undoubtedly, if lost permanently, inflict, a sad blow to those that were unwise enough not to retain it.

## LEGITIMATE EARNINGS OF AN EMPLOYEE.

It is indeed very wrong on the part of an employer to deprive an employee of his or her legitimate earnings, no matter how small it may be, without any reason or justice. For example if an employee has committed a mistake which may not be serious for the firm then it is only for the employer or the executive to go into the case and try to meet it with some kindness either wholly or partly and to dismiss the culprit with a warning or rebuke instead of throwing him out, as he may be a family man. In nine cases out of ten an operative will be found to mend and turn out a better man after a good fatherly advice instead of the severest punishment that can be inflicted upon him.

Also should there be fault committed by an operative due to or as the result of a cause directly or indirectly concerning the firm or its staff's negligence or oversight, or not having taken sufficient precautionary measure, must be righted at once.

It is really unwise for an officer to indulge in fining the operatives maliciously or out of a motive or due to pressure brought to bear upon him.

It is also absurd on the part of an employee to force the hands of the employer to submit to demands that are ridiculous and unjustifiable. A great reasoning power and perseverence unmingled with any sort of prejudice, and not too much of selfishness, should be the foundation of the argument of an employee's demand against the employer.

## RECOGNISE EMPLOYEES AT THE TIME OF PROSPERITY.

Similarly if there is a good or reasonably handsome income derived or resulted from a business at the end of an official year, the employees should be considered and allowed to benefit from the excess profit in some shape or form substantially, particularly if a provident fund or profit saving fund or bonus system does not exist in the firm. It is no use to act shortsightedly towards the employees and leave them unrecognized at the time of prosperity.

An employer is a master and a judge of an employee so he must hold the balance dead even and void of all partiality. After all said and done the labour of an operative is the productive factor. The principle of 'give and take' or 'live and let live' should be recognised both by the employer and the employee.

Every observant business man should know what is meant by the terms 'Struggle for existence', 'Survival of the fittest' adoption and 'variontional factors.'

## A PRIZE SHOULD BE OFFERED TO EMPLOYEES FOR GOOD SUGGESTIONS.

The production costs must be on a competitive basis and both the operatives and the machines should play their proper part. How many employees that see things wasted and destroyed and yet dare not go forward and report it. How many employees that can suggest improvements but dare not go forward lest they would be showing somebody up and thus stand the risk of getting a discharge. Every mill or office or business place should offer openly an encouragement to the employees to come forward with any practical, money or time-saving suggestions that may either go to improve in the working of machinery or efficiency in production and thus save the firm a lot of money.

### A Foolish Attitude.

Some employers do not like to receive from their employees suggestions of improvement, which is a foolish attitude. Many go-ahead business men and firms offer prizes to their employees for good suggestions, and that is a very wise procedure, for those constantly engaged at some little portion of work are at least in a good position for observing,–indeed, they often have, by constantly recurring experiences, truths forced upon their observation that would be otherwise unlikely to occur to any one.

Surely, now and then, a suggestion that is made by a young man should be listened to and if found satisfactory adopted. Surely, a competent young man should not be held back and told to wait or kept waiting for ten years for a pair of dead men's shoes. A firm needs all the ambition and energy and ideas of its young people. A firm should not allow itself to grow old.

There are various incentive methods which could be tried in India with advantage. One of them is to encourage labour to produce better quality and quantity by adjusting the wages on what are known as the "progressive wage basis." Profit sharing schemes will encourage the individual worker not only to look on the establishment as one in whose profit he has a share but also make him realise that any wastage either in raw material or through rough and careless use of tools and machinery would reduce the profit of the whole concern thereby reduce his share of profit in the long run.

*The most industrious and ambitious men are stimulated by competition, with the less industrious such a stimulation often brings wonders in its effects.*

## Labour Troubles

The writer ventures to assert that 95% of the mills in India have at one time or other had labour trouble. Not many years ago 'Strikes' were unknown, but the lowest of the operatives now treasure this word and with the slightest provocation will put a mill on strike. It is not so bad in up-countries where the labour is cheaper and not so much interfered with or dominated by trade unions, as it is in Bombay, Ahmedabad and Calcutta.

## The Weapon Of Labour.

Strike or lock out does not help unless it is bona fide either in protest or for the purpose of drawing attention of the authority to an evil that has been in existence or practised for some time.

*Far too often the weapon of strike is caved into requisition with a total disregard of the consequences. In India this is particularly the case. Labour in the mass in this country is steeped in ignorance, collectively illitrate, easily beguiled, as easily led, more easily because of its excitability, instigated to Violence Nobody can deny that working conditions in India are deprolable, but none can deny, too, that employers, generally, are making efforts to rectify this.*

## An Advice to Operatives.

The duty of employees, when they are asked to accept a reduction in wages, is not to go on strike. A strike means profit smashing and if it lasts for a long time it then means disaster both for the employees and the employer.

All feasible efforts at the outset for amicable settlement should be exhausted before submitting to a general strike, which should be for a short duration if it comes off in order to awaken the management from their slumber just as an alarm from a clock awakens its owner from his sleep. So that there can be no excuse brought by the employers whereby to attach the blame for not having received a fair warning before downing tools.

For a justifiable strike four conditions are necessary. The first is the existence of a real grievance.. Next, the grievance must be of such a nature that no other course of action than a strike can do away with it. Third, there must be reasonable ground for belief that the strike will remove, or at least lessen, the grievance. Finally, effective means must be taken by the strikers to damage no property, nor injure the interests of the employer or the public.

It is honest that the operatives should give the best work that is in him or her for the pay that he or she receives. Just as a milkman fills the messure to the top, the honest draper measures the cloth to the end of a stick measure and the honest green grocer gives full weight so the honest worker for wages does the full task for which he or she is paid.

The milkman, draper and green grocer who give their customer the best of quality and a little more than full quantity the opportunity of increasing their business will be enormous.

## The Causes of Low Wages.

(1) 'High Taxation'—This is the cause of all business troubles.

(2) 'Deflation'—when money is made scarce and dear, prices and wages go down. This decreases the rate of wages, but it increases the buying—power of wages, so that workers do not suffer as much as they think they do. Deflation injures workers by causing a depression. Business is not good when prices are falling.

(3) 'Obsolete Equipment'—High wages are made possible by up-to-date power machinery.

(4) Inefficiency of Workers.—Many workers have themselves to blame for their small pay. They do as little work as they dare. Lazy, Careless, unskilled workers rarely deserve what they get. They make it impossible for any employer to pay them well. Many

a grumbling worker can raise his own pay by making an effort, but he does not make the effort. He should never complain of his wages until he has done his part to make them higher.

(5) '*Inefficiency of Employers.*'

An employer who does not know how to make good profits is unable to pay good wages.

(6) '*Lack of Knowledge of Buying Raw Materials.*'

The Managing—Director or the Mill Manager must have a sound knowledge of buying the right sort or quality of raw materials suitable to his mill or the class of goods that are being manufactured such as cotton, coal, stores etc. in the cheapest market.

A mill is bound to suffer heavy loss or make very little profit or no profit at all if the Managing-Director or the Mill Manager has a selfish motive in buying raw materials and selling the finished goods.

The writer is confident that when the above facts are clearly understood, by both the Employer and Employee; there will be Co-operation, between them and thus a great deal of foolish conflict will be prevented.

## Trade Unions.

The wage earner or an operative who does better work than he or she is paid for does not fail to rise. Even were it to be otherwise, honesty would still be the best policy for a decent person. Nobody ever gained riches worth having except by honesty. Trade union in India are more or less a nuisance (as they are inexperienced), than useful for the following reasons, hence unsuccessful to a great extent inasmuch as they resort to might by employing vagabond for their lieutenants who in their mission do not educate the operatives, but when they do succeed in their attempts to attract an audience, they take advantage of abusive language against the employers and their officers.

The motives of their work so far have been more selfish and political than industrial. Most of the leaders are ignorant of the inside of the industries. Thus the operatives fall easy victims to their concealed designs, manipulations or whims which undoubtedly create at times a knotty and complicated position owing to unreasonable promises which are seldom carried out that are made by the union leaders whereby the operatives get the worst of it when the promises for which they pay perhaps through their nose are not achieved.

As a rule a business or an industry means the livelihood of too many persons to be tampered with. One that does tamper with it should be held responsible same as one who is found or caught throwing a lighted thing or butt-end of a cigarette in a cotton mill, is responsible for being or would have been the cause of endangering the lives of so many operatives. So why should not a labour leader, if he is found to be tampering without a genuine cause or reason with the livelihood of workers in a factory either by tempting or persuading or misleading, or by using indirect force, be held responsible and punished as a criminal that endangers or is found to be or would have been the cause of endangering the lives of so many operatives, putting their family and children to unnecessary inconvenience, or starvations which may lead to loss of lives either directly or indirectly which may be due to epidemics of some sort of disease that may break out amongst them owing to prolonged strike, etc. An agency that deliberately inflames to violence the masses whose illiteracy renders them an easy prey to unscrupulous agitators, should be dealt with very severely.

### The Mental State of People Can Threaten Business Growth.

Regardless of the potential wealth of a nation, such as amount of raw materials, peace with foreign countries, climate, geographic location, vigour of its citizens, transportation system, and equipment for production, all these economically potent resources amount to nothing if the mental state of the people is wrong. The secular trend of business, the curve of normal growth of a prosperous country, can be shattered by an unsound mind of the people which can be brought about by the Revolutionary and Communistic ideas.

Revolutionary and communistic ideas can only be made to thrive in an atmosphere of discontent which more often than not is the result of misleading the illiterate masses.

## FACTORY UNION.

There are many advantages in having a union for each mill. In the first place every mill-worker will thereby slowly learn to identify his own and his union's interests with those of the mill, as he will not be subject to outside influence so far as trade unionism is concerned. In case of differences with the management, it will be by peaceful means and negotiations within the mill precincts and unharassed by extraneous considerations that settlements will be arrived at. Thus the worker's first loyalties will be to his trade union and to his mill.

The management on their part would find it much easier to negotiate and arrive at amicable settlements when outside influences do not intervene to make negotiations difficult.

### THE TRUE LABOUR LEADER.

The only true labour leader is one who can lead the operatives with a sound reasoning to work honestly and to earn good wages (to live comfortably and not indulge in avoidable luxuries) and to create a real progressive ambition without having to resort to diastrous strikes which more often than not leads to unnecessary inconvenience, misery and starvation, particularly of the family and children of the operatives. He must have a great perseverance for reasoning and a clear foresight free from all sorts of selfish motives and he must be or has been a good honest worker himself and strictly a trade unionist in character. It is necessary that he should be a man of independent means or earning his living independently. He should try to produce skill and be educational. He must also bear in mind that all operatives are not skilled so he must grade the workers who are in his union. It is not fair to demand standard or more pay for inferior workers.

In whatever industries if labour is overpaid the result is absenteeism in the largest number and this will mean to the employers a loss of efficiency and hence a higher cost and the labourers do not receive a full week or a full month wages. The labourers must be educated to earn more wages and to apply the extra wages that they earn to specific purposes which conduce to their education, health and happiness.

## Lack of Harmony.

As the labour leaders in India are not drawn from the labouring classes there is not much harmony between them and the workers and hence the trade unions command a small percentage of membership compared to the labourers as a class.

## CHAPTER X.

## MILL ACCOUNTS.

The object of a manufacturer in keeping mill accounts is three-fold :

(1) to record and keep a check upon the labour expended and the material used in manufacture, (2) to inform him as to what each manufactured article costs to produce, (3) to place him in possession of detailed information by which the general activities of the business can be measured, thus, enabling easy comparison with competitive manufacturers. A system of checking daily all account books is very important and essential irrespective of the daily reports which to a certain extent cannot entirely be relied upon, as mistakes are of common occurrence due to carelessness, inefficient or insufficient clerks etc. No account work should be left over in abeyance for the next day. It is essential to a certain extent that an executive, should make it a point to acquaint himself with the working details of his mill.

### "STATISTICS DIVULGE FACTS."

Details provide the main result of an efficient organization by providing information to past, present and future work, and not only records of actual working results but records of the influence at work throughout the business obtained through the careful analysis which in themselves tell little but analysed and compared they tell much. Heaps of statistics are totally useless and sheer waste of time and money if there is not one with the necessary time and perception to learn the lessons and profits by the facts which those statistics divulge.

The main duty of a Managing Director or a Manager is to find out. But usually it is not done. He accepts difficulties as though they could not be avoided. He takes too many losses as inevitable. He is not at all a detective as he ought to be. He becomes a part of the routine.

### Statements to be Submitted from the Mills to the Head Office.

(1) DAILY:—All the departmental daily reports.

(2) WEEKLY:—On Mondays.

(*a*) Stores in stock.

(*b*) Reminder for article not received.

(c) Reminder for articles that were rejected and not removed by the merchants.

(d) Orders or Requisitions to be sent.

(3) MONTHLY:—On the 5th of each month.

(a) Stock statement.
(b) Salt consumption Statement.
(c) Waste Statement.
(d) Colours or dyes stock statement.

On the 10th of each month.

(1) Government return.
(2) Monthly statement of production etc.
(3) Cotton bales on hand with rates and amounts.
(4) Cotton mixed with rates and amounts.
(5) Cotton mixed and used.
(6) Spinning monthly stock.
(7) Spinning process statement.
(8) Yarn on spinning scale with amount.
(9) Unreeled yarn with particulars and amount.
(10) Reeled yarn with particulars and amount.
(11) Yarn in bales with particulars and amount.
(12) Coloured yarn in Godown.
(13) Yarn Grey and Colour in process in winding, warping and Sizing— with particulars and Amount.
(14) Yarn in weft room with particulars and amount.
(15) Cloth in bales.
(16) Cloth in loose pieces with amount.
(17) Cloth rejected with amount.
(18) Yarn produced with amount.
(19) Cloth produced with amount.
(20) Cloth and yarn dyed with amount.
(21) Cloth and yarn bleached with amount.
(22) Sized yarn in process with amount.

(23) Coal consumed with amount.
(24) Stores received, used and balance with amount.
(25) Machinery spare parts with particulars and amount.
(26) Colour cost statements with amount.
(27) Profit and Loss statement.

## "THE BALANCE SHEET."

When the balance sheets show poor results, the majority of us take consolation in blaming outside conditions. We forget that outside conditions cannot shake us if our working methods are efficient and progressive. We should look "inside" and not outside for the main cause of bad Balance Sheets.

"The vast majority of failures" is due to incompetence of management, either to control internal operations or to keep abreast of external conditions and triumph over them. Every business is more or less like a leaky bucket, and few are without weak spots, which if not controlled in time may cause disaster.

We may take it as a rule that whenever the heads of a firm begin to blame outside conditions and trust to good luck and fair weather to bring them to a desired destination, they are endangering their business.

"Facts and figures" are the elements out of which good luck is built. "Reason is behind everything." Manufacturing costs go up, why? Sales go down, why? Profit decreases, why? Facts to determine these problems are available in every plant, but they too frequently remain unstudied. We are in the habit of accepting such set-backs as if they could not be avoided. The consequence is that profits show a decrease even though we seem to be doing as much or even more business. Why is this? Simply because conditions change so steadily that the machinery bought a few years ago are soon out of date, or, the cotton that is used is unsuitable for the counts spun and the stores insufficient or of very inferior quality whereby the production is constantly hampered and consequently the quality of yarn and cloth suffers and thus the price realised for them might be lower than the cost price.

## Be Upright In Your whole Life.

In adversity man sees himself abandoned by others; he finds that all his hopes are centered within himself; he rouses his soul; he encounters his difficulties; and they yield before him.

In prosperity he fancies himself safe, he thinks he is beloved by all who smile upon him; he grows careless and remiss; he does not see the dangers before him; he trusts to others, and, in the end, they deceive him. Be upright in your whole life, be content in all its changes. And remember that he who despairs of the end shall never attain it.

## CHAPTER XI.

## "COTTON CARDING AND SPINNING MACHINERY."

To obtain 'economical power, speed and production', the right sort of raw material, good oiling, and care of machinery must strictly be supervised. The condition of machinery must strictly be kept upto date.

The condition of machinery is a great factor for economical 'Power Consumption' increase in 'Speed and Production'. The power, speed and production are given below by way of a guide for each of the following machinery and not as a standard. As, they are liable to vary from mill to mill to a certain extend.

### Seed Cotton Opener (single cylinder)

Disentangles seed cotton, which is more or less matted together by the interlacing of the fibres, thus preparing it for the gin, and thereby increasing the production of the ginning plant.

Power = 2 I.H.P.
Speed = 320 R.P.M.
Production = 2000 lbs per hour.

### Cotton Gins.

These gins remove the seed and husks from the raw cotton, preparatory to it being made up into bales for transit. The most universally adopted are the "Macarthy" (or roller) gin, which is used for both long and short fibre cotton. The Eagle gin is principally adopted to short staple cotton.

Power = 2 to 3 I.H.P.
Speed = 650 to 800 R.P.M.
Production = 50 to 80 lb. per hour.

### Cotton Baling Press.

The Cotton, after ginning, is carried by air currents, lattices, or by hand, to a press, where it is compressed into compact bales, under hydraulic presser for transport.

Power = 80 to 100 I.H.P.
Pressure = $1\frac{1}{4}$ to $1\frac{1}{2}$ ton for half press.
$2\frac{3}{4}$ to 3 tons for finisher press.
Production = 50 Bales per hour of 400 lbs. each.

## The Hopper Bale Breaker or Bale Opener

This machine breaks and opens the Cotton, when fed to it in slabs by hand or by lattice, direct from the bale, cleans it slightly and facilitates the mixing or blending of the various grades of cotton as required. The cotton is delivered in a fleecy state either to mixings or direct to the machine to follow. Severe beating not only breaks the fibres but accentuates the tendency to rolling, knotting, and napping at this stage.

Power = 3. I.H.P.
Speed = 300 to 550 R.P.M.
Production = 10,000 to 18,000 lbs. per day of 9 hours according to class of cotton and amount of opening required.

## The Mixing and Blending Cotton.

This is done for economical reasons, and to get a particular quality or colour of thread. Sometimes a good stapled cotton will be mixed with a poor staple, the length of fibre being about the same in each case.

The cotton usually passes from a bale breaker to a "mixing" or stack. In modern mills it is done on the pneumatic principle, and arranged so that when the cotton, from the bale-opener, is delivered into the mouth of a large pipe, it is drawn along by a fan, and deposited in the various stacks, as required through delivery boxes.

## Roving Waste Opener.

Breaks up and opens roving waste, Card waste, and clearer waste; and prepares it for mixing once more with the cotton coming from the bale-opener. By this mixing with the good cotton a considerable saving is effected in the raw material.

Power = 3 to 4 I.H.P.
Speed = 800 R.P.M.
Production in 9 hours = 270 lbs.

## Saw Tooth, Hard Waste Opener.

This machine is used for opening and reducing to a fibrous condition for re-manufacture of all kinds of Twisted woollen, worsted, and silk wastes, hosiery clipping, etc. If the waste is very hard

3 cylinders may be advisable, otherwise 1 or 2 cylinders will be adequate.

Power = about 5 to 6 I.H.P.
Speed = 200 to 300 R.P.M. Generally depending chiefly on the material being treated.
Production = For a 48″ machine with 2 cylinders 20 to 30 lbs. per hour.

## The "Tatham" Preparing Machine for Hard Waste.

In this machine the waste is passed through it preparatory to being treated by the breaking–up machine. The effect is to loosen or comb the waste such as ring frame waste, winder's waste etc. so as to be more readily broken up and at the same time take out any foreign substance which may be in the waste. This machine is preferable to the Opening and Cleaning or Willowing machine when a large production is required and is indispensable when foreign bale waste or thread waste in long lengths has to be used.

Power = 36″ Machine = 12 I.H.P.
40″ ,, 15 I.H.P.
48″ ,, 18 I.H.P.
Speed = 250 R.P.M.
Production = 36″ = 6500 lbs. per day of 9 hours.
= 40″ = 8000 ,, ,, ,, ,, 9 ,,
= 48″ = 11500 ,, ,, ,, ,, 9 ,,

## Zig–Zag Willow Machine.

This machine is capable of most effectively opening and cleaning soft waste.

Power = 6 I.H.P.
Speed of cylinder = 330 R.P.M.
Production = 500 to 1200 lbs. per hour.

## Hard Waste Breaking-up Machine.

The object of this machine is to tear up the hard waste into fibre . The term 'hard waste' includes all waste of a "thready" nature, such as winders, reelers, waste, slashers, and weavers, waste; in fact; all waste; into which the final twisting has been introduced.

Power = 5 to 6 I.H.P. per cylinder.
Speed of cylinder = 850 to 900 R.P.M.
Productionin9 hours = 1 to 2 cylindersfor Coarse Roving 900 to 1400lb
= 2 to 3 ,, medium to fine = 900 to 1400 lbs.
= 5 to 6 ,, ,, thread waste = 800 to 900 lbs.

## Soft Waste Opening Machine.

The object of this machine is for working up clean waste produced by Carding Engines, Drawing Frames and Flyer Frames.

Power =3 I.H.P. (Machine).
Speed of Driving Pulleys =650 R.P.M.
Production =about 70 lbs. per hour.

## Thread Extractor.

The object of this machine is mechanically to pick the hard ends or threads from the clearer waste made upon Mules or Ring Frames. It will deal with American and short fibred cottons. The machine not only performs its work efficiently, but very much more quickly than hand labour, and when the hard ends have been extracted the waste can be mixed with raw unworked cotton and passed through the various processes without being a source of injury to the card wires, or having a detrimental effect on the yarn.

Power =3 I.H.P.
Speed =Hand fed =2500 R.P.M. (Machine).
Production =45 to 190 lbs. per day. of 9 hours.

## Hopper Feeder.

Feeds automatically an even weight of cotton to creeper feed tables, direct to Crighton openers or on to lattices of large cylinder openers or scutchers, slightly opens the cotton and thus makes the next process more effective cleans the cotton and obviates the risk of the fire, as heavy objects cannot pass through, also ensures uniform laps.

Power =2. I.H.P.
Speed =225 to 300 R.P.M.
Production =6000 to 7500 lbs. per day. of 9 hours.

## The Porcupine Opener.

This machine not only opens, and cleans the cotton but prepares it for either the vertical or horizontal opener, to which it is connected by a mouth-piece, either direct or through piping.

Power $=1\frac{1}{2}$ I.H.P.
Speed =800 R.P.M.
Production in 9 hours =6300 to 6750 lbs.

## The "Super Grid Area" Porcupine Opener.

## With Shirely Patent High Speed Dust Extracting Cage.

This machine, is a powerful medium for the extraction of leaf, dirt and fine dust from cottom or cotton waste. It is generally used in waste plants for opening and cleaning Indian cotton which is to be mixed with the waste. It can conveniently be placed to deliver into a crighton Opener.

Power =36″ wide machine =3 to 4 I.H.P.
=48″ ,, ,, =4 to 5 I.H.P.
Speed of cylinder = 800 R.P.M.
Production =36″ wide, machine =up to 900 lbs. per hour.
48″ wide, machine =up to 1200 lbs. per hour.

## The "Vertical Beater" Crighton Openers.

These machinery are specially adapted for dirty and low grade cotton of short staple, such as Indian, on account of its excellent cleaning properties.

Power =4 I.H.P. (Single Beater)
8 I.H.P. (Double ,, )
Speed of cylinder =700 to 1000 R.P.M. Indian Cotton
=700 to 780 R.P.M. Egyptian Cotton.
=500 to 550 R.P.M. American Cotton.
Production in 9 hours =7200 to 7650 lbs.

## The "Horizontal Cylinder" (Buckley) Opener.

This is best suited for the treatment of medium and higher grade cotton. It is fitted with lap forming apparatus, the laps being taken direct to the scutcher and doubled usually four laps up.

Power =9½ I.H.P. (Single machine)
10 I.H.P. (Double ,, )
Speed of cylinder =400 to 500 R.P.M.
Production in 9 hours =3600 to 4500 lbs.

## Exhaust Opener and Lap Machine.

It is a porcupine cylinder machine containing few blades, which only occupy one quarter to one third of the width of the machine, so its opening and cleaning capacity can be judged. It creates a powerful air currents which enable cotton to be carried along the trunks.

It is generally placed between the Crighton opener and the breaker scutcher, all making one combination.

Power =6. I.H.P.
Speed =1000 to 1250 of beater or striker.
Production =6000 to 7000 lbs per day of 9 hours of Indian and American Cotton. 4500 lbs. per day of 9 hours of Egyptian Cotton.

## The "Scutchers."

These machinery do not only clean the cotton but forms it into laps of uniform width, weight, diameter (or thickness) ready for the carding engine. They consist of bladed beaters (one or two), cages, and lap-forming apparatus. It is usual to double up four opener laps, laid one upon the other, through feeding lattices.

Power =4 I.H.P. (for single beater)
=8 I.H.P. ( ,, double ,, )
Speed =900 to 1250 R.P.M. for beaters of 2 blades.
=750 to 1000 R.P.M. for beaters of 3 blades.
Production in 9 hours =1800 to 3200 lbs.

## Intermediate and Finisher Scutcher.

The duty of Intermediate and Finisher Scutcher is to continue to help to perfect the cleaning of the cotton. In case of short stapled cotton the Intermediate Scutcher is given a miss.

Power =4 I.H.P. (Single beater)
8 I.H.P. (double. ,, )
Speed =1400 to 1500 R.P.M. for beaters of 2 blades.
900 to 1000 R.P.M. ,, ,, ,, 3 ,,
Production in 9 hours =1350 to 2700 lbs.

## The "Carding Engine."

Combs the fibres of the Cotton, as fed to it in lap form, almost parallel, and cleans same of motes, neps, and other impurities. The Cotton leaves the doffer in the form of a web, and is converted by passing through a funnel and Calender rollers into a sliver or loose rope.

Power =1 I.H.P.
Speed =165 R.P.M.
Production =50 lbs. to 180 lbs. per day of 9 hours.
depending on the quality of cotton.

**Finisher Card (for Waste.)**

Power = about 2. I.H.P.
Speed = 65 to 85 R.P.M. (machine)
Production = about 100 lbs. of broken up cop bottoms, Comber waste etc., for counts average $8^s$ per day. 9 hours.

**Breaker Card (for Waste).**

Power = 4 I.H.P.
Speed = 100 R.P.M. (Machine).
Production = about 200 lbs. of soft waste counts 1s to 4s per day of 9 hours.

**Derby Doubler.**

The object of this machine is to unite a sheet or lap or a given number of slivers from the breaker card, for presentation to the Finisher Card.

Power = $\frac{1}{2}$ to $\frac{3}{4}$ I.H.P.
Speed = 300 R.P.M. (Machine)
= 170 R.P.M. ( of cylinder )
Production in 9 hours = 1400 to 1700 lbs.

**Sliver Lap.**

This machine unites a given number of sliver from the Carding engines and forms them into a lap of a given width, ready for the ribbon lap.

Power = $\frac{1}{2}$ I.H.P.
Speed = 228 R.P.M. (Machine)
20 to 50 R.P.M. (Fluted Rollers)
Production in 9 hours = 360 to 1080 lbs.

**Ribbon Lap Machine.**

The function of this machine is to draw six laps made by the sliver lap machines, and a suitable draft is therefore provided. The laps pass through drawing rollers, each over a curved plate, and the whole six are laid one upon the other and passing through heavily-weighted calender rollers, are re-wound upon a lap drum ready for the combing machine.

Power = 1 I.H.P.
Speed = 228 R.P.M. (Machine).
Production in 9 hours = 400 to 550 lbs.

## Combers.

This process is specially adapted for producing high counts and fine yarns, it being effective in removing short staples, placing all the fibres perfectly parallel, and cleaning to the finest possible degree. The "Draw Frame" is the machine always used before the slubbing frame which is the first Fly Frame, and in the case of mills spinning carded yarns it is the only machine between the carding engine and the slubbing frame. The function of this machine is to draw several slivers from the combers (in the case of fine counts) otherwise direct from the cards and reducing them to the dimensions of one. They thus become blended together, and any irregularities are eliminated or minimized. Thus improving the quality of the finished yarn to an inestimable degree. Several mills use three heads of draw frame.

Power =1 I.H.P.
Speed =365 R.P.M. (Machine).
Production in 9 hours =96 to 100 lbs.

## Drawing Frame.

The object of the Draw Frame process are to lay the fibres parallel along the length of the sliver and to form a sliver of uniform weight and thickness along its whole length. The first named object is obtained by the drafting action of the rollers, and the second by the repeated folding of a number of slivers taken from the card together into one. The slivers thus become blended together, and any irregularities therein are eliminated. The slivers are put through the drawing heads twice, thrice, or four times according to the class of cotton being treated.

Power =1 I.H.P. per 14 delivery.
Speed =200 to 420 R.P.M.
Production =90 to 215 lbs. per day of 9 hours.

## The "Slubbing Frame"

The function of this machine is to receive the sliver from the draw frame in cans, adds a required amount of draft, and gives to the cotton its first twist. The cotton is wound upon bobbins, and hence it becomes known as a "roving" instead of a sliver.

Power =1 I.H.P. per 50 Spindles.
Speed =200 to 300 R.P.M. (machine)
500 to 600 R.P.M. (spindle)
Production per 9 hours =6 to 25 lbs. per spindle.

## The "Intermediate Frame."

In this machine the bobbins prepared upon the Slubbing frame are placed in a creel behind this machine, and the rovings from two of these bobbins are run and twisted together, that is, doubled, passed through rollers, and more draft and twist is put in, thus the roving still reduces further in diameter.

Power=1 I.H.P. per 60 Spindles.
Speed =300 to 385 R.P.M. (Machine)
600 to 700 R.P.M. (Spindle).
Production=3 to 13 lbs. per spindles per day of 9 hours.

## Roving Frame.

This machine receives the twisted rovings from the Intermediate frame and adds still more twist and draft. Two bobbins per spindle are again fed up to ensure strength and uniformity as in the previous operation, and the diameter is again reduced. The lift or traverse in these frames varies according to the class of cotton and hank roving that is being produced.

Power =1 I.H.P. per 65 Spindles.
Speed =340 to 500 R.P.M. (Machine)
900 to 1350 R.P.M. (Spindle)
Production=15 ozs. to 4½ lb. per Spindle per day of 9 hours.

## Fine Jack Frame.

This machine is chiefly used for fine counts in addition to previous process which is repeated.

Power =1 I.H.P. per 65 Spindles.
Speed =310 to 450 R.P.M. (Machine)
1000 to 1200 R.P.M. (Spindle).
Production in 9 hours=½ to 3 lb. per Spindle.

## Ring Spinning Frame.

Like fly frames, the spinning of yarns in ring frames is continuous, that is, the roving is drawn out, twisted and wound on the bobbin (wood) simultaneously, and this is made possible by the use of hardened steel ring and traveller which encircles the spindle. The traveller in moving round the ring, exerts a pressure due to centrifugal force. The creel is arranged for either single or double roving, that is, one bobbin per spindle or two bobbins per spindle.

Power =1 I.H.P. per 70 spindles.
Speed =575 to 850 R.P.M. (machine)
6000 to 10,000 R.P.M. (spindle)
Production =8 ozs. to 16 ozs. per spindle per day of 9 hours

## Mule Spinning.

The Mule is specially adapted for fine and delicate yarn yet in India yarn from 2s to 20s is spun on this machine. The yarn is spun either upon the bare spindle, or upon paper tubes (short or long) during the outward run of the carriage.

Power =1 I.H.P. per 120 spindles.
Speed =600 to 900 R.P.M. (machine)
9600 R.P.M. (spindle)
Production = .070 to .354 lb. per spindle per day of 9 hours.

## Waste Mule.

Power =7.5 I.H.P. per 720 spindles.
6.5 I.H.P. ,, 510 ,,
5.5 I.H.P. ,, 442 ,,
Speed =400 R.P.M.
Production 1s =2.80 lbs. per spindle per day of 9 hours.
2s =1.90 ,, ,, ,, ,, ,, ,, ,, ,,
3s =1.35 ,, ,, ,, ,, ,, ,, ,, ,,
4s =1.00 ,, ,, ,, ,, ,, ,, ,, ,,
5s = .74 ,, ,, ,, ,, ,, ,, ,, ,,
6s = .68 ,, ,, ,, ,, ,, ,, ,, ,,
7s = .49 ,, ,, ,, ,, ,, ,, ,, ,,
8s = .44 ,, ,, ,, ,, ,, ,, ,, ,,
9s = .40 ,, ,, ,, ,, ,, ,, ,, ,,

## Ring Doubling.

The most popular form of doubling is the ring doubler constructed on the lines of the ring spinning frame, but without the drafting arrangements of the latter. The operation consists of drawing two or more threads together from warpers bobbins, cheeses or cones, twisting them with the required number of turns per inch, and finally winding upon a bobbin. The doubling may be effected either in wet or dry condition. The yarn thus doubled possesses greater strength, elasticity, and smoothness than single yarns of similar counts. The doubled yarn is used for Dhoty Borders, etc.

Power =1 I.H.P. per 35 spindles.
Speed =600 to 800 R.P.M. (machine)
6000 to 8000 R.P.M. (spindle).
Production in 9 hours =3 ozs. to 4½ lbs. per spindle.

## Gassing Frame.

The process of gassing or singeing yarns is intended to remove all projecting fibres and to produce a smooth Surface by passing it quickly through a flame. It is rendered darker in colour and its relative strength is slightly increased, besides being rounder and brighter in appearance. Incidently it raises the counts by destroying the loose fibres, which is equivalent to reducing weight. Gassed yarns are used for mercerising.

Power =1 I.H.P. per 80 drums.
Speed =100 R.P.M.
Production =144 lbs. per frame per 9 hours of 2/40s.

## Reeling.

This operation is effected when yarn is required to be exported dyed or bleached etc., and consists of making it into hanks of convenient size. Reeling machines are made either single, with one swift only or double, that is, with swift on either side. They reel from ring bobbins, cheeses or doubler bobbins.

Power =1 I.H.P. for Reels.
Speed =150 R.P.M.
Production =about 530 hanks per hour. or 135 lbs. per day of 9 hours of 20s counts.

## Yarn Bundling Press.

This machine compresses the yarn into compact bundles of 5 or 10 lb., as required, so as to occupy as little space as possible in transit, when the machine is worked by hand, the pressure is obtained by means of geared wheels, the struength of which, and the ratio of driving to driven, being such as to give great power.

Power =1½ I.H.P.
Speed =60 R.P.M.
Production in 9 hours =1620 lbs.

## Wrap Block.

It is used to test the counts in the preliminary and intermediate stages of spinning.

## Wrap Reel.

It is used to measure off a definite length of Hank, Skein or Lea from cop or bobbin preparatory to weighing and testing. To weigh the yarn after measuring off a definite length, a good sensitive balance is most essentially required. The weights used are in grains and fractions of a grain. The two essentials factors are accurate measuring and accurate weighing.

## Yarn Strength Tester.

To test the yarn for strength of a lea of yarn after being measured on a wrap reel.

## Yarn Examining Machine.

It is used for the visual examination of yarn, with the object of detecting defects in spinning and checking its quality and regularity.

## Yarn Twist Tester.

It is used for testing the amount of twist per inch in a double or multiple strand yarn.

## High-Speed Tubular Banding Machine.

This machine as its name implies prepares banding for use for Ring Frames etc.

| | | | |
|---|---|---|---|
| Power | =8 and 16-Spindle machine | | $\frac{1}{3}$ I.H.P. |
| | 24-spindle | ,, | $\frac{1}{2}$ I.H.P. |
| Speed | =8 and 16-spindle machine, 300 to 400 R.P.M. | | |
| | 24-psindle machine, 250 to 300 R.P.M. | | |
| Production | =8-spindle machine, | | 120 to 180 yds.per.hour. |
| | 16-spindle | ,, | 180 to 240 ,, ,, ,, |
| | 24-spindle | ,, | 120 to 180 ,, ,, ,, |

## Weaving Machinery.

There are several methods of preparing grey warps of ordinary single yarn for the loom.

(1) Winding from mule cops or ring bobbins on to warper's bobbin, thence on to back beams, and then slasher sizing.

(2) Winding from mule cops or ring bobbins on to warper's bobbins, beaming and slasher sizing concurrently on to back beams, then beaming from back beams on to weaver's beam.

(3) Winding from mule cops or ring bobbins on to warper's bobbins, warping by the circular mill and hand balling, or sectional warping frame and separate balling frame, or warping and flyer or cross-spool balling concurrently, then ball-warp sizing and ball-warp press beaming on to weaver's beam.

## Grey Winder.

To wind from mule cops or ring bobbins to warper's bobbin.

Power =1 I.H.P.
Speed =130 R.P.M. (machine).
790 to 660 R.P.M. (spindle Front and Back respectively).
Production =3 lbs. per spindle per day of 9 hours Average counts =20s.

## Drum Winding.

To wind yarn from hanks, cops or bobbins to warper's bobbin, Used chiefly for coloured yarns.

Power =.66 I.H.P. per 50 drums.
Speed =160–180 R.P.M. (machine)
Ratio of Drum to Loom =2 Drums (Loom R.P.M. =150)
For Loom R.P.M. 140=3 Drums.
Production for 60 Drums in 9 hours =190 lbs. of 20s Counts.

## Split Drum Winding.

To wind from Hank to Cheese or cone by a system of Cross-winding.

Yarn wound in the split drum winding machine possesses the characteristic of most open crossing cheeses, in being suitable for bleaching and dyeing, in the cheese or spool form winding is done due to splits in drums and yarn is wound on zinc tubes by friction. Empty conical bobbins of required diameter and degree of incline are used as required and each bobbin holder or cradle may readily be adjusted so that each empty cone bobbin presents a parallel face to the drum. The chief object of using conical bobbins or tubes is to permit unwinding freely over the thin end of each cone at the next process.

Power =.50 I.H.P.
Speed =600 R.P.M. (machine).
2400 R.P.M. (Drum).

## Pirn Winding (Leesona).

To wind yarn from hank on to a pirn for the shuttle.

Power =.28 I.H.P.
Speed =610 R.P.M. (frame)
2450 R.P.M. (spindles)
Production in 9 hours =4 to 5lbs. per spindle of 20s counts

## Beam Warper.

There are several methods of preparing the warp yarn. These include (1) Ball Warping (2) Cross warping (3) Sectional warping (4) Chain warping (5) Beam warping.

The object of warping is to collect the yarn from a number of warper's bobbins and wind it in sheet form to a back beam (for sizing)

Power =Six frames=1 I.H.P.
Speed =40 to 48 R.P.M. (frame)
Production =400 to 500 lbs. per frame per day of 9 hours
av. counts=20s.

## Sizing and Hot Air Drying Machine.

This machine contains creel, size box having brushing device, dry chamber having a number of revolving cages and fans with high speed. In this chamber the air enters at the bottom and is heated by passing over the tubes with steam and is forced against and through the warp. Above the drying chamber an exhaust fan is placed for drawing away the fully saturated air. Then opening rods device, measuring arrangement, pressing motion, slow motion etc., are also inserted. Double beaming arrangement is also kept for winding the sized yarn on two weaver's beam placed side by side.

Its advantages are—Less steam consumption, greater output, full strength and elasticity, less risk of tendering and burning the yarn. Ends remaining quite round and warps can be heavily sized. It gives a softer and mellow feel to the yarn. The drying chambers, of such modification of air drying sizing machinery may be readily adapted to the sizing apparatus and head stock of any slasher sizing machine having cylinders for drying, by simply removing the drying chamber in their place.

This machine gives 30 to 40 per cent more production than cylinder drying machine.

### Slasher Sizing.

To collect together the yarn from several back beams, size the yarns, dry it, and wind it on to a weaver's beam. Used for hot sizing of grey and coloured goods. Size of cylinder 72″×48″.

Power =1½ I.H.P.
Speed =180 to 200 R.P.M. (machine).
Production =1080 lbs. per day of 9 hours
av. counts =20s.

### Hank Sizing Machine.

Sizing in the hank form is a process usually employed for coloured yarns. Most yarn dyers can supply dyed yarn in the hank form ready sized, and after sizing, the yarn must be treated with three objects in view. First, the restoration of its full length; Second, the removal of the surplus size; and Third, to retain a good, round, even thread.

### Size Mixing Beck.

A receptacle for holding size during preparation usually fitted with revolving dashers to agitate the size during mixing.

Power =.50 I.H.P.
Speed =50 R.P.M. (machine)
Bevel wheels =19×38.
Production =depends on demand, number of becks available, nature or varieties of mixings.

### Reaching-in.

A small machine for selecting the threads for the drawer-in.

### Drawing-in (Hand).

A frame work to hold healds and warp in position to enable the threads to be drafted through the heald eyes.

### Drawing-in Mechanical.

A machine for mechanically performing the operation of drawing —in and denting of warp threads.

### Loom (Tappet).

To weave cloth requiring about 8-12 shafts and picks. The tappets may be under, on top, or at side of loom.

## Loom (Box.

A loom with multiple boxes at one or both sides of the sley to enable several colours of weft to be inserted to pattern as in checks etc.

Power =$\frac{1}{3}$ I.H.P.
Speed =140 to 175 R.P.M.--50" Reed space.
Production =depends upon speed of loom and picks per minute.

## Loom (Dobby).

To weave cloth requiring not more than 24 shafts, any number of picks; special dobbies for Dhoty Borders go up to 40 Shafts.

Power =$\frac{1}{4}$ I.H.P.
Speed =50"-Reed Space=190 R.P.M.
Production =depends upon speed of loom and picks per inch. Efficiency varies from 70 per cent. in ordinary looms to 98 per cent. in automatic loom.

## Loom Jacquard.

To weave fancy figured, Stripe, or compound fabric beyond the scope of a dobby.

Power =1 I.H.P.—Three to four looms.
Speed =200 R.P.M.—40-inches Reed Space.
Production =4–30 lbs. per loom per day of 9 hours. depending upon the quality and class of goods being woven.

## Piano Card Cutter.

To cut cards for Jacquard patterns.

## Card Lacing.

To stich together cards for Jacquard patterns, or to connect to-gether steel links for box loom pattern chains. An endless belt is formed.

## Card Repeating Machine.

Used when several sets of Jacquard cards of one pattern are required. It will cut or copy a set of cards like a given set.

## Cloth Inspecting Machine.

To inspect cloth before calendering or finishing. This machine by means of brushes also removes all loose ends from the back and face of cloth.

Power $=\frac{1}{2}$ I.H.P.
Speed. $=25$ R.P.M.
Production = one machine is sufficient for 500 to 1000 looms.

## Sewing Machine.

After the goods are inspected and sorted out, they are sewn together, end to end.

Power $=\frac{1}{4}$ I.H.P.
Production = 150 Ends or joints of 75 pieces per hour.

## Shearing and Brushing Machine.

Before going to the singeing machine it is sometimes necessary to eliminate a considerable amount of dust, shell or scale from cloth. Many cloths require to be sheared and brushed to remove loose ends of yarn, to smooth the nap and remove dust. It is largely used for grey or white fabrics.

Speed = 100 yards per minute.

## Singeing Machine.

The object of singeing is to remove the short fibres from the surface of cloth, such as cotton, linen, silk, etc., so that when finished it will have a clean surface. Cloth which has not been singed, will not be as white when bleached and will not give as bright shades after dyeing as singed cloth. Cloth, which has to be printed should be carefully singed as otherwise the printed pattern will not appear as accurate and the colours may be smeared. The process of singeing is done by passing the fabric through the blue part of the flame from a Bunsen gas burner–sometimes it is done electrically, using a charged plate instead of a gas flame. Gas singeing machine are made in various sizes with one burner or up to four burners.

## Saturating Machine.

After singeing the cloth has to pass a solution of lime. This process is done either in steeping vats or on a bleachers saturating machine.

## Kier.

After singeing, the cloth is usually allowed to steep in a de-sizing agent to remove in the course of boiling fatty matters and sizing ingredients. High pressure kiers are used for boiling cloth, yarn, cops, cross wound bobbins, loose cotton, linen and cotton cloths of all kinds in rope form. The Kier is generally made for a maximum daily working pressure of 45-lb. per square inch. Injector, steam valve, water gauge, air cock and pressure gauge are included. Kiers are usually made to hold one ton, two tons, and three or four tons of cloth.

Power =5 I.H.P. (motor)
Capacity = one to four tons.
Production =5000 lbs. in 16 hours.

## Chlorine Dissolver.

This apparatus consists of a wrought iron cistern covered with lead and a perforated iron drum covered with lead. An opening for pulling in the chloride of lime is provided. The apparatus is driven by means of fast and loose pulleys and spur wheels. The cistern is fitted with two lead outlet valves, one of which is arranged a little above the bottom.

The apparatus is made in 3 Sizes. It is erected on a cement tank. From this tank the bleaching liquor will flow into the chemicing machine through a lead pipe.

## Slack Washing Machine.

This machine is used for washing cloth in rope form after bleaching, boiling or souring. This machine is also known under the name of Bleachers Washing Machine. Two pieces pass through the machine at the same time.

Speed =200 yards per minute.

## Bleachers Liming, Chemicing, Souring and Washing Machine.

After singeing, the cloth has to pass a solution of lime. This process is done either in steeping vats or on a bleacher's liming machine. The machine is provided with a wooden guiding roller at the bottom of the tank in order to keep down the cloth which enters the machine in the dry state. The tank is made of wood or cement. The machine consists of 2 cast iron frames, three wooden rollers, peg rail, with automatic stopping device, one pair of squeezing rollers made of wood or brass and is driven by means of fast and loose pulleys and stopping and starting arrangement.

## Hydro Extractor.

In this device a perforated drum or basket of copper or steel is rapidly rotated round a central vertical spindle, the motive power being steam engine direct, belt, electric, friction drive, or even water turbine. Very many designs exist adopted to various industries, but the usual textile machine is a 60–72 inch cage, surrounded by an external casing of cast iron or preferably steel, this may be flashed internally with lead against corrosion. During rotation, the centrifugal force developed is resisted by the internal surface of the drum, and there is thus set up a pressure in the material, the excess liquid is thus squeezed out and, flying to the outer layers, escapes through the perforations and is drained away.

The following table gives the comparative figures of diameter, Speed o. rotation and gravity factor for various sizes of centrifuge.

| Diameter of cage. | Revs. per minute. | Gravity Factor. |
|---|---|---|
| 2 Ins. | 40000 | 45300 |
| 36 ,, | 1000 | 512 |
| 60 ,, | 750 | 479 |
| 72 ,, | 650 | 432 |
| 84 ,, | 500 | 300 |

when a hydro-extractor is applied to the removal from a mass of fibrous material of the excess liquid its efficiency must depend upon a number of factors.

(1) Centrifugal accelaration which may be made very high in machines of very small diameter.

(2) Liquid resistence to movement due to viscosity and surface tension and actual frictional reisistance in the capillary channels, if these are very small, it will be impossible to remove the contained liquor by ordinary centrifugal force.

(3) The wetting of the solid surface of the fibrous material by the liquid.

There are two ways of running a Hydro—extractor.

(*a*) Run up to top speed, cut off the power and at once apply the brakes. This is the system of least time but 'maximum power' and also 'wear and tear.'

(*b*) Run up to speed, cut off the power and allow to run down by friction. This is the method of 'minimum power' but longest time; also least wear and tear.

A Centrifuge does not dry all parts of its charge evenly; the inner upper portions are driest, the lowest the wettest, and the material lying next the walls of the cage wetter than the inside portions.

Power =8 I.H.P.
Speed =1000 R.P.M.
Production =9000 yds per day of 9 hours.

## Scutcher.

The scutcher or opener is used for opening cloth, which has been treated in rope form during the bleaching process. It is worked either in combination with the watermangle or drying machine or separately.

The run of the cloth to the scutcher should be as long as possible at least 20 feet and preferably horizontal.

## Water Mangle.

Water mangles are made with three, four, five, six, or seven bowls. If desired a special chasing arrangement for "closing up" the threads will be attached and a large copper drying cylinder at the outlet. Water mangles with three bowls may also be used in connection with a drying machine for blueing, starching or impregnating cloth.

Production =24.87 7yds. per minute.

## Drying Range.

Drying range is used to dry cloth after bleaching or dyeing and also after filling.

Drying machine are constructed either with horizontal or vertical rows of cylinders. They are worked either alone or in Combination with a starch-mangle, or padding-machine, or water mangle, or with a scutcher. Sometimes a short stentering frame is put in front of cylinders.

Power =8 I.H.P.
Speed =machine 30 cylinders =100 yards 21 cylinder 80 yards 15 cylinders =40 yards. variation speed =282 and 188.

### Stentering Range.

Stentering range is used to stretch and dry the cloth, straightens the weft threads, and when combined with a Starch Mangle is used to add weight and softness to the fabric.

Production =20.1 yds. per minute.

### Dye Jiggers.

These machinery are used for dyeing cloth in the full width. The back may be made entirely of cast iron, which is preferred where the Jigger is required for different colours. The beck may also be provided with cast-iron ends and wood sides, and may be lined with stainless steel, or monel metal, or vulcanite. The draw rollers on the top of the becks may be made of wood, cast iron, earthenware, or vulcanite. Vulcanite is preferable, as it is durable and can be easily cleaned. The guide rollers in the beck may be made of wood, iron, monel metal, stainless steel or hard rubber covered. The becks are fitted with perforated steam pipes to heat the liquor and let-off drain.

Brakes, consisting of strap and weight, are provided on the draw rollers to maintain the tension on the cloth when the direction of the cloth is reversed.

Power =.75 I.H.P. per Jigger.
Speed =50 yards per minute.
Production =38.95 yards per minute.

### Padding Machine.

These machinery consist of heavy cast iron frames, 3 iron rollers with double lever pressure, top and bottom rollers rubber coated, wrought iron cavity trough, the necessary tension and guide rollers, winding off and batching arrangement. The cloth passes the liquor twice and is sequeezed out twice. Machine is arranged to work either separate or in connection with stentering and neutralising frame.

### Mercerising of Piece Goods.

Mercerising gives to cotton woven cloth a silky lustre, and is the foundation of many improved and beautiful finishes. It is employed almost universally for the finishing of high quality piece goods, and in many cases, also for low qualities. Mercerised cloth possess a greater affinity for colouring matter, deeper and brighter shades are obtained, and less dye stuff is used.

## Colour Mixing Pan.

These pans are made in different sizes, from ½ to 100 gallons capacity each provided with single or double agitators made of brass, with Sun and "Planet motion." The inner casing of the pans made of copper and the outer one of cast iron, or copper, as desired.

The agitators are driven by means of fast and loose pullys, bevel wheels, and clutch, and arranged for being easily lifted for swivelling the pans. The swivelling arrangement consists of hand-wheel, worm and worm wheel. The machines are supplied complete with steam and water pipes safety valves, outlet taps and water and air taps.

## Silk Finishing Range With Palmer Stretcher and dyer.

This range is used for the finishing of silk and artificial silk, printed Japps, crepe, net, muslins, marocains, poplins, etc.

The finish obtained on this range is exceptionally pleasing and is unexcelled. It imparts a full handle to the cloth and gives a rich appearance obtainable in no other manner.

The range consists of :—

(1) A light impregnating mangle with rubber and iron bowls and copper impregnating trough. After leaving the mangle, the cloth is led over.

(2) A series of drying cylinders, usually three in number, which remove the excess moisture from the cloth before entering the "Palmer" stretcher. Between the "Palmer" Stretcher and the cylinders is placed a delicately—balanced compensator, which gives warning of any alteration in the tension of cloth.

(3) The Palmer apparatus is a special type of belt-stretching machine in which the belts are guided over the upper halves of the stretching pulleys. The frames carrying the pulleys are provided with worm and worm wheel gearing operated by hand--wheel. The pulleys are thus set at any angle which may be required to give the necessary stretch to the cloth. A weft straightening motion is also provided. This motion allows one of the belts to move faster than the other to straighten any weft threads which may have become misplaced. This apparatus is operated by hand wheel.

(4) After being stretched, the cloth immediately enters between the blanket and the large steam—heated drying cylinder. The cloth is carried round the large cylinder inside the endless felt blanket, and afterwards the cloth passes to the plaiting—down apparatus. A steam--heated cylinder for drying the endless felt

blanket is usually placed above the large cylinder. Both drying cylinders are mounted on ball bearings. The machine is provided with variable-speed arrangement and cone pulley adjustment between the various parts of the range in such a way that the tension of the cloth can be adjusted to a fine degree and the speed of the machine varied to suit different classes of material. The face of the large cylinder is well polished so as to give a finish to the face of the cloth. The machine may be driven by direct--coupled electric motor or belt pulley.

## Damping Machine.

To condition the cloth before calendering or after finishing or beatling.

Power =2 I.H.P.
Speed =86 R.P.M.
Production in 9 hours =3000 to 4000 yards.
about 70 yards per minute.

## Calendering Machine.

To close the threads of cotton etc., and impart to the cloth the gloss or feel required.

Power =56 I.H.P.
Speed =180 R.P.M.
Production =7-bowl =80 yards per minute.
5-bowl friction =60 ,, ,, ,,
3-bowl ,, 50 to 60 ,, ,, ,,
4- bowl ,, 50 to 60 ,, ,, ,,
Felt calender 20.0 yards per minute.

## Batching-off.

To wind cloth from loom take-up roller or to wind on calendering machine.

## Breaking Machine.

To impart a soft or supple "handle" or "feel" to certain classes of woven fabrics, which, after calendering, have a papery or "boardy" touch cloth treated on this machine, retains the filling.

## Button Breaking Machine.

This machine is principally used for softening the finish of silk and artificial silk finish.

## Combined Creasing, Plaiting and Measuring Motion.

This machine is of simple construction and designed to give accuracy in plaiting and large production. It will crease, plait and measure all kinds of cloth in one operation, and requires less power to drive than any other machine of this class.

Production =70 yards per minute according to the quality and finish of the cloth to be treated.

## Combined Creasing Lapping, Rolling and Measuring Motion.

This machine is same as creasing, Plaiting machine described above but combined with a Lapping and Rolling arrangement instead of a Plaiter.

## Lapping, Rolling and Measuring Motion.

This machine is used for lapping cloth on boards or on collapsible swords or for rolling it into a batch. It is fitted with a measuring apparatus to measure in yards or meters.

## Plaiting or Folding Maceine.

To fold cloth into a compact form of plaits to facilitate examining it also for packing purposes.

Power =½ I.H.P.
Speed =160 R.P.M.
Production =70 to 90 yards per minute.

## Stamping Machine.

For stamping names or marks on branded goods, usually at end of piece or selvedge.

Power =1 I.H.P.
Speed =115 R.P.M.
Production =One machine is enough for 500 to 1000 Looms

## Pressing Machine.

To press bundles of cloth into a compact 'lump' for export.

Power =6 I.H.P.
Pressure capacity =1½ to 2 tons.
Speed =200 R.P.M.
Production =one press is enough for 500 to 1000 Looms.

## Pattern Cutting Machine.

To cut patterns or samples of cloth to exact measurement.

## Tachometers and Speed Counters.

To give number of revolutions or surface speed per minute of spindles, shafting, etc. with three ranges, extending from 100 to 12000 R.P.M.

## Cloth Strength Testing Machine.

To test cloth for strength from samples either 4 in. wide or $6\frac{5}{8}$—in. wide. The length in either case being 9–in.

## Yarn Assorting Balance.

To use the assorting balance, a square cloth is cut out of the sample round the edges of a tempelate meant for the purpose, the weft or warp threads being then drawn out and placed successfully on a small wire hook, when a sufficient number of threads has been suspended the beam of the instrument will assume a horizontal position. The number of threads required to bring the beam to a state of equilibrium represents the count of the yarn.

## Yarn and Cloth Quadrant.

With this machine a definite length of yarn is measured off and its count quickly found by suspending upon a hook attached to a pointer which swings over an engraved scale whereby the count of weight of a price is read.

## A Fadeometer.

A Fadeometer tests the fastness of colours. It operates with a strong carbon arc light.

## A Photo-Micrograph.

A Photo–Micrograph magnifies the cloth and shows the weave. Any weakness or irregularity is shown up.

CHAPTER XII.

ENGINEERING.

## Engine.

Horizontal corliss cross compound condensing, steam engine* of 1500 I.H.P. For mills and factories horizontal compound or triple–expansion condensing engines are usual. They may be of the Corliss, or drop–valve type. Uniflow engines are also suitable. The steam may be saturated or superheated.

Single—cylinder engines are cheapest, but least efficient. For most purposes the compound engine is the standard type, although the uniflow is being widely adopted. Triple and quadruple—expansion engines are very economical in steam and fuel; but the first cost is high, and the machines are large and heavy. Plain slide valve engines are simple, but least economical. They are governed by throtling. Corliss and drop valves are elaborate, but save steam. With them cut–off governing is usual, and is most economical. They are, however, unsuitable for high speeds. Maximum Speed for Corliss valve engine is 90 R.P.M. while for drop valve is 130 R.P.M. In the case of high speed engine piston valves are generally used. The uniflow engine is supplied with steam at the ends, admission and cut–off being effected by drop valves. Exhaust takes place at a central belt at the mid-length of the barrel. The steam ends are never cooled hence there are no initial condensation losses; the clearance volume is only 2 or 3 per cent; the compression is 90 per cent; and the entire expansion takes place in one cylinder, the cut-off being at about 10 per cent. of the Stroke. The steam consumption of a uniflow engine is from 5 to 10 per cent. better than that of a compound engine.

## Prime Mowers.

The first essential of any mill engine, or other type of driving and power plant as a whole, is that it should work and give general satisfaction over long periods, with a minimum of skilled attention, or risk of failure, and without its being a source of constant worry and anxiety to all concerned.

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* The particulars of machinery, Stores consumed and hands employed pertains to a mill of about 50,000 spindles and 1,200 looms and are given only by way of information and guide.

In other words before selecting a prime mover one should investigate without prejudice the merits and demerits in reliability, durability, simplicity, efficiency, initial and running and maintainance cost of each and individual components of power plant, system of drive and machinery.

Load up to 400 to 500 H.P. and where non-condencing plant is desirable steam engine is considered favourable. Steam engines of 1000 h. p. or more are gradually getting out of vogue in textile mills and are being substituted by turbines.

Average cost per unit of power for stores and replacements for a 1500 K.W. turbine is 0.2148 pies whereas that of a 1500 K. W. reciprocating engine comes to 1.2458 pies. But bear in mind the average cost given here is only for a guide it cannot be taken as a working base for all mills.

## Power.

In a steam-driven mill the power is generated by boilers through steam or turbine, and transmitted through a system of gears, shafting belts or ropes.

For many years the water wheels and steam engines were the only prime movers employed to supply the power to the various machinery. In either case the prime movers supplied power to the second motion shaft and then to main line shafts from which it was transmitted to various machinery by means of belts and ropes.

In the cotton industry, the question of speed regulation is most vital, as upon it depends the quality of finished goods. Moreover by operating the machinery at the highest permissible speed the maximum production is obtained. Therefore any motive power that will operate the machine at a constant maximum speed is greatly to be desired.

"Rope Drive" is undoubtedly more efficient and more economical than any other system of drive. The disadvantages lie with this system are a complete shut down of the whole mills in case of any rope failure. Erection of a strong gangway throughout the whole length of mill building is necessary.

The 'Electrically—Driven' mill, if generating its own current, follows the same course as the mechanical one upto, and including the engine or turbine, from this point the transmission is by generator, through cables and motors, the latter direct coupled, or grouped driving by gears, ropes or belts.

If current be purchased, the whole generating plant is cut out from the low tension side of the transformer, transmission is by the same means as with the privately--owned plant complete. Electric drive may be adopted in individual drive system or group drive system.

As stated above the steam engine has for many years been the main source of power in textile mills, and in spite of keen competition from other types of power units it is claimed that, from the points of view of economy, reliability and constancy in comparison with the initial outlay, the installation of certain types of steam engines is still the most economical when a cotton mill obtains its power by steam it is practically always driven by a single engine. The reasons for this are (i) one engine is cheaper and more economical to run than two or more engines producing the same amount of power (ii) the modern mill, being compact and driven from one engine, has less losses than when driven by two or more engines.

## Rotating Shaft.

All manufacturing power originates in the form of a rotating shaft. Practically all manufaturing loads are carried by some form of power pertaining to rotary power. The loss occurs between these two rotary shafts. This loss is large under ideal conditions, in fact in old mills the friction loss excluding machinery may be found to be as high as 35 per cent; but large savings may be effected by careful mordenising the existing plants, and large losses may be prevented by careful planning of future construction.

## Bearings must be Kept Clean and well Lubricated.

The enormous power required to drive the machinery in textile mills and the heavy cost incurred for same renders it absolutely and emphatically necessary that every economy be exercised to make a horse power go as far as possible. As the cotton manufacturing mills are made up of spindles and so many small bearings, unless special care is taken up to rigidly maintain the cleanliness of all the bearings, and which must be lubricated with the right kind and quality of oil, more power will be consumed, which means more coal used up than is actually required. If too much tension is put on the bands that run the spindles, the excessive consumption of power will follow.

No dirt or sediment should be allowed to remain in the bearings. Buying cheap oil should neither be practised nor allowed by the management.

The tension of all belts, large or small, if too tight, will increase friction, consume more power, more oil, and more labour for repairs.

All Shaftings and pulleys must be kept very clean. If bevel wheels are set too deeply in gear they will take a great deal more power to drive them, to say nothing of the undue wear and tear.

### Roller Bearings.

All bearings should be fitted with roller ones, as although the initial cost of roller bearing system runs higher than ordinary ring oiling system, yet the friction load and maintenance charges are much low comparatively, and excess initial cost will be made good within a few years.

### Electric Driving.

This method of driving has not made much progress in the cotton mills. The reason is that the cotton mills can be more efficiently driven by mechanical transmission direct from the engine. Electrical transmission schemes show to most advantage as against mechanical means of transmission when one or more of the following conditions obtain (i) when speed regulation of individual machinery is required, (ii) when machinery is scattered, (iii) when the various machinery are operated intermittently and not simultaneously. Under normal conditions in a cotton mill none of these conditions hold to anything like the extent that they hold in many other industries, and it is on this account that electrical transmission has not been as much adopted in cotton mills as in many other kinds of factories.

### Individual Drive.

This can only be justified if the specific advantages it offers more than compensate for the increased cost, not only from the capital point of views, but from the running point of view—i.e., 'the total costs' of driving is greater with individual drive than with group driving. The advantages are (*a*) great convenience in running (*b*) great convenience of possible extension (*c*) smoothness of drive (*d*) sectional working is possible (*e*) greater cleanliness due to no moving belts (*f*) break down troubles are low (*g*) Building cost is less.

### Choice of a Type of Drive.

Individual drive is doubtless of advantage in places where large individual producing machinery are placed far apart and which consume an abnormal amount of power or operate irregularly and outside normal hours. Individual drive can also be used for machine utilised intermitently for instance hydraulic pumps, calenders, etc.

With individual drive it is necessary to choose a motor large enough to give the maximum horse power likely to be required. In such a case it seldom operates with full load and is thus less economical than the group drive motors, the size of which can generally be suited to the average power consumption of all the machinery driven by it. As a rule motors of group drive operate very uniformly with their most economical load and can therefore develop their maximum efficiency.

The economy that might be effected as shown by the advocates for individual drive would be counterbalanced by the heavier initial cost of motors and cables and the uneconomical consumption of current owing to the varying average load of the motors, and finally by the higher interest and depreciation of the capital invested in the individual drive as compared with the cost of group drive. According to careful calculations based on almost identical data, the initial cost for group drive in relation to the cost for individual drive with electric motors is 1 : 3.5 Moreover if the individual motors are handled by operatives of less intelligence, they very often go out of order and many stoppages and wear and tear are resulted. The efficiency and power factor of small motors are as low as 0.74 and 0.80 respectively which entails a heavy drain of power. The big induction motors such as 100 B.H.P. and above have the best efficiency and power factor which are 0.93 and 0.90 respectively.

## Water.

Water is very variable in composition, because it is influenced by the geological formation of the district through which it flows. Water from chalk-springs is generally pure and wholesome, clear and sparkling, of a slight bluish tint, and contains from 6 to 20 grains of mineral matters per gallon. Its temperature is generally about 52° Fahr. It is hard, but softens considerably by boiling. Water from lime stone and gypsum strata is hard, softens less by boiling, and is not so wholesome as chalk–water, but it is generally clear and sparkling and of agreeable taste.

Water from millstone—grit is pure, and contains from 4 to 9 grains per gallon of mineral matters. Water from granite is pure, and contains from 2 to 6 grains of mineral matters per gallon. Water from clay—slate is generally pure, and contains from 3 to 5 grains of mineral matters per gallon.

Water from gravel and loose sand is generally pure where the gravel and sand are free from impurities, but water from sand rich in salts is impure and unwholesome. Water from impure sand generally contains from 50 to 100 grains of mineral matters per gallon.

Water from clay, or from a mixture of clay and sand, is generally impure, and contains from 30 to 130 grains of mineral matters per gallon.

Surface—water from cultivated land, subsoil—water, marsh—water, ditch—water, and water from shallow wells and ponds, are all more or less impure, and dangerous to health.

## Water Softeners.

The dissolved impurities in feed water consist mainly of the sulphates, carbonates, and chlorides of calcium, magnesium, and Sodium; but there may also be present the nitrates of these metals and other salts of iron and alumina.

Calcuim carbonate, is only very slightly soluble in water, but if the water contains dissolved dioxide, the carbonate will dissolve easily, forming calcuim bicarbonate. When such water is boiled, the carbon dioxide is driven off and the carbonate is precipitated, forming a fairly soft scale.

Calcium sulphate dissolves in water, and on evaporation it is thrown down as a hard and tenancious scale which adheres very firmly to the plates.

Calcium chloride is very soluble in water, and does not form scale in the normal course of events, but it is liable to have a corrosive action on the plates.

Calcium nitrate is also very corrosive in its action since it may re-act with other salts liberating free nitric acid which vigorously attacks iron and steel.

Magnesium carbonate acts in a very similar manner to calcium carbonate, the sulphate is very soluble and does not in itself form scale, but it may react with calcium carbonate, forming mag—nesium carbonate and calcium sulphate.

The salts of sodium are all soluble, but if the carbonate is present in excess, it is liable to cause foaming and priming.

## Magnitude of Scale Formation.

With a fairly normal water containing 15 grains of scale—forming Constituents per gallon, the weight of scale produced in a Lancashire boiler operating ten hours per day at 800 gallons per hour will be approximately 16 lbs. per day. Professor Rankine has etimated that $\frac{1}{6}$ in. of average scale necessitates the expenditure of 16 per cent more fuel; $\frac{1}{4}$ in. of 50 per cent; and $\frac{1}{2}$in. of 150 per cent more fuel than a perfectly clean boiler. If the temperature of the clean plate of a boiler is about 350°F., The effect of $\frac{1}{2}$ in. of scale is to increase the temperature of the shell to 750° Fah. for the same evoporation.

Hardness which can be removed by boiling is called "temporary hardness" whilst that which cannot be removed in such a manner is called "permanent hardness." These two forms of hardness together form the "total hardness." In order to neutralize the effect of the free carbon dioxide in the water and precipitate the Constituents which produce temporary hardness, lime is added. To remove the constituents which produce the permanent hardness, carbonate of soda is added; this reacts with the sulphates to form carbonates of these metals and sulphate, chloride, or nitrate of soda. This is roughly the principle on which many water softeners work, although in the case of the Permutit process artificial Zeolites are used in which calcium and magnesium replace sodium in a slicate, the material being renewed by treatment with common salt after it has become exhausted.

## Softening Water.

For softening water and preventing incrustation, pure caustic soda has been found to be the most effective, its strength should be 98 per cent., that is containing only 2 per cent. impurities. Some caustic soda has only 60 per cent. strength, and contains common salts and sulphur salts, which injure the boiler plates. The pure caustic soda in powder should be dissolved in water, and introduced continually with the feed water, by connecting the suction-pipe of the pumps with the vessel containing the composition. The proper amount is, for very hard water, 1 oz to every 5 gallons of water, and for water of medium hardness 1 oz. for every 10 gallons, and for fairly good water 1 oz. for every 15 gallons. In using caustic soda, the boiler should be frequently blown off.

Soda—ash is some times used, but it is not nearly so effective as pure caustic soda, besides, soda-ash often contains impurities which injure the plates.

## Avoidance of Trouble Due to Grease and Oil.

Grease and oil in the feed water are always objectionable, since they prevent the free transmission of the heat of the furnace gases through the boiler plates and tend to cause distortion and bulging of the plates and general increased wear and tear on the plant. If the mineral deposit is small in quantity and floury in nature a very troublesome state of affairs is set up, and overheating is very liable to occur. Oil in the water is also liable to prevent the free evolution of steam from the bulk of the water.

When the feed water has been heated by exhaust steam or by blowing with live steam, it is particularly liable to contain oil, and water returned from the condensers or reciprocating engines almost always contains sufficient oil to cause trouble. This oil cannot be removed by filtration since it is in the form of an emulsion, the oil globules being of the order of one eighty—thousandth of an inch in diameter. Exhaust steam separators are therefore used, and in these the velocity of the steam is reduced, and it is simultaneously subjected to a baffling action which leads to change of direction of the steam with deposition of the oil.

Chemical treatment of feed water containing oil consists in adding chemical reagents, of the type of Alumino-ferric, to coagulate the oily particles in masses, which may then be removed by filtration. Electrical separators are also used in which the effect of the passage of an electrical current is to cause coagulation of the oily particles. The water is then filtered, and attention must be paid to the filters in order to prevent the oil passing on to the boilers.

## Damper and Boiler Settings.

The dampers and boiler settings should be periodically inspected in order to detect any leakage of heat that may be occuring in this way. Badly fitting dampers allow of the in—leakage of considerable quantities of cold air, thus spoiling the draught and leading to waste of fuel by dilution of the furnace gases. In batteries of boilers, a badly fitting set of dampers, on a boiler which is shut down, may lead to inrush of cold air to the main breeching, thus spoiling other boilers which may be in perfectly good order.

The boiler settings should be examined for short—circuiting which is particularly liable to occur at the downtake so that the furnace gases, instead of passing through the bottom flue and back through the side flues, may pass straight from the downtake to the back end of the side flues.

The efficient lagging of the plant should also receive attention, since losses through the exposure of unlagged surfaces may assume serious dimensions.

## Feed Water.

The feed water should be fed to the boiler steadily and not in large quantities at a time. Where economizers are installed, such irregular feeding means that at one minute cold water is being rushed through the economizers, whilst at another time these are being subjected to the heat of the furnace, gases without any water being passed through them. They are then liable to become overheated, generating steam and functioning more as a boiler than as an economizer. Such alternations lead to strain, both of the boiler and economizer. The feed water should preferably be measured through a reliable feed water meter, as it is impossible to say what performance a plant is making without accurate figures of the water and fuel consumption.

## Consumption of water per head per day.

The minimum quantity of water in gallons per head per day, sufficient for all the requirements of a clean household, without allowance for waste, may average as follows :—

| | | |
|---|---|---|
| Water for drinking and making tea and coffee .. | ½ | gallon. |
| „ „ Cooking purposes .. .. .. | 1 | „ |
| „ „ washing the house and utensils .. | 2 | „ |
| „ „ laundry purposes .. .. .. | 2½ | „ |
| „ „ water—closet .. .. .. .. | 4 | „ |
| „ „ bath .. .. .. .. .. | 5 | „ |
| | 15 | „ |

## Boilers.

Four* Lancashire boilers equipped with super—heaters maximum steam pressure is 180 lbs. per sq. inch.

## Purpose of a Boiler.

The purpose of a steam—generating equipment is to convert available energy in the form of fuel into heat energy carried by steam in order that it may be employed to provide mechanical energy. To convert the energy of steam into mechanical energy the steam must be generated at a higher pressure than the atmosphere. Obviously, therefore, a boiler must be made strong enough to withstand the pressure intended, and must also be protected against the consequences of carelessness, unskilful and dangerous operating methods, in order that long service may be obtained for an installation.

## Choice of a Type of Boilers.

The following considerations are very important when making a selection for a boiler.

(1) the area of the heating surface, (2) the area of the grate surface, (3) the area and route of the gas passages from the combustion chamber, (4) the free circulation of water in the boiler, (5) facilities for inspecting, cleaning, repairing and keeping the boiler free from soot and ashes without and, free from scale and sediment within, (6) the kind of fuel to be used, (7) area of space available for installation.

The following facters are necessary to be stated when buying a new boiler.

(1) the number of pounds of water required to be evaporated per hour; (2) the temperature of feed—water, (3) the pressure of the steam, (4) the calorific value of the fuel to be used, (5) the efficiency of the boiler which should be guaranteed.

## Lancashire Boilers.

These boilers are similar to the Cornish, but have two internal flues running the whole length, and range in standard size from

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* The Particulars of machinery, Stores consumed and hands emqloyed pertains to a mill of about 50000 Spindles and 1200 looms and are given only by way of information and guide.

24ft, by 6ft. 6ins., with an evaporation of about 5000 lb. of water per hour, to 30ft. by 9ft. 3in., giving an evaporation of about 9500 lb. per hour, and are suitable for any pressure up to about 200 lb. per square inch.

## Cornish Boilers.

These boilers have one internal flue running from end to end. Usually about one-fifth of the length is taken up by the grate, the hot gasses thus passing to the end of the boiler and back along the sides and bottom before reaching the chimney. Cornish type boilers vary in size from about 10ft. by 4ft. diameter having an internal flue of 2ft. diameter, and evaporating, say, 850 lb. of water per hour to boilers 24ft. long 6ft. 6ins. diameter, with a flue 3 ft. 6 ins. diameter. Such a boiler could evaporate about 3000 lb. of water per hour and work up to 150 lb. per sq. inch pressure. Economical combustion is obtained when the gasses given off from the burning fuel are properly combined with suitable quantities of oxygen from the atmosphere. An intelligent appreciation of the laws governing combution is, therefore, essential if steam boilers are to be efficiently operated.

## Loss of Heat.

Coke,—contains .86 carbon, but no hydrogen or oxygen, and yields (14,500 multiplied by .86) =12,470 units of heat.

Wood,—when dry, contains .50 carbon, and the hydrogen and oxygen combine without yielding heat, and yields (14,500 multiplied by .50) =7,250 units of heat per lb.

Heat,—lost by radiation =10 per cent.

Heat,—lost by ashes falling unburnt through the fire bars =10 per cent.

Heat,—lost by gases escaping at a high temperature to the chimney—20 per cent.

Heat,—used in producing steam in internally fired boilers =60 per cent.

In externally fixed boilers the loss is 10 per cent. greater.

## Average Boiler Efficiency.

| | 30 lb. per. sq. inch. no super heat. | 15 lb. per sq. inch 500F. Temp. | 50 lb. per sq.inch. 750F. Temp. |
|---|---|---|---|
| Efficiency<br>Coal burnt. | 70 per cent.<br>Tons. 11.8 per hour | 75 per cent.<br>Tons. 12.03per hr. | 77 per cent.<br>Tons 12.81per hr. |

## General Data for Fixing Size of Boiler for Any Purpose.

The following figures may be taken as a rough guidance for average conditions :—

1 sq. ft. of heating surface should evaporate about 5 to 7 lbs. of water per hour.

1 lb. of good steam coal should evaporate about 7 to 8 lb. of water per hour.

About 30 lbs. of steam are required for one indicated horse power per hour.

About 20 lbs. of fuel can be consumed per sq. foot of grate per hour.

It is of the utmost importance, before installing a boiler, to make certain that the right size has been selected. Too small a boiler is a source of perpetual worry, whereas too large a boiler is apt to be extravagant. It is, however, better to err on the large side rather than on the small. The true measure of the capacity of a boiler is the amount of water which the boiler will evaporate. This depends upon two things :—

1. The grate area of the boiler;
2. The heating surface.

The first determines the amount of fuel which the boiler will consume; the second determines the amount of heat which the boiler can absorb. This is the only true way of estimating the power of a boiler. Horse power is the property of a steam engine. Some engines are more economical than others, and the amount of steam required to drive them varies considerably. In some engines 15 lbs. of steam per hour is sufficient for one indicated horse power, while in other as much as 40—50 lbs. may be required. When possible the maker of a steam engine should be asked to state the amount of steam required per hour, and the size of the boiler should be determined from this, or the amount worked out as shown below. The amount of steam required per I.H.P. or B.H.P. varies largely with the size and type of engine, but the following table may be taken as a rough guide for different classes of engines :—

| Type and Class of Engine. | Lbs. of steam required per hour. I.H.P. | B.H.P. |
|---|---|---|
| *Class* 1. Compound condensing engines of not less than 250 I.H.P. fitted with special corliss or other trip valve gear .. .. .. .. | 15 | 19 |
| *Class* 2. Compound condensing engine .. .. | 20 | 25 |
| *Class* 3. Single cylinder condensing engine .. | 25 | 31 |
| *Class* 4. Single cylinder non-condensing engines working expansively, such as small mill engines, winding engines, and air compressor engines .. | 30 | 37 |
| *Class* 5. Single cylinder non-condensing engines, fast running, with late cut off, such as electric engines, vertical portable engines, etc. .. .. | 35 | 44 |
| *Class* 6. Small engines similar to class 5, having cylinders less than 10″ dia. .. .. .. | 40 | 50 |

The foregoing figures are for good new engines of their class. When the engine is old and therefore more wasteful of steam, the figures of the next lower class should be taken, and in the case of class 6, 50 lbs. and 60 lbs. per I.H.P. and B.H.P. respectively.

## TO CALCULATE AMOUNT OF STEAM REQUIRED FOR A STEAM ENGINE.

In cases where the exact dimensions and revolutions of an engine are known the amount of steam can readily be calculated by means of the following formula: $\frac{A \times 2S \times R \times 60}{1728} \times C =$ lb. of steam required per hour.

When A = area of cylinder in sq. inches

„ S = distance steam is carried in cylinder in inches

„ R = number of revolutions per minute

„ C = weight of steam in lbs. per cubic foot at working pressure. (*See* table below for the various values of C.)

*Note.*—In most engine the steam is seldom carried more than 75 per cent of the stroke, or less than 50 per cent.

## Lbs. Per Square Inch Above Atmosphere.

| Working Pressure | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Weight of steam in lbs per c. ft. | .08 | .11 | .13 | .15 | .17 | .20 | .22 | .24 | .26 | .28 | .30 | .32 | .35 | .37 | .39 | .41 |

*Boiler feed water should be tested for :—*

(1) Total solids ;
(2) „ hardness ;
(3) Temporary and permanent hardness.

*Condensed water should be examined at intervals for :—*

(1) Re-action to lacmoid ;
(2) Chlorides ;
(3) Iron.

### VOLUME AND SAVING OF SUPERHEATED STEAM.

| Pressure in lbs. per Square Inch | Temperature on the Fahr. Scale in Degrees | Temperature on the Centigrade Scale in Degrees | Volume of 1 lb. of Saturated Steam in Cubic Feet | Volume of 1 lb. of Steam Superheated 100° Fahr. in Cubic Feet | Volume of 1 lb. of Steam Superheated 150° Fahr. in Cubic Feet | Volume of 1 lb. of Steam Superheated 200° Fahr. in Cubic Feet |
|---|---|---|---|---|---|---|
| 50 | 297.8 | 147 | 6.52 | 7.49 | 7.95 | 8.35 |
| 100 | 338 | 169.2 | 3.81 | 4.38 | 4.64 | 4.87 |
| 120 | 350 | 175.5 | 3.27 | 3.76 | 3.98 | 4.18 |
| 160 | 370 | 188 | 2.91 | 2.94 | 3.12 | 3.27 |
| 180 | 379 | 193 | 2.31 | 2.65 | 2.81 | 2.95 |
| 200 | 386 | 197.3 | 2.10 | 2.41 | 2.56 | 2.68 |

### ECONOMY IN STEAM CONSUMPTION.

| Degrees of Superheat (Fahrenheit) | Slow Speed Engines. | | High Speed Engines. | |
|---|---|---|---|---|
| | Average Consumption in lbs. per hour per 1 H.P. | Average Percentage Saving in Steam | Average Consumption in lbs. per hour per 1 H.P. | Average Percentage Saving in Steam |
| Saturated | 14 | — | 15 | — |
| Superheat added | | | | |
| 50° Fah | 13 | 7% | 13 | 6.5% |
| 100° Fah | 12 | 14% | 13 | 13 % |
| 150° Fah | 11 | 21% | 12 | 20 % |
| 200° Fah | 10 | 27% | 11 | 26 % |
| 250° Fah | 9.5 | 32% | 10.5 | 30 % |

when used in conjuction with Turbine Engines, the improvement in steam consumption may be taken as not less than 1 per cent. for each 10° Fah. of superheat.

## "STEAM BOILER PLANT EFFICIENCY."

It is well known that natural draught is obsolete for almost every type and size of industrial steam boilers, and especially "Lancashire" boilers, if only because the intensity of the draught depends upon the waste of heat in the chimney base. Obviously, the ideal practice is to work with some form of forced or induced draught under easy control, entirely independent of the chimney, and allowing at the same time full utilisation of the waste heat in the feed water economisers, superheaters, and other equipments. Forced draught, whether by means of steam jets or mechanically operated fans, has many advantages, always providing, of course, that it is designed and equipped on scientific lines, giving a high temperature in the furnace with the heat "localised" in the boiler. Ordinarily about 50 to 55 per cent. of the energy in fuel is lost in boilers in unburnt coal, improper $Co_2$. inefficient conduction due to scales and soots adhered in boiler tubes and plated, heat absorption by the brick work, loss in chimney gas and percentage of ash.

Selection of boilers depends much upon the nature and quality of feed water available and demand of steam in working hours.

In cotton mills steam demand is almost regular throughout the day except the demand of heating and dye and bleach house steam. The heating and process steam required is about 20 to 25 per cent. of the total steam generated.

In an average size of dye and bleach works about 8000 pounds of steam per hour for dyeing and bleaching process will be required. Besides this another 7000 pounds for sizing and heating per hour will be necessary.

## CAUSES THAT TEND TO SHORTEN THE LIFE OF A BOILER.

There are several causes which tend to shorten and destroy the life of every boiler. These are divided into two general classes, chemical and mechanical, and are usually the result of improper feed water or of improper care. Pure water, free from air and carbon—dioxide, has no evil effect on the boiler plates; but all natural waters, whether from rain, lake, river or sea, contain air and a little carbon—dioxide in solution, and such water, will cause iron to corrode, even though no other impurities are present, and since boilers installed in textile mills are almost inveriably fed with natural waters.

The primary cause of internal corrosion is the chemical action resulting from impure feed water. This may occur as a general wasting away of the boiler plates, or in the form of pitting and grooving. When corrosion takes place uniformly over the surface or when pitting is the cause, the result is due entirely to chemical action; in the case of grooving, however, it is the result of chemical and mechanical action combined.

The external corrosion may be due to faulty setting, to improper care, or to moisture from external sources, or from leakage from joints and valves. Although considerable deterioration may take place without being detected, with reasonable care and systematic inspection less difficulty will be experienced than with internal corrosion.

When the plates are attacked uniformly a form of corrosion results which is most difficult to detect, and drilling may have to be resorted to in order that the thickness of the plate can be gauged, and if it is materially reduced, the working pressure of the boiler must be lowered in proportion.

## Nominal Horse-Power of Boilers.

The nominal horse–power of a boiler is estimated by its size, and may be found by the following rules deduced from practice.

Multiply the diameter in feet by the length in feet and divide by 6. or, Divide the I.H.P. of the engine by 8 and the result thus obtained will be the H.P. of the boiler.

## Nominal Horse-Power of Cornish Boilers

Add the diameter of the shell, and the diameter of the flue together, in feet, and multiply the sum by the length in feet, and divide the product by 8.

## Nominal Horse-Power of Lancashire Boilers.

Add the diameters of both flues, and the diameter of the shell together, in feet, multiply the sum by the length in feet, and divide the product by 8.

## Safety Valves.

A safety-valve should be capable of discharging considerably more steam than the boiler can generate, by the combustion of all the coal that can be burnt upon its fire-grate, to prevent the blowing-off pressure being materially exceded, and the area should be proportioned both to the fire-grate surface and to the pressure of steam. The lower the pressure the larger must the safety—valve be. When steam flows through an orifice with a square edge such as a safety-valve, its flow is considerably reduced, and the weight in lbs. of steam discharged per minute, per square inch in opening, corresponds nearly with three—fourths of the absolute pressure in the boiler, when that pressure is not less than 25 lbs., or 10 lbs. above the atmosphere. The area of opening requisite for the discharge of any given constant weight of steam, is in inverse ratio of the pressure; that is to say, it requires an orifice of three times larger area, to discharge steam of 30 lbs. pressure, than is required to discharge the same weight of steam per minute at 90 lbs. pressure.

## Size of Chimney.

| BOILERS | | CORNISH | | | | | LANCASHIRE | | | | | | | TUBULAR BOILERS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIAM. OF BOILER | | 4'6" | 5'0" | 5'6" | 6'0" | 6'6" | 6'0" | 6'6" | 7'0" | 7'6" | 8'0" | 8'6" | 9'0" | 5'0" | 5'6" | 6'0" | 6'6" | 7'0" | 7'6" | 8'0" | 8'6" | 9'0" | 9'6" | 10'0" |
| GRATE AREA IN SQ. FEET | | 10 | 14 | 15 | 16 | 21 | 22 | 26 | 30 | 36 | 39 | 44 | 47 | 10 | 14 | 16½ | 21 | 30 | 34 | 38 | 39 | 43 | 46 | 49 |
| CHIMNEY | | NUMBER OF BOILERS TO ONE CHIMNEY | | | | | | | | | | | | | | | | | | | | | | |
| HEIGHT | DIAM. | | | | | | | | | | | | | | | | | | | | | | | |
| 40' | 2' 0" | 1 | 1 | 1 | | | | | | | | | | 1 | 1 | 1 | | | | | | | | |
| 45' | 2' 3" | 2 | | | | | | | | | | | | 2 | | | | | | | | | | |
| 50' | 2' 6" | | 2 | | 1 | | 1 | | | | | | | | 2 | | 1 | | | | | | | |
| 55' | 2' 9" | 3 | | 2 | | | | 1 | | | | | | 3 | | 2 | | | | | | | | |
| 60' | 3' 0" | 5 | 3 | | | | | | 1 | 1 | | | | 5 | 3 | | | 1 | 1 | | | | | |
| 65' | 3' 3" | | | 3 | 2 | | 2 | | | | 1 | 1 | | | | 3 | 2 | | | 1 | 1 | 1 | | |
| 70' | 3' 6" | | 4 | | | | | 2 | | | | | 1 | | | | | | | | | | | |
| 75' | 3' 9" | | | 4 | | | | | | | | | | | | | | | | | | | | |
| 80' | 4' 0" | | 5 | | 3 | 2 | 3 | | 2 | | | | | | 5 | | 3 | 2 | | | | | | |
| 85' | 4' 3" | | | | | | | 3 | | 2 | | | | | | 5 | | | 2 | | | | | |
| 90' | 4' 6" | | | | 4 | 3 | 4 | | 3 | | 2 | | | | | 6 | 4 | 3 | | 2 | 2 | | | |
| 95' | 4' 9" | | | | 5 | | 5 | 4 | | | | 2 | | | | | 5 | | | | | 2 | 2 | |
| 100' | 5' 0" | | | | | 4 | 6 | | 4 | 3 | 3 | | 2 | | | | 6 | 4 | 3 | 3 | 3 | | | 2 |
| 105' | 5' 3" | | | | | | 7 | 5 | | | | | | | | | 7 | | | | | | | |
| 110' | 5' 6" | | | | | 5 | 8 | 6 | 5 | 4 | | 3 | | | | | 8 | 5 | 4 | | 3 | | | |
| 115' | 5' 9" | | | | | | 9 | 7 | | | 4 | | 3 | | | | | 4 | 4 | | | 3 | | |
| 120' | 6' 0" | | | | | | 10 | 8 | 6 | 5 | | 4 | | | | | | 6 | 5 | | | 4 | | 3 |
| 125' | 6' 3" | | | | | | | 9 | 7 | | 5 | | 4 | | | | | 7 | | 5 | 5 | | 4 | |
| 130' | 6' 6" | | | | | | | 10 | 8 | 6 | | 5 | | | | | | 8 | 6 | | | 5 | | 4 |
| 135' | 6' 9" | | | | | | | | 9 | 7 | 6 | | 5 | | | | | | 7 | 6 | 6 | | 5 | |
| 140' | 7' 0" | | | | | | | | 10 | | 7 | 6 | | | | | | | 8 | 7 | 7 | 6 | | 5 |
| 145' | 7' 3" | | | | | | | | | 8 | | | 6 | | | | | | | | | | 6 | |
| 150' | 7' 6" | | | | | | | | 12 | 9 | 8 | 7 | | | | | | | | 8 | 8 | 7 | | 6 |
| 155' | 7' 9" | | | | | | | | | 10 | 9 | 8 | 7 | | | | | | | 9 | 9 | 8 | 7 | |
| 160' | 8' 0" | | | | | | | | | | 10 | | 8 | | | | | | | 10 | 10 | 9 | 8 | 7 |
| 165' | 8' 3" | | | | | | | | | 12 | | 9 | | | | | | | | | | | | 8 |
| 170' | 8' 6" | | | | | | | | | | 12 | 10 | 9 | | | | | | | | | 10 | 9 | |
| 175' | 8' 9" | | | | | | | | | | | | 10 | | | | | | | | | | 10 | 9 |
| 180' | 9' 0" | | | | | | | | | | | 12 | | | | | | | | | | | | 10 |
| 185' | 9' 3" | | | | | | | | | | 15 | | 12 | | | | | | | | | | | |
| 190' | 9' 6" | | | | | | | | | | | 15 | | | | | | | | | | | | |
| 195' | 9' 9" | | | | | | | | | | | | 15 | | | | | | | | | | | |
| 200' | 10' 0" | | | | | | | | | | | | | | | | | | | | | | | |

The above table shows (for normal working conditions) at a glance the size of chimney required for a single boiler up to a range of fifteen 9 feet 9″ diameter boilers.

In Manchester the mill chimneys are often 320 feet high and even higher, whereas the average height of mill chimneys in India is only about 180 feet.

## Air To Coal Ratio.

With heavy intermittent firing and very thick fires the proper regulation of the air supply is also rendered much more complicated by reasons of the draught requiring to be varied from maximum directly after firing to a minimum when the fire has burned or attained its state of maximum incondescence. From 18 to 22 lbs. of air per pound of coal consumed has been given as the amount necessary to give a proper supply of oxygen, and hence it will be evident that, even under good conditions, not less than 13 or 14 lbs. of useless nitrogen must be heated from the temperature of that of the entering air to that of the gases given off during combustion. These factors must be taken into consideration as bearing on the resultant furnace temperatures. It will be found that the ultimate composition of the flue gases will be affected by the relative proportions of oxygen to carbon.

## Double Loss Due To Excess Air.

Excess air thus leads to losses in two directions, since it leads to diminished temperature of the furnace gases produced on combustion, and therefore to diminished heat transference, and also to increased losses as sensible heat in the flue gases. Paradoxical though it may sound, a plant running with a large percentage of excess air may have a higher exit temperature than one in which the air is regulated correctly. With an undue amount of excess air, the volume of gases passing through the flues is tremendous, amounting to about 750,000 cu. ft. per ton of coal burnt, with approximately twice the theoretical quantity of air. The greater the amount of air admitted per lb. of coal, the greater will be the volume of flue gas generated, and therefore the greater will be the velocity of the flue gas through the flues. In certain cases, then, the gas will be hurried through the flues before it has had time to impart its heat to the boiler shell, and therefore the exit temperature of the flue gas may be higher than in a case where the correct amount of air is being used, and where the flue gas is passing more slowly through the flues and is giving up the maximum proportion of its heat to the surface of the plates, and through them to the water. In a fast—moving current of gas, it is only the outer layers of the current which come into intimate contact with the furnace plates, whilst the central portion of the current passes on without coming in contact with any cooling surface.

## Firing Steam Boilers.

The temperature of the fire should be as high as possible, in order to effect the rapid diffusion and combination of the gases, and so securing the complete combustion of the carbon to carbonic acid. The best thickness of fire depends upon the character of the fuel and strength of the draught. The more freely the coal burns, the thicker the fire may be; and a thick fire is necessary for a high furnace temperature. Irregular firing results in waste of fuel. Heavy charging at long inervals is objectionable, as its damping effect produces a lowering of temperature. The coal on the top is quickly coked by the heat below, and the gases driven off pass away to the chimney unconsumed.

## Fuel Economy.

The aim is greatest output of power or heat for least expenditure of fuel. Usually too much air is admitted to boiler furnaces in order to keep chimney smokeless. A smokeless chimney may accompany very poor fuel economy. A good practical check on the fireman on plants not using any instruments is to insist that the chimney top shall show a very faint light brown smoke, which is barely visible. Such conditions indicate very fair economy. Too little air is worse even than too much, it not only create black smoke, but wastes over 70 per cent of the heat in the fuel.

## Coal.

Coal and water are looked upon as being the raw material for the production of energy.

In the early stage of industrialisation coal held almost a monopoly in the field of power production. England achieved her industrial pre-eminence in the first years of the last century mainly because of her abundant supply of coal. Similar utilization of coal in Germany, France and U.S.A. led to the progress of industry in those countries. This meant a greater utilization of coal in industry.

But later on there was a reduction in coal consumption when methods were discovered to extract more of energy from a given amount of coal. In 1920, 3.5 lbs. of coal were needed to generate one kilowatt hour of electricity in central generating stations while in 1929 only. 1.9 lbs were needed. The use of coal became further reduced on account of very rapid development of water power in U.S.A., Japan, New Zealand, Canada, Scandinavia and in central and Southern Europe. Nearly 88.5 per cent. of the world's production of power was supplied by coal in 1913, while in 1931 only 66.5 per cent. was supplied by coal. The supply of power from water was 4.3 in 1913 and 12.4 in 1931. Since then there has been rapid progress in the supply of power from water. Coal is still being largely used in India for industries and transport. Most of the coal produced in India comes from Bengal, Bihar and Orissa. Coal is also produced at Singareni in Hyderabad. Coal has to be transported from these places to other parts of India by rail and sea and hence it adds to the cost.

The high cost of coal has, in recent years, enforced the attention of steam users to the necessity of economizing in their fuel consumption to the utmost degree. Pronounced as this necessity is, it is amazing how slip shod and lax are the methods applied to control of the boiler-house.

## Coal Consumption per I.H.P.

A good quality of coal should evaporate 9 lbs. of water for each one lb. burnt, and for a manufacturing concern (including sizing, which takes a great amount of steam) the consumption of coal should not be more than 3¼ lbs. per indicated horse power per hour. Thus 600 horse power would use about 47 tons per week, of 9 hours per day, excluding sizing 2¾ lbs. per I.H.P. per hour would suffice.

## Evaporative Power.

The 'average evaporative power', of various kinds of fuels, is as follows :—

1 lb. good coal will evaporate 9lbs.water which has been raised to212°

⅝ lb. of petroleum ,, ,, 9 ,, ,, ,, ,, ,, ,, 212°

2 lb. of dry peat ,, ,, 9 ,, ,, ,, ,, ,, ,, 212°

3½ lbs. of dry wood ,, 9 ,, ,, ,, ,, ,, ,, 212°

3¼ lbs. of cotton stalks ,, 9 ,, ,, ,, ,, ,, ,, 212°

3½ lbs. of brush wood ,, 9 ,, ,, ,, ,, ,, ,, 212*

3¾lbs.of wheat or barely straw 9 ,, ,, ,, ,, ,, 212°

4lbs. of megas or sugar cane refuse 9 ,, ,, ,, ,, ,, 212°

The consumption of coal per I.H.P. per hour, in first-class triple—expansion surface—condensing engine, is about $1\frac{1}{2}$lbs., in double—expansion condensing engines, from $1\frac{3}{4}$ to 2 lbs., in single cylinder condensing engines, $2\frac{1}{2}$ to 3 lbs.; in locomotives, $2\frac{1}{2}$ lbs.; and in high pressure non-condensing simple engines, 3 to 4 lbs.

## Fuel Oil.

Fuel oil or other liquid fuel is used in those plants where space is limited, as in marine boilers, where cleanliness of operation is a first consideration, or where the price of liquid fuel is less than that of coal, taken on a basis of equal calorific values. In tropical regions other fuel are used according to the cost of coal and native supplies. Bagasse, or sugar-cane refuse, which is frequently used in the East and West Indies, Mexico, and Peru, consists chiefly of woody fibre and water. Wood is also largely burnt in countries where coal can be purchased at a relatively high price, whilst other installations are being operated with fuels such as coffee husks, rice husks, sawdust peat etc. All fuels consist mainly of carbon, hydrogen, and oxygen, with varying small proportions of sulphur, nitrogen, and adventitions mineral matter which forms ash on combustion of the fuel. Liquid—Fuels comprise all classes of fluid hydrocarbons, such as, the mineral hydrocarbons of bitumen and asphalt; oils obtained by destructive distillation of coal, shale and Schist; and animal and vegetable fats and oils. The heating-effect of liquid-fuel, when injected into the furnace in the form of spray, is about 3 times as great as that of coal.

## Fuel Testing.

To make a complete boiler test it is necessary to have the fuel analysed to determine (i) moisture, (ii) ash, (iii) volatile matter, (iv) coke, (v) sulphur (vi) calorific value; and these determinations can be carried out quite easily with very simple apparatus. Before testing, the coal should be carefully sampled so as to get a truly representative specimen. The sample should be ground up in an iron mortar, mixed by sieving (60 mesh), and immediately bottled in a well-stoppered bottle.

A coal contract should contain definite stipulations as to the heat value of the coal ordered. Coal exposed to the atmosphere or weather loses heat value. Experience and research have proved beyond doubt that, although the cost of fuel may be a very important factor in steam power plant costs, efficiency of operation is of equal importance, since it is only by intelligent manipulation of the plant that the most economical results are obtained.

## To Determine Moisture.

Heat between 50 and 100 grains in a porcelain dish to 100°c to 105°c until no further loss occurs. The loss in weight represents moisture which should not exceed 8 per cent.

## To Determine Ash.

About 5 grams should be weighed in a silica basin and carefully heated over a bunsen flame in a muffle furnace, taking care not to fuse the ash—the difference in weight represents ash.

## To Determine Calorific Value.

When coal burns in air or oxygen, or in any other medium capable of sustaining its combustion, the chemical changes thereby produced result in liberation of heat. In determinations of calorific value, the amount of heat evolved by the complete combustion of one pound of coal is measured.

Quantities of heat can be expressed in several ways, but for calorific values of coal it is most usual to do in what are known as British Thermal Units (written B.T.U.). One B.T.U. is the amount of heat required to raise one pound of water through one degree Fah. in temperature.

In transforming water into vapour or steam, a large amount of energy (in the form of heat) has to be expended. In physics the amount of heat is measured by heat units or calories, one caloric being the amount of heat necessary to raise a unit (1 gramme) of water through 1°c. Thus, in order to raise one gramme of water from 0° to 100°c., 100 Calories would be required. The same amount of heat would suffice on the other hand to raise 100 grammes of water from 0° to 1° or 5° to 6°, or 25 grammes of water from 0° to 4°, and so on. But in order to raise one gramme of water at 100° into steam of the same temperature, the amount of heat required is no less than 537 calories. In the operation of non-condensing engines, the quantity of so-called latent heat which thus passes away into the surrounding atmosphere is absolutely lost for all practical purposes. In like manner a great loss of heat may be sustained by condensation in steam-pipes which are badly or nsufficiently insulated.

The heat apparently lost in the conversion of water into steam shows itself again in the condensation of the steam into water, one gramme of steam at 100° containing sufficient heat to raise 537 grammes of water at 1°c. Thus, in the heating of dye-vats or sizing cylinders or size mixing becks by steam practically no heat need be lost if the pipes are well insulated, the steam merely serving as a convenient medium for transferring the heat produced in the boiler to the parts of the works in which it is required.

With a good boiler installation, one pound of coal should convert not less than 7 lbs. of water into steam at 100°c. and this might be practically taken as equivalent to $7 \times 537 = 3759$ pounds—calories, from this it would, for example, be easy to calculate the amount of coal necessary to raise a 300—gallon vat of water from the ordinary temperature (say 10° in winter to boiling point). Using the pound as unit in the caloric, we have 300 gallons or 3000 lbs. to be raised from 10° to 100° through 90°c $= 3000 \times 90$ or 270000 pound-calories.

Now 3759 pound Calories require 1 lb. coal.

or 1 ,, ,, ,, $\frac{1}{3759}$

:. 270000 ,, ,, ,, $\frac{270000 \times 1}{3759} = 72$ lbs. practically.

## Effect of Coal On Draught And Economy.

No definite rule can be stated as applying to every type of plant and every type of coal, but the person in charge of the plant, should adjust the dampers of the plant and vary the draught until the point is found at which the carbon dioxide content of the flue gas is highest without the formation of any carbon monoxide taking place. To secure this result, the flue gas must be analysed with every adjustment of the draught, and when the carbon dioxide content is highest, carbon monoxide being absent, the position of the dampers should be noted and the draught measured for future reference.

The best draught to use will, of course, vary with different loads, a heavier draught being required with increasing loads in order to burn more fuel per Sq. ft. of grate area. The use of a reliable carbon dioxide recorder or indicator will be apparent and with a carbon dioxide indicator, the draught can be regulated until the instrument shows the highest figure.

The weights of oxygen Combining with carbon, Hydrogen, and sulphur are as follows :—

1 lb. of carbon combines with 2.667 lbs. of oxygen.

1 lb. hydrogen combines with 7.936 lbs. of oxygen.

1 lb. of Sulphur combines with 0.9983 lbs. of oxygen.

Since air contains 23.01 per cent by weight, and 20.81 per cent. by volume of oxygen, it follows that the quantities of air theoretically required for the combustion of the various constituents of the coal are as follows :—

1 lb. Carbon, burning to carbon dioxide, needs 11.595 lbs. (143.63 cu. ft.) of air.

1 lb. carbon burning to carbon monoxide, needs 5.798 lbs. (71.82 cu. ft.) of air.

1 lb. hydrogen, burning to water, needs 34.49 lbs. (427.40 cu.ft.) of air.

1 lb. sulphur, burning to sulphur dioxide, needs 4.338 lbs. (53.75 cu. ft.) of air.

## Economisers.

The most popular type of economiser is the Green's economiser which consists of a series of cast iron vertical pipes. These pipes are arranged in rows of 6, 8, or 10 per row. The waste heat from the boilers is led to the economiser by the ordinary flue from the boilers to the chimney. The feed water is forced into the economiser by the boiler feed pump into the bottom branch pipe at the end farthest from the boilers and leaves the economiser by the top branch pipe at the end nearest to the boiler. Thus it absorbs a large proportion of the waste and effects a saving in fuel of about 15 per cent of the total fuel consumed. The pipes are fitted with scrapers which travel slowly up and down so as to keep them free from soot, which is a non-conductor of heat. The gearing for working the scrapers is placed on the top of the economiser outside the brick chamber, and the scrapers are traversed up and down by means of chains and rods which pass through small holes between the top boses. The scraper gearing is generally driven by a belt from a shaft. The economiser is fitted with blow-off and safety valves. A space is provided at the bottom of the chamber, under the economiser for the collection of soot thrown off by the scrapers which can be emptied by means of soot doors built into the side wall.

The temperature of the feed water is raised up to about 280° Fah. when passed through the economiser. The feed water should be supplied to the economiser at as high a temperature as possible to prevent the pipes of the economiser from sweating. Such sweating causes rapid external corrosion of the pipe. The feed water should never be below 85° Fah. The number of economiser pipes recommended for a boiler is 4 pipes per ton of coal consumed per week.

## Condensers.

Condensers are of two kinds: jet condenser and surface condenser. In the jet condenser the steam is condensed by being brought into actual contact with cold water, while in the surface condenser the steam condenses upon thin metallic surfaces which are kept cool by cold water circulating on the other sides.

The jet condenser consists of a cast iron chamber into which the exhaust steam from the cylinder of the engine passes and comes in contact with a jet or spray of cold water issuing into it. Jet condensers are largely used for land engines, and as far as mere efficiency goes, they are quite as good as surface condensers. The great objection to the jet condenser is that the water formed is not free from both boiler soot or dust which is a bad conductor of heat. The feed water for boiler is drawn from the hot well, so that if the water used for condensation be dirty or impure, the boiler becomes clogged with mud or scale, and the plates encrusted with impurities. Where good water may be obtained for condensation, jet condensers are always used, but if the water to be used for this purpose be impure, surface condensers should be adopted.

The surface condenser consists of a cast iron chamber, having a large number of thin brass tubes passing from one side to the other. These tubes are kept cool by forcing cold water through them by means of a pump known as the circulating pump. The exhaust steam which is admitted into the condensing chamber comes in contact with the exterior surface of the tubes and is condensed by the cooling effect of the water they contain. In some cases this order of things has been reversed and the steam passed through the tubes while the cold water is circulated outside.

## Pressures of Steam.

The pressure of steam is equal in all directions, therefore each square inch of surface exposed to its action must be equally capable of bearing the given pressure. The pressure is measured from that of the atmosphere, or 14.7 lbs. per square inch.

## Effective Pressure.

In a non-condensing engine the pressure of the steam is opposed by that of the atmosphere, therefore only pressures above that of the atmosphere are effective for work, and a deduction must also be made for the resistance due to back-pressure, caused by the resistance of the exhaust—passages, which may be reckoned at 2 lbs. per quare inch. In a condensing engine the pressure of the steam is only opposed by a back pressure of from 2 to 3 lbs. per square inch, due to imperfect vaccum.

The 'initial—pressure' of steam is its pressure when admitted to the cylinder.

The 'final—pressure' of steam is its pressure when discharged from the cylinder.

The 'mean—pressure' is the average pressure upon the piston through the whole stroke.

The 'effective mean—pressure' is the mean—pressure less the back-pressure.

The 'ratio of expansion' is the proportion which the final volume bears to the initial volume of steam.

The 'relative volume' of steam is the volume of steam generated from a given volume of water divided by this volume.

The 'Absolute—pressure' of steam is the pressure of steam given by the steam—gauge plus the pressure of the atmosphere.

'To find the quantity of steam used by an engine,' multiply the area of the cylinder in square feet by the speed of the piston in feet per minute, and divide the result by the nominal ratio of expansion. The result will be the member of cubic feet of boiler—pressure—steam consumed per minute, to which 10 per cent. must be added for the clearance of the cylinder and capacity of the steam-passages.

'To find the pressure' in lbs. per square inch of the steam at any point of the period of expansion, multiply the initial-pressure by the distance moved by the piston when the steam is cut off and divide the product by the distance of the given point from the beginning of the stroke.

'To find the point to cut off' the steam for a given actual ratio of expansion, add the clearance to the length of stroke and divide by the ratio of expansion, from the quotient deduct the clearance, and the remainder will be the point of the stroke at which to cut off the steam.

'The Action of the Governor' of a steam–engine is controlled by two forces, viz., centrifugal force, or the tendency of the revolving balls to fly away from the spindle or vertical axis, and centripetal force, or the tendency of the balls to hang in a vertical line from the centre of the pin suspending the arm, due to the force of gravity.

'To find the centrifugal force' of a governor in terms of the weight of the balls. Multiply the square of the number of revolutions per minute by the radius of the circle described by the centres of the balls in inches, and divide the product by the constant number 35,226.

'To find the centripetal force' of a governor in terms of the weight of the balls. Divide the horizontal distance of the balls from the centre of the suspending pin, by the vertical height of the same centres.

## Vacuum.

A vacuum gauge is an instrument for indicating the different pressures between a perfect vaccum and the pressure of the atmosphere. When the engine is working satisfactorily, it should show about 26 inches. The vacuum gauge alone does not tell what pressure there is in the condenser. To arrive at this we must have recourse to the barometer. The actual amount of back pressure in the condenser can be ascertained by subtracting the inches of vacuum shown by the vacuum gauge from the reading of the barometer. If the hot well is worked at a high temperature, there will be a saving of fuel, but the vaccum will be impaired. The advantage by working at low temperature will be an increase in the vacuum, but the feed water will be returned to the boiler much cooler, and more fuel would be consumed. Vacuum, depends on the efficient working of the air pump and the amount of water circulated through the tubes of the condenser.

## Steam Engine Indicator.

The Indicator is a small instrument temporarily applied either at the top or bottom of the cyinder, for the purpose of ascertaining the pressure of steam at each point of the stroke of the piston. The principal use of the indicator is to give a graphic representation of the varying pressure of steam through the stroke. Thus enabling the work which is being done by the engine to be correctly determined.

The variety of diagrams obtained from different engines, and by the same engine under different circumstances, is endless and there is perhaps nothing more instructive to the student of Engineering as there is nothing more interesting to the accomplished engineer than their careful and comprehensive study, with a knowledge of the modifying circumstances, under which it was taken. Lines at first meaningless become full of meaning, that which scarcely arrested his attention comes to possess an absorbing interest, he becomes acquainted with the inumerable variety vicious forms and learns the points and degrees, as well as the causes, of their departure from the single perfect form, he becomes familiar with the effects produced by different constructions and movements of parts, and competent to judge correctly as to the performance of engines, and to advise changes by which it may be improved.

The following illustration Fig. 1 represents a diagram illustrating the leading points in connection with the working of an engine :—

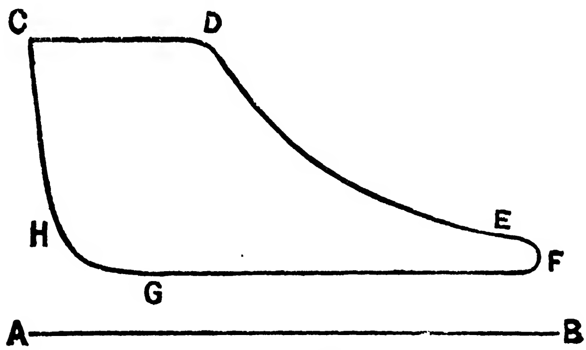


FIG. I

AB is the line of atmospheric pressure. Commencing with the piston at the beginning of the stroke at C, the line CD shows how much the piston has moved through a length of the stroke without any cut off. At D the steam admission valve is closed and the steam within the cylinder is allowed to expand. The result is that the pressure falls. This is indicated on the diagram by the curve extending from D to E. At E it will be observed, the pressure falls more rapidly in consequence of the opening of the exhaust valve at this point and by the time the piston has reached the end of its stroke, at the point F the pressure reaches its lowest point. At G the exhaust valve is closed, and compression causes a rise in the line. The calculation of the power developed by the engine is found by dividing the diagram into a number of sections by lines drawn at right angles to the atmospheric line at equal intervals and measuring the pressure according to the scale of the spring at the middle of each one of these divisions. By adding the whole of these dimensions together and dividing by their number the average pressure is at once obtained. It is usual in making such calculations to take ten divisions. This is found to give sufficient accuracy and also convenient, since the division of the total number simply means the shifting of the decimal point.

The illustration in Fig. II shows some of the defects in the indicator diagrams :—

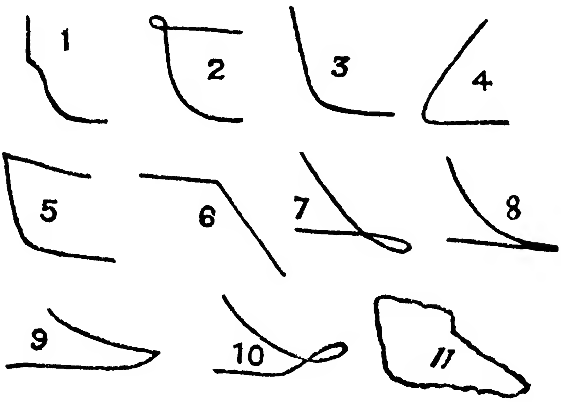


Fig. II

1st is due to excessive cushioning ;

2nd is due to excessive lead or excessive cushioning ;

3rd is due to excessive lead ;

4th is due to want of lead ;

5th is due to insufficiency of steam valve opening or contracted ports ;

6th is due to condensation of steam ;

7th is due to early cut off ;

8th is due to early exhaust ;

9th is due to late exhaust ;

10th is due to the late opening of exhaust valve ;

11th is due to the indicator piston not working freely.

It is better to use a separate indicator for each end of the cylinder so as to obtain cards simultaneously if possible, but one instrument will suffice for ordinary occasions of connecting sockets and unions which are conveniently fitted. The indicator spring should be of a tension suitable for the steam pressure in use. Great care must be taken to see that the indicator levers and piston work freely and that there are no loose pins to cause vibrating action, as such an action often gives variations in the diagrams indicating defective valves or connections.

The chief difference in the diagrams of the high pressure and low pressure cylinders is that the atmospheric line in the diagram of a high pressure cylinder is below the exhaust line, while the atmospheric line is above the exhaust line in the diagram of a low pressure cylinder. In the case of an intermediate cylinder, the atmospheric line is below the exhaust line.

## To Obtain the Indicated Horse Power.

A diagram (Fig. I) is taken from each end of each cylinder by means of a little piece of apparatus known as an indicator as described above. This diagram shows the initial pressure of steam against the piston, and also the gradual lowering of pressure as the piston continues its stroke. An average is made at ten points of this steam pressure, and thus the average pressure is obtained throughout the stroke. This multiplied by the area of the piston gives the total pressure on the piston in pounds and multiplied by the speed of the piston per minute in feet gives the number of foot-pounds of work done per minute.

*Example :—*

Find indicated horse power from the following particulars :—

Average pressure =39.81
Area of piston =400 sq. in.
Length of stroke $=5\frac{1}{2}$ ft.
(equally 11 feet both ways)
Strokes per minute =40.

***Rule :***—Multiply the average pressure of steam in the cylinder by the area of the piston, and by the speed of the piston which is obtained by multiplying the length of stroke by 2, and by the number of strokes per minute. Divide the result by 33,000, which gives the indicated horse power.

| | | | | |
|---|---|---|---|---|
| 39.81 | × | 400 | = | 15,924.00 |
| 15,924.00 | × | 5.5 | = | 87,582 |
| 87,582 | × | 2 | = | 1,75,164 |
| 1,75,164 | × | 40 | = | 70,065,560 |
| 7,00,65,560 | ÷ 33,000 | | = | 212.32 I.H.P. |

*Example* :—

Required the power of the engine from which diagram, was taken. Diameter of cylinder, 12 inches; length of stroke, 2 feet; number of revolutions, 80 per minute. The mean pressure according to the diagram is 32.2 lbs., from which deduct 2 lbs. for the friction of the engine, leaving 30.2 lbs. pressure; the area of the cylinder is 113 inches; then :—

$$\frac{113 \times 30.2 \times 2 \times 2 \times 80}{33000} = 33 \text{ indicated horse-power.}$$

## Horse—Power.

A strong horse can travel 2½ miles per hour and work 8 hours a day, doing the equivalent of pulling a load of 150 lbs. weight up out of a shaft by means of a rope. 2½ miles an hour is 220 feet per minute, and at that speed the load of 150 lbs. is raised vertically the same distance, that is equal to 300 lbs. raised 110 feet high, or 3000 lbs. raised 11 feet high,, or 33,000 lbs. raised one foot high per minute. The unit power is the mechanical force necessary to lift 33,000 lbs. one foot high in one minute; but, in dealing with steam engines, two terms are used, viz., nominal horse-power, and actual horse-power.

## Nominal Horse-Power.

Nominal Horse-power is a commercial term used by makers of engines to denote only the size of an engine without regard to the actual power it will exert.

## Nominal Horse-Power of Non-Condensing Steam-Engines.

The rule of ordinary practice is to make the sectional area of the cylinder equal to from 9 to 10 square inches for each nominal horse-power. The nominal horse-power of non-condensing engines may be found by the following rule, which accords with the best modern practice. Rule: Multiply the square of the diameter of the cylinder in inches by 7, and divide the result by 80.

## Nominal Horse-Power of Condensing Steam-Engine.

*Rule* :—Multiply the square of the diameter of the cylinder in inches by 7, and divide the product by 120.

## Actual Horse-Power of Steam-Engines.

To find the actual horse-power.

*Rule* :—Multiply the area of the cylinder in square inches by the average effective mean pressure of the steam in lbs. per square inch, minus 3 lbs. per square inch for friction, and by the speed of the piston in feet per minute. The product will be the number of foot.—pounds per minute which the engine will raise. Divide this product by 33,000, and the quotient will be the actual horse-power of the engine.

## Brake Horse Power.

This is the useful horse power delivered by the engine to the shaft, and is the I.H.P. minus the horse power required to overcome the friction of the engine.

The ratio $\frac{\text{B.H.P}}{\text{I.H.P.}}$ is known as the mechanical efficiency of the engine. This rarely exceeds 0.8 for an internal combustion engine, but may be as much as 0.92 in a well designed steam engine at full load.

To ascertain the Chimney area.

$$\frac{\text{Pounds of coal per hour} \times 12}{\sqrt{\text{height in feet}}}$$

## Pump House.

High pressure, high temperature and high capacity feed pumps are turbo pumps and adding to these its reliability, its low maintenance cost, its sustained efficiency and its flexibility both as regards pressure and output, its automatic regulation, noiseless and free from vibration and combined maximum efficiency with minimum space is ideal in economy for duties over 7000 gals. per hour, but duties less than that, standard size Weir shuttle valve pumps are recommended. Out of all steam feed pumps Weir shuttle valve type pumps supersede all others owing to its simplicity, durability and efficiency. They are free from failure and are very easy to start at any part of its stroke. These pumps are fool-proof so to say and occupy very little space.

For feeding water tube boilers direct acting steam pumps are most suitable, because these boilers contain a relatively small quantity of water and to maintain a constant water level in the boiler for continuous steady steaming, the feed pump should be such as would provide a regular and uninterrupted supply of feed water at any pressure necessary. Standard size Weir feed pumps, size $7'' \times 9\frac{1}{2}'' \times 21''$ would supply 4000 gals. per hour normally at 13 double stroke per minute. As regards sprinkler and hydrant pump, a duplex double acting steam pump working at reduced pressure, say 100 lbs per sq. inch through a suitable reducing valve, will serve the purpose.

Pumps suitable for 100 lbs. pressure are advantageous for the sort of slow speed reciprocating engines.

Delivery pressure of sprinkler pump to be 100 lbs. maximum but that of hydrant pump to be of 700 feet head.

Before a site is selected for building a mill, the most important question of water problem must be solved thoroughly. Abundant, cheap and good quality of water supply is one of the main requisites in running textile industry. One must be sure of getting more than a sufficient quantity of pure water throughout the year specially for boiler feed and dyeing and bleaching works.

It is not desirable to construct mills where double the quantity of water required is not available, as there must be provision of water supply for double shift working in case of demands.

The following are the approximate maximum figures for the water which should be drawn and used for the various purposes by the mills in a day of 9 hours.

| | Gals. Drawn. | Gals. consumed per day | Remarks. |
|---|---|---|---|
| Turbine steam .. .. | 12960 | 130 | 1% wastage. |
| Sizing and heating steam .. | 5400 | 2700 | 50% ,, |
| Dyeing and bleaching steam | 7200 | 7200 | full quantity |
| Air pump and drains .. | 198 | 198 | ,, ,, |
| Steam pumps .. .. | 2700 | 2700 | ,, ,, |
| Economiser and boiler blow down. .. .. | 250 | 250 | ,, ,, |
| Humidifiers .. .. | 360000 | 36000 | 10% wastage. |
| Circulating water. .. .. | 810000 | 16200 | 2% automises |
| Dye and bleach house water | 50000 | 50000 | Full quality. |
| Latrines .. .. .. | 50000 | 50000 | ,, ,, |
| Surface evaporation .. | 6000 | 6000 | full quantity |
| Approximate Total .. | 1,304,708 | 171,378 | |

It can now be seen that there must be a stock of about 2,600,000 gals. of water in the reservoir. For a single shift work a daily supply of 120,000 gals. of pure water and 50,000 gals. of ordinary water must be available throughout the year without interruption. Without this assured quantity of water, launching upon an industry like a cotton mill will be an utter failure.

The reservoir to be connected with the Jack well through an aqueduct and the highest water level should be a foot below the engine room floor level. Spray cooling plant and aqueduct suction should be laid diagonally opposite. A separate storage tank of about 80,000 gals. Capacity for boiler make up water and dye and bleach works supply is necessary.

## Speed of Pump.

The greatest speed at which water will flow through a suction-pipe, is 500 feet per minute, but, in practice, water should not flow through a suction pipe at a greater speed than 200 feet per minute to ensure the pump-barrel being properly filled at each stroke, that is 200 feet of the suction-pipe should hold as much water as the pump will deliver per minute, and the pump should work at such a speed that it will deliver per minute the quantity of water contained in 200-feet of its suction-pipe. For pumping engines, the most economical speed is from 4 to 5 strokes per minute, the length of stroke being generally 8 feet for small pumping engines, 10 feet for medium size, and 12 feet for large sizes.

## Mechanic Shop.

A fully equipped mechanic shop should be electrically driven if possible with a motor of 30 B.H.P. and an oil engine of 30 B.H.P. as a stand by for night work. Every mill should have its own moulding and welding plants which will minimise the cost of repairs and in-convenience.

## Power—Useful Information.

Foot lbs. $\times 0.13825$ = kilogrammetres (units of work, French).
Kilogrammetres $\times 7.233$ = foot lbs. (units of work).
Horse power $\times 0.9863$ = force de cheval (French horse power).
Force de cheval $\times 1.01385$ = horse power.
Lbs. per square foot $\times 4.882$ = kilogrammes per square metre.
Kilogrammes per square metre $\times 0.2048$ = lbs. per square foot.
Lbs. per sq. inch $\times 0.0703$ = kilogrammes per sq. centimetre.
Kilogrammes per sq. centimetre $\times 14.223$ = lbs. per sq. inch.

Foot lbs. (units of work) $\times 0.0000303$ = horse power.

Each nominal horse power of a boiler requires 30 to 35lbs. of water per hour.

The average consumption of coal for steam boilers is 12 lbs. per hour for each sq. ft. of great surface.

There are 9 square feet of heating surface to each square foot of great surface.

One cubic foot of Anthracite coal weighs about 53 pounds.

1 inch water gauge = .03604 lbs. = .57664 oz. per sq. in.

1 inch mercurial gauge = .49116 lbs. per sq. in. or approx. $\frac{1}{2}$ lb.

1 atmosphere = 14.7 lb. per sq. in. = 33.99ft. water = 29.99 in. mercury. (1 atmosphere is usually taken = 15 lbs.)

1 pound of carbon burning to carbon dioxide develops 14500 units of heat.

1 pound of hydrogen develops 62500 units of heat.

The heat produced by hydrogen is $\frac{62500}{14500} = 4.3$ times as great as that of carbon.

1 pound of hydrogen requires 8 lbs. of oxygen for complete combustion and atmospheric air contains about 20 per cent of oxygen.

The approximate weights of Indian coal, taking the maund at 27.222 to the ton, of 1.35 specific gravity, may be taken as follows:—

weight of cubic yard = 20.33 cwts.

„ „ foot = 1.0025 maunds.

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## Measures of Pressures

| Name of Units | Atmospheres | Pounds on Square Inch | Inches of Mercury at 32° F | Feet of Water at 60° F. | Millimeters of Mercury at 320° F. | Pounds on Square Foot | Kilograms on Square Meter |
|---|---|---|---|---|---|---|---|
| Atmospheres | 1. | 14.7 | 29,922 | 33.94 | 760. | 2,116 | 10,333. |
| Pounds on square inch | .068,03 | 1. | 2.036 | 2.309 | 51.7 | 143.946 | 702.925 |
| Inches of mercury at 32° F | .033,42 | .491,3 | 1. | 1.134 | 25.398 | 70.7 | 345.331 |
| Feet of water at 60° F | .029,47 | .433,2 | .881,8 | 1. | 22.399 | 62.35 | 304.565 |
| Millimeters of mercury at32°F. | .001,316 | .019,34 | .039,37 | .044,64 | 1. | 2.784 | 13.596 |
| Pounds on square foot | .000,472,6 | .006,947 | .014,13 | .016,03 | .359,2 | 1. | 4.883 |
| Kilograms on square Meter | .000,096,77 | .001,432 | .002,895 | .003,283 | .073,55 | .204,8 | 1. |

## Measures of Work.

| Name of Unit | Ergs | Gram Degree Centigrade | Pound Degree Fahrenheit | Watt Second | Kilogram-meter | Foot Pound | Horse Power—Second |
|---|---|---|---|---|---|---|---|
| Gram-degree Centigrade. | 41,549.500. | 1. | .000,968,3 | 4.154,95 | .423,54 | 3.063,5 | .005,57 |
| Pound degree Fahrenheit | 10,470,300,000. | 252.11 | 1. | 1,047.03 | 106.731 | 772. | 1.403 |
| Watt second.................. | 10,000,000. | .240,7 | .000,955,1 | 1. | .101,937 | 737,324 | .001,340,6 |
| Kilogram-meter............ | 98,100.000. | 2.361 | .009,369 | 9.81 | 1. | 7.233,14 | .013,151 |
| Foot-pound.................. | 13,562.600. | .326,4 | .001,295,3 | 1,3562,6 | .138.25 | 1. | .001,818,18 |
| Horse-power-second....... | ..................... | 179.5 | .712,4 | 745.24 | 76.039 | 550. | 1. |

## Energy Equivalents.

One horse power =

550 ft.-lb. per second;

33,000 ft.-lb. per minute. (The actual work of a horse is about 22,000 ft.-lb. per minute);

1,980,000 ft.-lb. per hour;

23,760,000 inch-lb. per hour;

$\frac{1}{4}$ft.-ton per second;

$\frac{7}{10}$ British heat unit per second (B. Th. U.);

42.4 British heat units per minute (B.Th.U.);

746 watts or volt amperes;

0.746 Kilowatts or Board of Trade Units (B.T.U.) hours.

1 Kilowatt =

1000 watts;

1.34 horse power;

2,654,200 ft.-lb. per hour;

44,240 ft.-lb. per minute;

737.3 ft. lb. per second;

56.9 B.Th.U. per minute;

0.948 B.Th. U. per second.

1 B.Th.U.—heat to raise 1 lb. of water through 1°F.
=778 ft.-lb. = .000293 k.w. hours;
=.000393 horse power hours.

1 C.H.U. =heat to raise 1 lb. of water through 1°C.
=1400 ft.-lb.

**One Brake House Power**—approximately, will in one hour:

Raise 1000 gallons of water or sewage 100 feet, or cut 75 feet of 9 in. Deal.

Grind $1\frac{1}{4}$ Bushels of Corn to Fine Meal;

Crack or Kibble 8 Bushels of corn;

Cut 4 cwts. of straw to ½ in. chaff.
Separate 180 Gallons of Milk;
Run 16–C.P. Metallic Filament Lamps.
Make 12 lbs. Ice with Refrigerator.
Maintain 200 cubit feet at a temperature of 32°
Cool 80 Gallons of Milk to 25°
Churn 40 to 50 Gallons of Cream;
Break 8 cwts. of Stone;
Hoist 3 tons 200 feet vertically.
Run an Arc Lamp of 1000 candle power.

**Flow of Steam through Pipes.**

| Gauge pressure in lb. per sq. in. | Diameter of pipe in inches (length of each = 240 diameters). | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 8 | 10 | 15 |
| | Weight of steam per minute in lb. with 1 lb. loss of pressure. | | | | | | | | |
| 10 | 2.57 | 12.72 | 31.45 | 58.05 | 95.8 | 143.6 | 262.0 | 422.7 | 996 |
| 20 | 3.02 | 14.94 | 36.94 | 68.20 | 112.6 | 168.8 | 307.8 | 496.5 | 1170 |
| 40 | 3.74 | 18.51 | 45.77 | 84.49 | 139.5 | 209.0 | 381.3 | 615.3 | 1450 |
| 60 | 4.32 | 21.38 | 52.87 | 97.60 | 161.1 | 241.5 | 440.5 | 710.6 | 1675 |
| 80 | 4.82 | 23.82 | 58.91 | 108.74 | 179.5 | 269.0 | 490.7 | 791.7 | 1866 |
| 100 | 5.25 | 25.96 | 64.18 | 118.47 | 195.6 | 293.1 | 534.6 | 862.6 | 2032 |
| 120 | 5.63 | 27.85 | 68.87 | 127.12 | 209.9 | 314.5 | 573.7 | 925.6 | 2181 |
| 150 | 6.14 | 30.37 | 75.09 | 138.61 | 228.8 | 343.0 | 625.5 | 1009.2 | 2378 |

**Fuels.**

Air supply necessary for the combustion of various fuels.

| Fuel. | Proportion by weight of given constituent. | | | Pounds of air required per pound of fuel. |
|---|---|---|---|---|
| | Carbon % | Hydrogen % | Oxygen % | |
| Wood charcoal .. .. | 93 | | | 11.16 |
| Peat „ .. .. | 80 | | | 9.60 |
| Coke .. .. .. .. | 94 | | | 11.28 |
| Anthracite coal .. .. | 91.5 | 3.5 | 2.6 | 12.13 |
| Dry Bituminous coal .. | 87 | 5.0 | 4.0 | 12.06 |
| Lignite .. .. .. | 70 | 5.0 | 20.0 | 9.30 |
| Dry peat .. .. .. | 58 | 6.0 | 31.0 | 7.68 |
| Dry wood .. .. .. | 50 | 6.0 | 41.0 | 6.00 |
| Mineral oil .. .. .. | 85 | 13.0 | 2.0 | 15.65 |

Heat units carried off by escaping gases at various temperatures above that of the atmosphere and with various excess air supplies.

| Excess of air. | Temperature of waste gases above that of atmosphere. | | | | | |
|---|---|---|---|---|---|---|
| % | 300 B.Th.U. | 350 B.Th.U. | 400 B.Th.U. | 450 B.Th.U. | 500 B.Th.U. | 550 B.Th.U. |
| 0 | 695 | 812 | 928 | 1044 | 1160 | 1276 |
| 50 | 1016 | 1185 | 1354 | 1524 | 1693 | 1862 |
| 75 | 1176 | 1372 | 1568 | 1764 | 1959 | 2155 |
| 100 | 1336 | 1558 | 1781 | 2003 | 2226 | 2448 |
| 125 | 1495 | 1745 | 1994 | 2243 | 2493 | 2742 |
| 150 | 1655 | 1931 | 2207 | 2483 | 2759 | 3035 |
| 175 | 1815 | 2118 | 2420 | 2715 | 3025 | 3328 |
| 200 | 1975 | 2304 | 2633 | 2975 | 3291 | 3621 |

## Diagram Report.

..............................19....

.....................................................................

*Diagram No*.......................*Time*......................

*Taken at*............................................

*Style of Engine*........................................

*Made by*............................................

*Cyls*................*&*..............................*Stroke*.....

*Revolutions per minute*..................................

*R. H. or L. H. Engine*....................................

*Which Cyl*...........................................

*Which End*...........................................

*Diam. Piston Rod*......................................

*Boiler Pressure*....................*Vacuum*..................

*Height of Barometer*..............................

*Temporature Injection*..............................

,, *Hotwell*..............................

*Amount of Load*..............................

*Scale of Spring used*..............................

*Notes*..............................

..............................

..............................

..............................

*The Examination of Flue Gases.*—It is not sufficient for a mill-owner or mill-manager to know how much heat his fuel is capable of evolving. He should know also how efficiently it is being used. In this connexion it is most desirable systematically to test the gases escaping through the flues and up the chimney stack.

If complete combustion of the fuel has been effected, the flue gas should contain nirtogen and carbon dioxide only; as a matter of fact oxygen and carbon monoxide are present also.

*Example* :—Engines of 440 horse power require 37½ tons of coal per week engine running 60 hours. Find the weight of coal used per indicated horse power per hour.

*Rule* :—Reduce the weight used in a week to pounds, divide by the horse power and by the number of hours run per week.

$$\frac{37.5 \times 2240}{440 \times 60} = 3.18 \text{ lbs. per I.H.P. per hour.}$$

*Example* :—The I.H.P. of an engine is 1000 and it uses 20 lbs. of steam per hour per I.H.P. If 1lb. of steam on being condensed give out sufficient heat to raise 1000 lbs. of water 1° Fah. and if the temperature of the injection water is 80° Fah, and that of the discharge 110° Fah., find how many tons of injection water would be used in 10 hours.

$110-80 = 30$

$1000-30 = 33.3$ lbs. of water to condense one lb. of steam.

$33.3 \times 20 = 666$ lbs. of injection water per hour per I.H.P.

$666 \times 1000$ (I.H.P. the engine works) $= 66000$ lbs. of water used per hour per 1000 I.H.P.

$666000 \times 10$ hrs. $= 6660000$

$6660000 - 2240 = 2973.21$ tons of injection water used in 10 hours.

*Example* :—How many pounds of water will be pumped out in one hour by a pump 10″ dia. and 16″ stroke making 40 revolutions per min., the pump being ⅝ full at each stroke ?

Pounds of water

$$\text{per hour} = \frac{10 \times .7854 \times 16 \times 40 \times 5 \times 60 \times 62.5}{12 \times 12 \times 12 \times 8} = 68177.83$$

**BOILERS.**

H/G=ratio of total heating surface to grate area.

| Type. | H/G (average). |
|---|---|
| Lancashire .. .. .. .. .. .. .. | 27 |
| Water-tube (Large-tube) .. .. .. .. | 40 to 60 |
| Locomotive (stationary) .. .. .. .. .. | 40 to 65 |
| Scotch Return-tube .. .. .. .. .. | 25 |
| Vertical .. .. .. .. .. .. .. | 20 |

**Approximate Savings which may be effected.**

| Temperature of steam. | Average steam consumption in lb. per I.H.P. per hour. | Average return in steam used. |
|---|---|---|
| Saturated .. .. .. | 14 to 15 | |
| Superheated 50 degrees .. | 13 to 14 | 8 per cent. |
| ,, 100 ,, .. | 12 to 13 | 14 ,, |
| ,, 150 ,, .. | 11 to 12 | 21 ,, |
| ,, 200 ,, .. | 10 to 11 | 26 ,, |
| ,, 250 ,, .. | 9.5 to 10.5 | 30 ,, |
| ,, 300 ,, .. | 9 to 10 | 34 ,, |

## STEAM TABLE.

$h+L=Hs$ Total Heat.

| Alsolute Press. in lb. per sq. in. | Temp. in Deg. F. | Sensible Heat from 32°F (B. Th. U.) $h$ | Latent Heat (B. Th. U.) $L$ | Specific Volume in C.ft. per lb. $Vs$. |
|---|---|---|---|---|
| 1 | 101.7 | 69.5 | 1032.9 | 333.1 |
| 2 | 126.1 | 93.9 | 1019.7 | 173.5 |
| 3 | 141.5 | 109.3 | 1011.3 | 118.6 |
| 4 | 153.0 | 120.8 | 1004.9 | 90.54 |
| 5 | 162.3 | 130.0 | 999.8 | 73.44 |
| 6 | 170.1 | 137.9 | 995.3 | 61.91 |
| 7 | 176.9 | 144.7 | 991.4 | 53.39 |
| 8 | 182.9 | 150.8 | 987.8 | 47.30 |
| 9 | 188.3 | 156.3 | 984.6 | 42.36 |
| 10 | 193.2 | 161.1 | 981.9 | 38.39 |
| 14.689 | 212. | 180.0 | 970.7 | 26.79 |
| 15 | 213.0 | 181.0 | 970.2 | 26.27 |
| 20 | 22.80 | 196.1 | 961.0 | 20.08 |
| 25 | 240.1 | 208.4 | 953.3 | 16.29 |
| 30 | 250.3 | 218.8 | 946.8 | 13.74 |
| 35 | 259.2 | 227.9 | 940.9 | 11.90 |
| 40 | 267.2 | 235.9 | 935.8 | 10.50 |
| 45 | 274.4 | 243.3 | 930.9 | 9.41 |
| 50 | 280.9 | 250.0 | 926.5 | 8.520 |
| 55 | 287.7 | 256.2 | 922.3 | 7.845 |
| 90 | 292.6 | 262.0 | 918.4 | 7.184 |
| 65 | 297.8 | 267.4 | 914.7 | 6.666 |
| 70 | 302.8 | 272.5 | 911.2 | 6.218 |
| 75 | 307.5 | 277.2 | 908.8 | 5.829 |
| 80 | 311.9 | 281.9 | 904.7 | 5.487 |
| 85 | 316.1 | 286.2 | 901.6 | 5.184 |
| 90 | 320.2 | 290.4 | 898.7 | 4.913 |
| 95 | 324.0 | 294.4 | 895.7 | 4.670 |
| 100 | 327.7 | 298.3 | 893.0 | 4.451 |
| 105 | 331.2 | 302.0 | 890.3 | 4.251 |
| 110 | 334.7 | 305.6 | 887.7 | 4.070 |
| 115 | 338.0 | 309.0 | 885.2 | 3.903 |
| 120 | 341.1 | 312.3 | 882.8 | 3.751 |
| 125 | 344.2 | 315.6 | 880.3 | 3.609 |
| 130 | 347.2 | 318.7 | 878.0 | 3.479 |
| 140 | 353.0 | 324.8 | 873.4 | 3.245 |
| 150 | 358.4 | 330.5 | 869.2 | 3.041 |
| 160 | 363.5 | 335.9 | 865.1 | 2.862 |
| 170 | 368.4 | 341.1 | 861.1 | 2.703 |
| 180 | 373.0 | 346.1 | 857.3 | 2.562 |
| 190 | 377.5 | 350.9 | 853.5 | 2.435 |
| 200 | 381.8 | 355.5 | 849.9 | 2.320 |
| 225 | 391.9 | 366.3 | 841.4 | 2.076 |
| 250 | 401.2 | 376.3 | 833.4 | 1.880 |
| 275 | 409.8 | 385.6 | 825.9 | 1.718 |
| 300 | 417.8 | 394.4 | 818.7 | 1.583 |

## Board of Trade Rules for Boiler Safety Valves.

In the following table, P indicates boiler pressure in lb. per square inch and A indicates area of safety valve in square inches per square foot of fire-grate.

| *P* | *A* | *P* | *A* | *P* | *A* |
|---|---|---|---|---|---|
| 60 | .500 | 110 | .300 | 160 | .214 |
| 65 | .468 | 115 | .288 | 165 | .208 |
| 70 | .441 | 120 | .277 | 170 | .202 |
| 75 | .416 | 125 | .267 | 175 | .197 |
| 80 | .394 | 130 | .258 | 180 | .192 |
| 85 | .373 | 135 | .249 | 185 | .187 |
| 90 | .357 | 140 | .241 | 190 | .182 |
| 95 | .340 | 145 | .234 | 195 | .178 |
| 100 | .326 | 150 | .227 | 200 | .174 |
| 105 | .312 | 153 | .220 | 205 | .170 |

Each boiler must be fitted with at least two safety valves. They must be so arranged that the springs and valves are cased in, that the valves cannot be overloaded when steam is up, that they can be lifted by casing gear and turned on their seats by hand and that they cannot lift out of their seats in the event of the fracture of a spring.

No safety valve may be less than 1½″ diameter.

Each safety valve box or chest must be provided with a means of draining it.

## Temperature and Pressure of Steam for each half-inch of Vacuum.

| Inches of Vacuum | Absolute Pressure lb. per. sq. in. | Temperature Degree F. | Inches of Vacuum. | Absolute Pressure lb. per. sq. in. | Temperature. Degree F. |
|---|---|---|---|---|---|
| 0 | 14.697 | 212.00 | 15 | 7.329 | 178.96 |
| ½ | 14.451 | 211.15 | 15½ | 7.084 | 177.44 |
| 1 | 14.206 | 210.29 | 16 | 6.838 | 175.87 |
| 1½ | 13.960 | 209.42 | 16½ | 6.592 | 174.26 |
| 2 | 13.715 | 208.54 | 17 | 6.347 | 172.59 |
| 2½ | 13.469 | 207.64 | 17½ | 6.101 | 170.86 |
| 3 | 13.223 | 206.73 | 18 | 5.856 | 169.07 |
| 3½ | 12.978 | 205.80 | 18½ | 5.610 | 167.23 |
| 4 | 12.732 | 204.86 | 19 | 5.364 | 165.31 |
| 4½ | 12.487 | 203.91 | 19½ | 5.119 | 163.32 |
| 5 | 12.241 | 202.94 | 20 | 4.873 | 161.25 |
| 5½ | 11.995 | 201.95 | 20½ | 4.628 | 159.09 |
| 6 | 11.750 | 200.95 | 21 | 4.382 | 156.83 |
| 6½ | 11.504 | 199.93 | 21½ | 4.136 | 154.46 |
| 7 | 11.259 | 198.89 | 22 | 3.891 | 151.97 |
| 7½ | 11.013 | 197.83 | 22½ | 3.755 | 149.34 |
| 8 | 10.767 | 196.75 | 23 | 3.410 | 146.55 |
| 8½ | 10.522 | 195.65 | 23½ | 3.164 | 143.59 |
| 9 | 10.276 | 194.53 | 24 | 2.918 | 140.42 |
| 9½ | 10.031 | 193.39 | 24½ | 2.673 | 137.01 |
| 10 | 9.785 | 192.23 | 25 | 2.427 | 133.32 |
| 10½ | 9.539 | 191.03 | 25½ | 2.172 | 129.31 |
| 11 | 9.294 | 189.81 | 26 | 1.926 | 124.89 |
| 11½ | 9.048 | 188.57 | 26½ | 1.680 | 119.94 |
| 12 | 8.803 | 187.30 | 27 | 1.435 | 114.34 |
| 12½ | 8.567 | 186.00 | 27½ | 1.189 | 107.84 |
| 13 | 8.311 | 184.66 | 28 | 0.944 | 100.5 |
| 13½ | 8.066 | 183.29 | 28½ | 0.698 | 90.24 |
| 14 | 7.820 | 181.88 | 29 | 0.483 | 78.80 |
| 14½ | 7.575 | 180.44 | 29½ | 0.237 | 58.21 |

### Vacuum and Barometer.

To find the absolute pressure in a condenser in lb. per square inch, subtract the reading of the vacuum gauge in inches of mercury from the barometer reading in inches and divide the result by 2 (2.04 more exactly).

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## APJOHN'S DEW POINT FORMULA.

When temperature is below 32° Fahrenheit:—

$$F = f - \frac{d}{96} \times \frac{h - f}{30}$$

When temperature is above 32° Fahrenheit, "87" must be substituted for "96" in the above formula.

F = Elastic force at dew point temperature.

f = Elastic force of temperature of wet bulk thermometer.

d = Difference of the two thermometers.

h = Observed height of barometer.

## "VALUES OF SPECIFIC HEAT"

| Description | Units. | Description | Units. |
|---|---|---|---|
| Asphalte | .2150 | Pine | .5174 |
| Brass | .0939 | Portland Stone | .1928 |
| Brick | .1900 | Silver | .0570 |
| Charcoal (wood) | .2415 | Slate | .1924 |
| Coal | .2777 | Tin | .0565 |
| Copper | .0952 | Zinc | .0956 |
| Glass | .1977 | Water (62°F) | 1.001 |
| Gold | .0324 | Water (212°F) | 1.013 |
| Ice | .5040 | Alcohol | .622 |
| Iron (cast) | .1298 | Naptha wood | .601 |
| Iron (wrought) | .1138 | Turpentine | .431 |
| Lead | .0314 | Petroleum | .430 |
| Mercury | .0333 | Olive oil | .309 |
| Oak | .4042 | Motor Spirit | .396 |

Dimensions of British Standard Pipe Flanges for steam pressures up to 55 lbs. per square inch, and for water pressures up to 200 lbs. per square inch.

| Internal Diameter Pipe | External Diameter Flange | Pitch Centre of Bolt Holes | No. of Bolt Holes | Diameter of Bolt Holes |
|---|---|---|---|---|
| Ins. | Ins. | Ins. | | Ins. |
| $\frac{1}{2}$ | $3\frac{3}{4}$ | $2\frac{5}{8}$ | 4 | $\frac{1}{2}$ |
| $\frac{3}{4}$ | 4 | $2\frac{7}{8}$ | 4 | $\frac{1}{2}$ |
| 1 | $4\frac{1}{2}$ | $3\frac{1}{4}$ | 4 | $\frac{1}{2}$ |
| $1\frac{1}{4}$ | $4\frac{3}{4}$ | $3\frac{7}{16}$ | 4 | $\frac{1}{2}$ |
| $1\frac{1}{2}$ | $5\frac{1}{4}$ | $3\frac{7}{8}$ | 4 | $\frac{1}{2}$ |
| $1\frac{3}{4}$ | $5\frac{1}{2}$ | $4\frac{1}{8}$ | 4 | $\frac{1}{2}$ |
| 2 | 6 | $4\frac{1}{2}$ | 4 | $\frac{5}{8}$ |
| $2\frac{1}{2}$ | $6\frac{1}{2}$ | 5 | 4 | $\frac{5}{8}$ |
| 3 | $7\frac{1}{4}$ | $5\frac{3}{4}$ | 4 | $\frac{5}{8}$ |
| $3\frac{1}{2}$ | 8 | $6\frac{1}{2}$ | 4 | $\frac{5}{8}$ |
| 4 | $8\frac{1}{2}$ | 7 | 4 | $\frac{5}{8}$ |
| $4\frac{1}{2}$ | 9 | $7\frac{1}{2}$ | 8 | $\frac{5}{8}$ |
| 5 | 10 | $8\frac{1}{4}$ | 8 | $\frac{5}{8}$ |
| 6 | 11 | $9\frac{1}{4}$ | 8 | $\frac{5}{8}$ |
| 7 | 12 | $10\frac{1}{4}$ | 8 | $\frac{5}{8}$ |
| 8 | $13\frac{1}{4}$ | $11\frac{1}{2}$ | 8 | $\frac{5}{8}$ |
| 9 | $14\frac{1}{2}$ | $12\frac{3}{4}$ | 8 | $\frac{5}{8}$ |
| 10 | 16 | 14 | 8 | $\frac{3}{4}$ |
| 11 | 17 | 15 | 8 | $\frac{3}{4}$ |
| 12 | 18 | 16 | 12 | $\frac{3}{4}$ |
| 13 | $19\frac{1}{4}$ | $17\frac{1}{4}$ | 12 | $\frac{3}{4}$ |
| 14 | $20\frac{3}{4}$ | $18\frac{1}{2}$ | 12 | $\frac{7}{8}$ |
| 15 | $21\frac{3}{4}$ | $19\frac{1}{2}$ | 12 | $\frac{7}{8}$ |
| 16 | $22\frac{3}{4}$ | $20\frac{1}{2}$ | 12 | $\frac{7}{8}$ |
| 17 | 24 | $21\frac{3}{4}$ | 12 | $\frac{7}{8}$ |
| 18 | $25\frac{1}{4}$ | 23 | 12 | $\frac{7}{8}$ |
| 19 | $26\frac{1}{2}$ | 24 | 12 | $\frac{7}{8}$ |
| 20 | $27\frac{3}{4}$ | $25\frac{1}{4}$ | 16 | $\frac{7}{8}$ |
| 21 | 29 | $26\frac{1}{2}$ | 16 | $\frac{7}{8}$ |
| 22 | 30 | $27\frac{1}{2}$ | 16 | 1 |
| 23 | 31 | $28\frac{1}{2}$ | 16 | 1 |
| 24 | $32\frac{1}{2}$ | $29\frac{3}{4}$ | 16 | 1 |

Dimensions of British Standard Pipe Flanges for Working Steam Pressure up to 125 lbs. 225 lbs. and 325 lbs. per square inch.

| Internal Diameter of Pipe. | External Diameter of Flange | Pitch Centres of Bolt Holes. | No. of Bolt Holes. | Diameter of Bolt Holes 125 & 225lbs | Diameter of Bolt Holes 325 lbs. |
|---|---|---|---|---|---|
| ins. | ins. | ins. | | ins. | ins. |
| ½ | 3¾ | 2⅝ | 4 | ½ | ½ |
| ¾ | 4 | 2⅞ | 4 | ½ | ½ |
| 1 | 4¾ | 3 7/16 | 4 | ⅝ | ⅝ |
| 1¼ | 5¼ | 3⅞ | 4 | ⅝ | ⅝ |
| 1½ | 5½ | 4⅛ | 4 | ⅝ | ⅝ |
| 1¾ | 6 | 4½ | 4 | ⅝ | ⅝ |
| 2 | 6½ | 5 | 4 | ⅝ | ¾ |
| 2½ | 7¼ | 5¾ | 8 | ⅝ | ¾ |
| 3 | 8 | 6½ | 8 | ⅝ | ¾ |
| 3½ | 8½ | 7 | 8 | ⅝ | ¾ |
| 4 | 9 | 7½ | 8 | ⅝ | ¾ |
| 4½ | 10 | 8¼ | 8 | ¾ | ⅞ |
| 5 | 11 | 9¼ | 8 | ¾ | ⅞ |
| 6 | 12 | 10¼ | 12 | ¾ | ⅞ |
| 7 | 13¼ | 11½ | 12 | ¾ | ⅞ |
| 8 | 14½ | 12¾ | 12 | ¾ | ⅞ |
| 9 | 16 | 14 | 12 | ⅞ | 1 |
| 10 | 17 | 15 | 12 | ⅞ | 1 |
| 11 | 18 | 16 | 16 | ⅞ | 1 |
| 12 | 19¼ | 17¼ | 16 | ⅞ | 1 |
| 13 | 20¾ | 18½ | 16 | 1 | 1⅛ |
| 14 | 21¾ | 19½ | 16 | 1 | 1⅛ |
| 15 | 22¾ | 20½ | 16 | 1 | 1⅛ |
| 16 | 24 | 21¾ | 20 | 1 | 1⅛ |
| 17 | 25¼ | 23 | 20 | 1 | 1⅛ |
| 18 | 26½ | 24 | 20 | 1⅛ | 1¼ |
| 19 | 27¾ | 25¼ | 20 | 1⅛ | 1¼ |
| 20 | 29 | 26½ | 24 | 1⅛ | 1¼ |
| 21 | 30 | 27½ | 24 | 1⅛ | 1¼ |
| 22 | 31 | 28½ | 24 | 1⅛ | 1¼ |
| 23 | 32½ | 29¾ | 24 | 1¼ | 1⅜ |
| 24 | 33½ | 30¾ | 24 | 1¼ | 1⅜ |

## SIZE OF PIPES FOR GAS SUPPLY.

$$Q=1000\sqrt{\left(\frac{d^5 p}{gl}\right)};\quad d=\cdot 063\sqrt[5]{\left(\frac{gl\,Q^2}{p}\right)}$$

$g$ (specific gravity of the gas) usually equals .45. $d$ = diameter in ins. $l$ = length in yards. $p$ = pressure of gas in ins. $Q$ = supply in cubic ft. per hour.

## MACHINERY SHAFTS.

$$d=\frac{\sqrt[4]{12\,r\,F}}{C};\quad F=\frac{C\,d^4}{12r}$$

**$d$ =diam. of shaft in ins. $r$ = radius of wheel or arm at end of which F acts. $F$= greatest force allowable without twisting shaft more than $\frac{1}{12}$th degree per ft. in length. $C$ = 3000 cast steel; 1700 wrought iron, 940 cast iron: 20 oak. 15 fir or pinc**

## CHIMNEY SHAFTS.

$$A=C\frac{F}{\sqrt{H}} \qquad d=13{\cdot}54\sqrt{A}$$

$A$ = Area of flue at up in sq. ft. $d$ = diameter of flue in ins. $F$ = fuel in lbs. consummed per hour. $H$ = vertical height of shft above furnace bars in ft. C is a coefficient which if taken as $=\frac{1}{12}$ will give very accurate results.

## CUBICAL EXPANSION OF GASES.

The cubical expansion of air and other gases is according to Regnault :—

| **Fahrenheit** | **Centigrade** |
|---|---|
| .0020361 | .003665 |

for each degree of their respective scales. In other words for every 1° Fahr. it expands or contracts $\frac{1}{491}$th part.

### Capacity of cylinderical Steel Tanks.

| Diam. Inches | Gals. per ft. Length | Diam. Inches | Gals. per ft. Length | Diam. Inches | Gals. per ft. Length | Diam. Inches | Gals. perft length | Diam. Inches | Gals. per ft. length | Diam. Inches | Gals. per ft. length |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 5.87 | 17 | 11.79 | 22 | 19.75 | 27 | 29.74 | 32 | 41.78 | 57 | 55.86 |
| 13 | 6.89 | 18 | 13.22 | 23 | 21.58 | 28 | 31.99 | 33 | 44.43 | 38 | 58.92 |
| 14 | 8.0c | 19 | 14.73 | 24 | 23.50 | 29 | 34.31 | 34 | 47.16 | 39 | 62.06 |
| 15 | 9.18 | 20 | 16.32 | 25 | 25.50 | 30 | 36.72 | 35 | 49.98 | 40 | 65.28 |
| 16 | 10.44 | 21 | 17.99 | 26 | 27.38 | 31 | 39.21 | 36 | 52.88 | | |

### Capacity of cylinderical Tank in LB./Inch.

| Diam. in ins. | Galls. per in. | Petrol | Refined Paraffin | Scotch Paraffin | Crude Oil | Lubri-cating Oil | Fuel Oil | Water. |
|---|---|---|---|---|---|---|---|---|
| | | Sp. Gr. ·73 | ·796 | .81 | .85 | .895 | ·93 | 1.0 |
| | | (5 per cent has been deducted) | | | | | | |
| 6 | .0969 | ·7074 | ·7713 | ·7849 | .8236 | .8672 | ·901 | .969 |
| 7 | ·1304 | ·9520 | 1.038 | 1.056 | 1.108 | 1.167 | 1.213 | 1.204 |
| 8 | ·1719 | 1.255 | 1.368 | 1.393 | 1.461 | 1.539 | 1.599 | 1.719 |
| 9 | .2180 | 1.591 | 1.735 | 1.766 | 1.853 | 1.951 | 2.027 | 2.18 |
| 10 | .2690 | 1.964 | 2.149 | 2.186 | 2.294 | 2.416 | 2.510 | 2.69 |
| 11 | ·3253 | 2.375 | 2.589 | 2.635 | 2.765 | 2.912 | 3.026 | 3.253 |
| 12 | .3876 | 2.829 | 3.085 | 3.14 | 3.294 | 3.469 | 3.605 | 3.876 |
| 14 | ·5270 | 3.847 | 4.195 | 4.269 | 4.48 | 4.717 | 4.901 | 5.270 |
| 16 | .6887 | 5.027 | 5.482 | 5.579 | 5.854 | 6.164 | 6.405 | 6.887 |
| 18 | .8722 | 6.376 | 6.942 | 7.064 | 7.414 | 7.806 | 8.112 | 8.722 |
| 20 | 1.076 | 7.855 | 8.566 | 8.716 | 9.146 | 9.632 | 10.07 | 10.76 |
| 22 | 1.302 | 9.504 | 10.036 | 10.55 | 11.07 | 11.65 | 12.11 | 13.02 |

## Rectangular Tanks.

| Capacity (About) | Capacity (About) | Length. | | Width. | | Depth. | |
|---|---|---|---|---|---|---|---|
| Imp. Gall. | U.S.A. Gall. | Ft. | In. | Ft. | In. | Ft. | In. |
| 25 | 20 | 2 | 0 | 1 | 5 | 1 | 5 |
| 30 | 36 | 2 | 0 | 1 | 6 | 1 | 7 |
| 40 | 48 | 2 | 3 | 1 | 8 | 1 | 8 |
| 50 | 60 | 2 | 5 | 1 | 10 | 1 | 10 |
| 60 | 72 | 2 | 6 | 1 | 11 | 2 | 0 |
| 70 | 84 | 2 | 8 | 2 | 2 | 2 | 0 |
| 80 | 96 | 2 | 10 | 2 | 3 | 2 | 0 |
| 100 | 120 | 3 | 2 | 2 | 3 | 2 | 3 |
| 125 | 150 | 3 | 4 | 2 | 7 | 2 | 4 |
| 150 | 180 | 3 | 6 | 2 | 7 | 2 | 8 |
| 200 | 240 | 3 | 10 | 2 | 11 | 2 | 11 |
| 250 | 300 | 4 | 2 | 3 | 3 | 3 | 0 |
| 300 | 360 | 4 | 6 | 3 | 7 | 3 | 0 |
| 400 | 480 | 5 | 10 | 3 | 9 | 3 | 0 |
| 509 | 600 | 6 | 6 | 4 | 1 | 3 | 0 |
| 600 | 720 | 7 | 6 | 4 | 1 | 3 | 2 |
| 700 | 840 | 8 | 3 | 4 | 1 | 3 | 4 |
| 800 | 960 | 8 | 3 | 4 | 5 | 3 | 6 |
| 900 | 1080 | 8 | 3 | 4 | 11 | 3 | 8 |
| 1000 | 1200 | 8 | 3 | 4 | 11 | 4 | 0 |
| 1250 | 1500 | 9 | 0 | 5 | 0 | 4 | 4 |
| 1500 | 1800 | 9 | 0 | 6 | 0 | 4 | 8 |
| 1750 | 2100 | 9 | 6 | 6 | 0 | 5 | 0 |
| 2000 | 2400 | 9 | 6 | 6 | 3 | 5 | 4 |
| 2500 | 3000 | 10 | 6 | 7 | 0 | 5 | 6 |
| 3000 | 3600 | 10 | 0 | 8 | 0 | 6 | 0 |
| 2500 | 4200 | 11 | 6 | 7 | 6 | 6 | 8 |
| 4000 | 4800 | 11 | 6 | 8 | 0 | 7 | 0 |
| 4500 | 5400 | 12 | 0 | 8 | 0 | 7 | 6 |
| 5000 | 6000 | 10 | 0 | 10 | 0 | 8 | 0 |

For cylindrical tanks—To find capacity.

Gallons $=(\text{diam. in ft.})^2 \times \text{depth in ft.} \times 4.897$

$=(\text{diam. in ft.})^2 \times 5$ times depth in ft.

Gallons in 3ft. depth of tanks or 3ft. length of pipe

$=(\text{diam. in ins.})^2 \div 10.$

Volume $\times D^2$ins. $\times$0034 =U. S. gals. /inch.
=$D^2$ ,, $\times$.00283 Imp. gals./inch.

| | | | |
|---|---|---|---|
| =$S^2$ ,, | $\times$.0017 | =42 U.S. gall./barrels/inch. | D=dia. in ft. C=circumf. in ft. |
| =$D^2$ ,, | $\times$.00979 | =50 U. S. ,, ,, | |
| =$C^2$ ,, | $\times$.0496 | =U. S. gallons/inch. | |
| =$C^2$ ,, | $\times$.0413 | =Imperial gallons/inch. | |
| =$C^2$ ,, | $\times$.00118 | =42 U.S. gall/barrels/inch. | |
| =$C^2$ ,, | $\times$.000992 | =50 U.S. ,, ,, | |

Canadian barrel =35 Imperial gallons.
U. S. barrel =42 gallons (approx.).
Pressure of a column of oil $h$ ft. high, gravity (Be)

$$=P=\frac{61.4h}{131.5\times Be}\text{ pounds/sq. inch.}$$

## Rectangular Tanks.

No. of gallons contained =Length $\times$ Breadth $\times$ Depth (in feet) $\times$6.25

## Circular Tanks.

$$\text{Area in square feet}=\frac{\text{Gallons.}}{\text{depth in feet}\times 6.25}$$

### Barometer and Altitude.

| Barometer Inches Hg. | 30 | 28 | 26 | 24 | 22 | 20 |
|---|---|---|---|---|---|---|
| Altitude Feet. | Sea Level 0 | 1,600 | 3,500 | 5,500 | 7,800 | 10,300 |

### Barometric Pressures at Different Altitudes.

With Equivalent Head of Water and the Vertical Suction Lift of Pumps.

| Altitude | Barometric Pressure | Equivalent Head of Water | Practical Suction Lift of Pump. | |
|---|---|---|---|---|
| | | | Vertical Cylinder | Horizontal Cylinder. |
| Sea Level .................... | 14.70 lbs. per sq. in. | 33.95 ft. | 25 ft. | 22 ft. |
| ¼ mile (1320 ft.) above sea level | 14.02 lbs. per sq. in. | 32.38 ft. | 24 ft. | 21 ft. |
| ½ mile (2640 ft.) above sea level | 13.33 lbs. per sq. in. | 30.79 ft. | 23 ft. | 20 ft. |
| ¾ mile (3960 ft.) above sea level | 12.66 lbs. per sq. in. | 29.24 ft. | 21 ft. | 18 ft. |
| 1 mile (5280 ft.) above sea level | 12.02 lbs. per sq. in. | 27.76 ft. | 20 ft. | 17 ft. |
| 1¼ miles (6600 ft.) above sea level | 11.42 lbs. per sq. in. | 26.38 ft. | 19 ft. | 16 ft. |
| 1½ miles (7920 ft.) above sea level | 10.88 lbs. per sq. in. | 25.13 ft. | 18 ft. | 15 ft. |
| 2 miles (10560 ft.) above sea level | 9.88 lbs. per sq. in. | 22.82 ft. | 17 ft. | 14 ft. |

Temperature Errors in Barometer Readings.

To correct, use Schumacher's Rules.

correction to be subtracted :—

$$B\frac{m(t-32^\circ)-s\,(t-62^\circ)}{1+m(t-32^\circ)}$$

when

B = Reading of Barometer in inches.

m = Expansion in volume of mercury for 1° mercury for 1° Fah. = .0001001

t = Temperature of the mercury and scale.

s = Expansion of the Brass scale in length for 1° Fah. = .000010434 (the normal temperature being 62°).

Temperature conversion Formulæ.

Fahrenheit to centigrade :—

$$5\,\frac{(F-32)}{9}$$

Fahrenheit to Reaumur :—

$$4\,\frac{(F-32)}{9}$$

Centigrade to Fahrenheit :—

$$\frac{9c}{5}+32$$

Reaumur to centigrade :—

$$\frac{5R}{4}$$

Centigrade to Reaumur :—

$$\frac{4c}{5}$$

Reaumur to Fahrenheit :—

$$\frac{9R}{4}+32$$

## ABSOLUTE ZEROS.

| Farenheit | Centigrade | Reaumur |
|---|---|---|
| 493.2 | 274 | 219.2 |

Being absolute zero below the freezing point of water.

## Comparative Equivalent of Liquid Measure and Weights.

| Measures and weights for Comparison | U.S. Gallon. | Imperial Gallon. | Cubic Inch. | Cubic Foot. | Cubic Metre. | Litre | Vedro | Pood | Pound |
|---|---|---|---|---|---|---|---|---|---|
| U. S. Gal. | 1. | .833 | 231. | .1337 | .00378 | 3.785 | .308 | .231 | 8.33 |
| Imp. Gal. | 1.20 | 1. | 277.27 | .1604 | .00454 | 4.542 | .369 | .277 | 10. |
| C. Inch. | .0043 | .00358 | 1. | .00057 | .000016 | .0163 | .00132 | .001 | .0358 |
| C. Foot. | 7.48 | 6.235 | 1728. | 1. | .02827 | 28.312 | 2.304 | 1.728 | 62.355 |
| C. Metre | 264.17 | 220.05 | 61023. | 35.319 | 1. | 1000 | 81.364 | 61.023 | 2200.54 |
| Litre | .26417 | .2200 | 61.023 | .0353 | .001 | 1. | .08136 | .6102 | 2.2005 |
| Vedro | 3.249 | 2.706 | 750.1 | .4344 | .01228 | 12.29 | 1. | .7501 | 27.06 |
| Pood | 4.328 | 3.607 | 1000. | .578 | .01636 | 16.381 | 1.333 | 1. | 36.07 |
| Pound. | .12 | .1 | 27.72 | .016 | .00045 | .454 | .0369 | .0277 | 1. |

## Metric Liquid Measures.

Milliliter (1/1000 liter) =0.0388 fluid ounce.
Centiliter (1/100 liter) = 0.338 fluid ounce.
Deciliter (1/10 liter) = 0.845 gill.

Liter =1.0567 qts.
Decaliter (10 litres) =2.6418 gals.
Hectoliter (100 liters) =26.417 gals.
Kiloliter (1,000 liters) =264.18 gals.

## Metric Measures of Length.

Millimeter (1/1000 meter) =0.0394 in.
Centimeter (1/100 meter) =0.3937 in.
Decimeter (1/10 meter) =3.937 ins.
Meter =39.37 ins.

Decameter (10 meters) =393.7 ins.
Hectometer (100 meters) =328 ft. 1 in.
Kilometer (1,000 meters) =0.62137 mile. (3,280 ft., 10 ins.)

Myriameter (10,000 meters)=6.2137 miles

## Number of Gallons in Cisterns and Tanks.

| Depth in Feet | DIAMETER IN FEET | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 5 | 725 | 1,060 | 1,440 | 1,875 | 2,380 | 2,925 | 3,550 | 4,237 | 4,960 | 5,765 | 6,698 | 7,520 |
| 6 | 870 | 1,270 | 1,728 | 2,250 | 2,855 | 3,510 | 4,260 | 5,084 | 5,952 | 6,918 | 8,038 | 9,024 |
| 7 | 1,015 | 1,480 | 2,016 | 2,625 | 3,330 | 4,112 | 4,970 | 5,931 | 6,944 | 8,071 | 9,378 | 10,528 |
| 8 | 1,160 | 1,160 | 2,304 | 3,000 | 3,805 | 4,680 | 5,680 | 6,778 | 7,936 | 9,224 | 10,718 | 12,032 |
| 9 | 1,308 | 1,900 | 2,592 | 3,375 | 4,280 | 5,265 | 6,380 | 7,625 | 8,928 | 10,377 | 12,058 | 13,536 |
| 10 | 1,450 | 2,110 | 2,880 | 3,750 | 4,755 | 5,850 | 7,100 | 8,472 | 9,920 | 11,530 | 13,398 | 15,040 |

## Atmospheric Pressures.

*The Pressure of:*

| | | |
|---|---|---|
| ½ atmosphere is | 7.348 lb. per sq. in. | 5.144 Kilos per sq. cm. |
| 1 ,, | 14.696 ,, ,, | 10.287 ,, ,, |
| 1½ ,, | 22.044 ,, ,, | 15.431 ,, ,, |
| 2 ,, | 29.392 ,, ,, | 20.574 ,, ,, |
| 2½ ,, | 36.740 ,, ,, | 25.718 ,, ,, |
| 3 ,, | 44.088 ,, ,, | 30.862 ,, ,, |
| 3½ ,, | 51.436 ,, ,, | 36.005 ,, ,, |
| 4 ,, | 58.784 ,, ,, | 41.148 ,, ,, |

## Freezing Mixtures.

Alcohol 77: Snow 73 gives—30°c.
Alcohol and $Co_2$ Solid gives—72°c
Ammonium chloride 30: water 100 gives—5.1°c.
Ammonium chloride 25: Snow 100 gives—15.5°c
$Cacl_2$ $2H_20$ 100: Snow 70 gives—50°c
66 per cent. $H_2SO_4$ 100: Snow 110 gives—37°c.

## Thermometer Scales.

| Thermometer Reading. | | | Temperature Rise. | | |
|---|---|---|---|---|---|
| Cent. | Fahr. | Réaumur. | Cent. | Fahr. | Reaumur. |
| 0 | 32 | 0 | 0 | 0 | 0 |
| 10.00 | 50 | 8.00 | 20.00 | 36 | 16.00 |
| 15.55 | 60 | 12.44 | 27.78 | 50 | 22.22 |
| 21.11 | 70 | 16.89 | 33.33 | 60 | 26.67 |
| 26.67 | 80 | 21.33 | 38.89 | 70 | 31.11 |
| 32.22 | 90 | 25.78 | 40.00 | 72 | 32.00 |
| 37.78 | 100 | 30.22 | 44.44 | 80 | 35.56 |
| 48.89 | 120 | 39.11 | 50.00 | 90 | 40.00 |
| 65.56 | 150 | 52.44 | 55.00 | 99 | 44.00 |
| 100.00 | 212 | 80.00 | 60.00 | 108 | 48.00 |
| 260.00 | 500 | 208.00 | 75.00 | 135 | 60.00 |

## Inches to Millimetres.

| Ins. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Milli-metres | Milli-metres | Milli-metres | Milli-metres | Milli-metres | Milli' metres | Milli-metres | Milli-metres | Milli-metres | Milli-metres |
| | —— | 25·4 | 50·8 | 76.199 | 101·599 | 126·999 | 152·399 | 177·798 | 203.198 | 228·598 |
| 10 | 253·998 | 279·397 | 304·797 | 330.197 | 355·597 | 380·997 | 406·396 | 431·796 | 457.196 | 482·596 |
| 20 | 505·995 | 533·395 | 558·795 | 584.195 | 609·595 | 634·995 | 660·394 | 685·794 | 711.194 | 736·593 |
| 30 | 761·993 | 787·393 | 812·793 | 838.192 | 863·592 | 888·992 | 914·392 | 939·792 | 965.192 | 990,592 |
| 40 | 1.015·990 | 1.041·392 | 1,066·790 | 1,092.190 | 1,117·590 | 1,142·990 | 1,168·390 | 1,193·790 | 1,219.190 | 1,244·590 |
| 50 | 1.269·998 | 1.295·388 | 1,320·788 | 1,346.188 | 7,371·588 | 1,396·988 | 1,422·398 | 1,447·788 | 1,473·186 | 1,498·586 |
| 60 | 1.523·986 | 1.549·386 | 1,574·786 | 1,600.186 | 1,625·586 | 1,650·985 | 1,676·385 | 1,701·784 | 1,727·184 | 1,752·584 |
| 70 | 1.777·984 | 1.803·384 | 1.828·784 | 1,854.184 | 1,879·584 | 1,904·982 | 1,930·384 | 1,955·784 | 1,981·184 | 2,006·582 |
| 80 | 2.031·982 | 2.057·382 | 2,082·782 | 2,108.182 | 2,133·582 | 2,158·980 | 2,184·380 | 2,209·780 | 2,235·180 | 2,260·580 |
| 90 | 2.285·980 | 2.311·378 | 2,336·778 | 2,362.178 | 2,387·578 | 2,412·978 | 2,438·378 | 2,463·778 | 2,489·176 | 2,514·576 |

| Ins. | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Milli--metres | Milli-metres | Milli-metres | Milli-metres | Milli-metres | Milli-metres | Milli-metres | Milli-metres | Milli-metres | Milli-metres |
| 100 | 2·539;98 | 2·793'97 | 3·047'97 | 3·301'97 | 3·555'97 | 3,809'97 | 4,063'96 | 4,317'96 | 1,571'96 | 4,825.96 |
| 200 | 5·079;95 | 5·333'95 | 5.587'95 | 5·841'95 | 6,095'95 | 6,349'95 | 6,603'94 | 6,857'94 | 7,111'94 | 7,365.93 |
| 300 | 7,619;93 | 7·873;93 | 8·127'93 | 8·381'92 | 8,635'92 | 8,889'92 | 9,143'92 | 9,397'92 | 9,651'92 | 9,905.92 |
| 400 | 10·159;90 | 10·413'92 | 10,667'90 | 10·921'90 | 11·175'90 | 11,429'90 | 11,683'90 | 11,937'90 | 12,161'90 | 12,445.90 |
| 500 | 12·699;98 | 12·953'88 | 13,207'88 | 13·461'88 | 13,715'88 | 13,969'88 | 14,223.98 | 14,477'88 | 14,731'86 | 14,985.86 |
| 600 | 15·239;86 | 15·493'86 | 15·747'86 | 16·001'86 | 16·255'86 | 16,509,85 | 16,763'85 | 17,017'84 | 17,271'84 | 17,525.84 |
| 700 | 17·779;84 | 18·033'84 | 18·287'84 | 18·941'84 | 18·705'84 | 19,049,82 | 19,303'84 | 19,557'84 | 19,811'84 | 20,065.82 |
| 800 | 20·319;82 | 20·573'82 | 20·827'82 | 21·081'82 | 21,335'82 | 21·589'80 | 21,843'80 | 22,097,80 | 22,351'80 | 22,605.80 |
| 900 | 22·859'80 | 23.113·78 | 23·367'78 | 23·621'78 | 23,975'78 | 24,129'78 | 24,383'78 | 24,637'78 | 24·891'76 | 25,145.76 |

THE USE OF THE TABLES.—In each table, the row of figures at the extreme top, and the figures in the left hand column, represent inches. In the first Table, immediately under the number, 1, 2, 3, etc. to 9, are the equivalents in m. m. of these numbers of inches. The second row of figues (on a level with 10" in the inches column) gives the equivalents in m. m. of 10" (under 0), 11" (under 1), and so on to 19" (to be found under 9). Similarly with each of the other rows of figures. Thus, the figure in the bottom right-hand corner represents the equivalent of 99 ins., being under 9 in the 90 row. The second table shows the similar information, but rising in tens instead of units, of from 100 ins. to 990 ins., e.g., the metric equivalent of 560 inches (14,223'98 m.m.) will be found in the 500 row, under 60.

## Metrical equivalents of Feet and Inches.

| In. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Feet |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.0 | 0.305 | 0.610 | 0.914 | 1.219 | 1.524 | 1.829 | 2.133 | 2.438 | 2.743 | 3.048 | 3.352 | 3.657 | Metres |
| 1 | 0.0254 | 0.330 | 0.635 | 0.940 | 1.244 | 1.549 | 1.854 | 2.158 | 2.463 | 2.768 | 3.073 | 3.378 | 3.682 | ,, |
| 2 | 0.0508 | 0.356 | 0.660 | 0.965 | 1.269 | 1.575 | 1.880 | 2.184 | 2.489 | 2.794 | 3.099 | 3.403 | 3.708 | ,, |
| 3 | 0.0762 | 0.381 | 0.686 | 0.991 | 1.295 | 1.600 | 1.905 | 2.209 | 2.514 | 2.819 | 3.124 | 3.429 | 3.733 | ,, |
| 4 | 0.1076 | 0.406 | 0.711 | 1.016 | 1.320 | 1.626 | 1.931 | 2.235 | 2.540 | 2.844 | 3.150 | 3.454 | 3.759 | ,, |
| 5 | 0.1270 | 0.432 | 0.737 | 1.041 | 1.346 | 1.651 | 1.956 | 2.260 | 2.565 | 2.870 | 3.175 | 3.479 | 3.784 | ,, |
| 6 | 0.1524 | 0.457 | 0.762 | 1.066 | 1.371 | 1.676 | 1.981 | 2.286 | 2.590 | 2.895 | 3.200 | 3.505 | 3.810 | ,, |
| 7 | 0.1778 | 0.483 | 0.787 | 1.092 | 1.397 | 1.702 | 2.007 | 2.311 | 2.616 | 2.921 | 3.226 | 3.530 | 3.835 | ,, |
| 8 | 0.2032 | 0.508 | 0.813 | 1.117 | 1.422 | 1.727 | 2.032 | 2.336 | 2.641 | 2.946 | 3.251 | 3.555 | 3.860 | ,, |
| 9 | 0.2286 | 0.533 | 0.838 | 1.142 | 1.448 | 1.753 | 2.057 | 2·362 | 2.667 | 2.972 | 3.276 | 3.581 | 3.886 | ,, |
| 10 | 0.2540 | 0.559 | 0.864 | 1.168 | 1.473 | 1.778 | 2.083 | 2.387 | 2.692 | 2.997 | 3.302 | 3.606 | 3.911 | ,, |
| 11 | 0.2794 | 0.584 | 0.889 | 1.193 | 1.498 | 1·803 | 2.108 | 2.412 | 2.717 | 3.022 | 3.327 | 3.632 | 3.936 | ,, |

## British & Metric Equivalents.

| To convert | Into | Multiplier | Reciprocal |
|---|---|---|---|
| Inches .. .. | Millimetres .. .. | 25.40 | .0394 |
| Feet .. .. | Metres .. .. | .3048 | 3.2809 |
| Yards .. .. | Metres .. .. | .9144 | 1.0936 |
| Miles .. .. | Kilometres .. .. | 1.6093 | .6214 |
| Sq. Inches .. .. | Sq. Centimetres .. | 6.4514 | .155 |
| Sq. Feet. .. .. | Sq. Metres .. .. | .0929 | 10.7643 |
| Cub. Inches .. | Cub. Centimetres .. | 16.3862 | .0610 |
| Cub. Feet .. .. | Cub. Metres .. .. | .0283 | 35.3166 |
| Pints .. .. | Litres .. .. | .5679 | 1.7608 |
| Lbs. (av.) .. .. | Kilograms .. .. | .4536 | 2.2046 |
| Tons .. .. | Tinnes .. .. | .9842 | 1.0161 |
| Ft. Pounds .. | Kilog-Metres .. | .1382 | 7.2331 |
| Lbs. per Sq. Inch .. | Kilos per Sq. Centimetre .. | .0703 | 14.223 |
| Lbs. per Sq. Foot .. | Kilos per Sq. Metre | 4.8826 | .2048 |
| Lbs. per Yard .. | Kilos per Metre .. | .4961 | 2.0159 |
| Tons per Sq. Inch.. . | Kilos per Sq. mm. .. | 1.5749 | .6350 |

## Table for Conversion of Millimetres into Inches.

| Mm. | Inches | Mm. | Inches | Mm. | Inches. |
|---|---|---|---|---|---|
| 1 | 0.0394 | 35 | 1.3780 | 68 | 2.6772 |
| 2 | 0.0787 | 36 | 1.4173 | 69 | 2.7166 |
| 3 | 0.1181 | 37 | 1.4567 | 70 | 2.7559 |
| 4 | 0.1575 | 38 | 1.4961 | 71 | 2.7953 |
| 5 | 0.1968 | 39 | 1.5354 | 72 | 2.8347 |
| 6 | 0.2362 | 40 | 1.5748 | 73 | 2.8740 |
| 7 | 0.2756 | 41 | 1.6142 | 74 | 2.9134 |
| 8 | 0.3150 | 42 | 1.6536 | 75 | 2.9528 |
| 9 | 0.3543 | 43 | 1.6929 | 76 | 2.9922 |
| 10 | 0.3937 | 44 | 1.7323 | 77 | 3.0315 |
| 11 | 0.4331 | 45 | 1.7717 | 78 | 3.0709 |
| 12 | 0.4724 | 46 | 1.8110 | 79 | 3.1103 |
| 13 | 0.5118 | 47 | 1.8504 | 80 | 3.1406 |
| 14 | 0.5512 | 48 | 1.8898 | 81 | 3.1890 |
| 15 | 0.5906 | 49 | 1.9291 | 82 | 3.2284 |
| 16 | 0.6299 | 50 | 1.9685 | 83 | 3.2677 |
| 17 | 0.6693 | 51 | 2.0079 | 84 | 3.3071 |
| 18 | 0.7087 | 52 | 2.0473 | 85 | 3.3465 |
| 19 | 0.7480 | 53 | 2.0866 | 86 | 3.3859 |
| 20 | 0.7874 | 54 | 2.1260 | 87 | 3.4252 |
| 21 | 0.8268 | 55 | 2.1654 | 88 | 3.4646 |
| 22 | 0.8661 | 56 | 2.2047 | 89 | 3.5040 |
| 23 | 0.9055 | 57 | 2.2441 | 90 | 3.5433 |
| 24 | 0.9449 | 58 | 2.2835 | 91 | 3.5827 |
| 25 | 0.9843 | 59 | 2.3228 | 92 | 3.6221 |
| 26 | 1.0236 | 60 | 2.3622 | 93 | 3.6614 |
| 27 | 1.0630 | 61 | 2.4016 | 94 | 3.7008 |
| 28 | 1.1024 | 62 | 2.4410 | 95 | 3.7402 |
| 29 | 1.1417 | 63 | 2.4803 | 96 | 3.7796 |
| 30 | 1.1811 | 64 | 2.5197 | 97 | 3.8189 |
| 31 | 1.2205 | 65 | 2.5591 | 98 | 3.8583 |
| 32 | 1.2598 | 66 | 2.5984 | 99 | 3.8977 |
| 33 | 1.2992 | 67 | 2.6378 | 100 | 3.9370 |
| 34 | 1.3386 | | | | |

## Fractions of inches, with Decimal and Metric Equivalents.

| Fractions of inches. | Decimals. | Milli-metres. | Fractions of inches. | Decimals. | Milli-metres. |
|---|---|---|---|---|---|
| 1 | 1.0 | 25.4 | $\frac{1}{26}$ | .038462 | .976923 |
| $\frac{1}{2}$ | .5 | 12.7 | $\frac{1}{27}$ | .037037 | .940741 |
| $\frac{1}{3}$ | .333333 | 8.466667 | $\frac{1}{28}$ | .035714 | .907142 |
| $\frac{1}{4}$ | .25 | 6.35 | $\frac{1}{29}$ | .034483 | .875862 |
| $\frac{1}{5}$ | .2 | 5.08 | $\frac{1}{30}$ | .033333 | .846667 |
| $\frac{1}{6}$ | .166666 | 4.233333 | $\frac{1}{31}$ | .032258 | .819355 |
| $\frac{1}{7}$ | .142857 | 3.628571 | $\frac{1}{32}$ | .03125 | .79325 |
| $\frac{1}{8}$ | .125 | 3.175 | $\frac{1}{33}$ | .030303 | .769697 |
| $\frac{1}{9}$ | .111111 | 2.822222 | $\frac{1}{34}$ | .029411 | .747058 |
| $\frac{1}{10}$ | .1 | 2.54 | $\frac{1}{35}$ | .028571 | .725714 |
| $\frac{1}{11}$ | .090909 | 2.309091 | $\frac{1}{36}$ | .027777 | .705556 |
| $\frac{1}{12}$ | .083333 | 2.116667 | $\frac{1}{37}$ | .027027 | .686476 |
| $\frac{1}{13}$ | .076923 | 1.953846 | $\frac{1}{38}$ | .026316 | .667631 |
| $\frac{1}{14}$ | .071429 | 1.814286 | $\frac{1}{39}$ | .025641 | .651282 |
| $\frac{1}{15}$ | .066666 | 1.693333 | $\frac{1}{40}$ | .025 | .635 |
| $\frac{1}{16}$ | .0625 | 1.5875 | $\frac{1}{41}$ | .024390 | .619512 |
| $\frac{1}{17}$ | .058824 | 1.49118 | $\frac{1}{42}$ | .023809 | .604761 |
| $\frac{1}{18}$ | .055555 | 1.411111 | $\frac{1}{43}$ | .023256 | .590698 |
| $\frac{1}{19}$ | .052632 | 1.336842 | $\frac{1}{44}$ | .022727 | .577272 |
| $\frac{1}{20}$ | .05 | 1.27 | $\frac{1}{45}$ | .022222 | .564444 |
| $\frac{1}{21}$ | .47619 | 1.209524 | $\frac{1}{46}$ | .021739 | .552174 |
| $\frac{1}{22}$ | .045455 | 1.154545 | $\frac{1}{47}$ | .021277 | .540426 |
| $\frac{1}{23}$ | .043478 | 1.104348 | $\frac{1}{48}$ | .020833 | .529166 |
| $\frac{1}{24}$ | .041666 | 1.058333 | $\frac{1}{49}$ | .020408 | .518367 |
| $\frac{1}{25}$ | .04 | 1.016 | $\frac{1}{50}$ | .02 | .508 |

## 64th of an inch. with their Equivalents in Decimals and Millimetres.

| Fractions of Inches. | Decimals. | Milli-metres. | Fractions of Inches. | Decimals. | Milli-metres |
|---|---|---|---|---|---|
| 1/64 | .015625 | 0.3969 | 33/64 | .515625 | 13.0970 |
| 1/32 | .03125 | 0.7938 | 17/32 | .53125 | 13.4938 |
| 3/64 | .046875 | 1.1906 | 35/64 | .546875 | 13.8906 |
| 1/16 | .0625 | 1.5876 | 9/16 | .5625 | 14.2884 |
| 5/64 | .078125 | 1.9844 | 37/64 | .578125 | 14.6844 |
| 3/32 | .09375 | 2.3814 | 19/32 | .59375 | 15.0812 |
| 7/64 | .109375 | 2.7781 | 39/64 | .609375 | 15.4781 |
| 1/8 | .125 | 3.1752 | 5/8 | .625 | 15.8760 |
| 9/64 | .140625 | 3.5719 | 41/64 | .640625 | 16.2720 |
| 5/32 | .15625 | 3.9690 | 21/3 | .65625 | 16.6688 |
| 11/64 | .171875 | 4.3657 | 43/64 | .671875 | 17.0656 |
| 3/16 | .1875 | 4.7628 | 11/16 | .6875 | 17.4636 |
| 13/64 | .203125 | 5.1592 | 45/64 | .703125 | 17.8592 |
| 7/32 | .21875 | 5.5566 | 23/32 | .71875 | 18.2562 |
| 15/64 | .234375 | 5.9551 | 47/64 | .734735 | 18.6531 |
| 1/4 | .25 | 6.3504 | 3/4 | .75 | 19.0512 |
| 17/64 | .265625 | 6.7480 | 49/64 | .765625 | 19.4470 |
| 9/32 | .28125 | 7.1442 | 25/32 | .78125 | 19.8438 |
| 19/64 | .296875 | 7.5420 | 51/64 | .796875 | 20.2408 |
| 5/16 | .3125 | 7.9380 | 13/16 | .8125 | 20.6388 |
| 21/64 | .328125 | 8.3344 | 53/64 | .828125 | 21.0342 |
| 11/32 | .34375 | 8.7312 | 27/32 | .84375 | 21.4312 |
| 23/64 | .359375 | 9.1280 | 55/64 | .859375 | 21.8280 |
| 3/8 | .375 | 9.5256 | 7/8 | .875 | 22.2264 |
| 25/64 | .390625 | 9.9220 | 57/64 | .890625 | 22.6220 |
| 13/32 | .40625 | 10.3187 | 29/32 | .90625 | 23.0190 |
| 27/64 | .421875 | 10.7158 | 59/64 | .921875 | 23.4160 |
| 7/6 | .4375 | 11.1132 | 15/16 | .9375 | 23.8140 |
| 29/64 | .453125 | 11.5092 | 61/64 | .953125 | 24.2093 |
| 15/23 | .46875 | 11.9062 | 31/32 | .96875 | 24.6062 |
| 31/64 | .484375 | 12.3030 | 63/64 | .984375 | 25.0031 |
| 1/2 | .5 | 12.7008 | 1 | 1.0 | 25.4 |

## Useful Rules.

To convert *inches vacuum* into feet suction, multiply by 1.13

To reduce pounds pressure to feet head, multiply by 2.3.

To reduce heads in feet to pressure in pounds, multiply by .434.

Friction of liquids in pipes increases as the square of the velocity.

Doubling the diameter of a pipe increases its capacity four times.

To find the area of a pipe, square the diameter and multiply by .7854.

A cubic foot of water weighs 62½ pounds and contains 1728 cubic inches or 7½ U. S. gallons.

Approximately, every foot elevation of a column of water produces a pressure of ½ pound per square inch (actual .434).

A 'miner's inch' of water is approximately equal to a supply of 12 gallons per minute. In California, 9 gallons.

The gallons per minute which a pipe will deliver equals .0408 times the square of the diameter, multiplied by the velocity in feet per minute.

To find the capacity of a pipe or cylinder in gallons, multiply the square of the diameter in inches by the length in inches and by .0034.

The weight of water in any length pipe is obtained by multiplying the length in feet by the square of the diameter in inches, and by .34.

To find the discharge from any pipe in cubic feet per minute, square the diameter and multiply by the velocity in feet per minute and by .00545.

U. S. gallon of water weighs 8⅓ pounds and contains 231 cubic inches.

Imperial gallon weighs 10 pounds and contains 277 cubic inches.

To find the diameter of a pipe in inches, divide the gallons per minute by the velocity in feet per minute, and multiply the square root of the quotient by 4.95.

To find the capacity of a given tank or cistern in U.S. gallons, square the diameter (in feet), and mu.tiply by .7854, multiply by the height in feet, and by 7.48.

To find the discharge in U.S. gallons per minute from any pipe, square the diameter in inches, multiply by the velocity in feet per second and by 2.448.

The discharge from a pipe in cubic feet per second is equal to the mean velocity in feet per second multiplied by the area of cross section or pipe in square feet.

Sharp angles or sudden bends in pipes cause increase in friction, consequently increase of power is necessary. Where change of direction is desired the same should be made by means of long easy curves or by using 45 degree ells.

## To find the Capacity of a Cylinder in Gallons.

Multiply the square of the diameter in inches by the length of the stroke in inches and by .0034.

To get the capacity per minute, multiply by the number of strokes.

For a double acting pump, multiply by 2.

*Example :—*

A safety valve 2″ dia. is loaded with 4 dead weights of 40 lbs. each and 4 of 60 lbs. each; the valve itself weighs 3 lbs. and the casing weighs 65 lbs., what is the pressure of steam per square inch on the valve ?

| | |
|---|---|
| $4 \times 40$ | =160 lbs. 1st dead weights |
| $4 \times 60$ | =240 lbs. 2nd ,, ,, |
| Weight of valve | = 3 lbs. |
| Weight of casing | = 65 lbs. |
| weight Total | 468 lbs. |

$$\text{Pressure per sq.in.} = \frac{468}{2 \times 2 \times .7854} = 148.90.$$

*Example :—*

If the diameter of a valve is 4″ and it is at a distance of 2″ from the fulcrum; if the steam pressure is 160 lbs. per square inch, find at what distance a weight of 120 should be placed, the weight of the valve being 6 lbs. and the weight of the lever 40 lbs.

| | |
|---|---|
| $4'' \times 4'' = 16'' \times .7854$ | =12.5664 area of valve |
| $12.5664 \times 160$ (lbs. steam pressure) | =2010.6240 weight of the valve. |
| 2010.6240—6 (weight of the valve) | =2004.6240. |

2004.6240 × 2 (distance from the fulcrum) = 4009.2480.
4009.2480 — 40 (weight of the lever) = 3969.2480.
3969.2480 ÷ 120 (weight given) = 33.07 inches.

*Example :—*

A safety valve lever is pivoted 3 inches from the top of the centre of the valve and 16 inches from the weight of 50 lbs. The diameter of the valve is 2 inches; at what pressure will it blow? The area of the valve is $2^2 \times .7854$.

*Rule :—*

Multiply the weight in pounds by the distance of its point of suspension from the pin or fulcrum, and divide by the area of the valve and the distance from the fulcrum of its point of contact with the lever.

| | |
|---|---|
| 4 × .7854 | = 3.1416 |
| 50 × 16 | = 800 |
| 3.1416 × 3 | = 9.4248 |
| 800 ÷ 9.4248 | = 84.8 lbs. pressure. |

---

Q. In a safety valve the total upward pressure on the valve, when steam is blowing off, is 320 lbs. The total length of the lever is 3 feet and the distance from the fulcrum to the valve is 4 inches. Find the weight which must be hung at the end of the lever so that the steam may just blow off.

A. $\frac{320 \times 4}{3 \times 12} = \frac{320}{9} = 35.5$ lbs.

Q. The lever of a safety valve is 28 inches long from the fulcrum to the load, the valve spindle presses on the lever at the underside at 3 inches from the fulcrum. Find what load must be applied to the end in order to put a pressure of 300 pounds on the valve spindle?

A. $\frac{300 \times 3}{28} = \frac{900}{28} = 32.14$ lbs.

Q. To ascertain the Horse-power, where Q = cubic feet per minute, and F = fall in feet.

A. $\frac{Q \times F}{706} = \text{H.P.}$

Q. To ascertain the Quantity of water required for a given power.

A. $\frac{\text{H.P.} \times 706}{\text{F}}$ =Quantity in cubic feet per minute.

Q. To ascertain the Height of Fall in feet required to produce the H. P.

A. $\frac{\text{H. P. } 70}{\text{Q}}$ =Fall in feet.

*N.B.* The above figures are based upon 75 per cent. efficiency. For 80 per cent. efficiency take 660 as the constant; and for 70 per cent. efficiency take 754 instead of 706.

## Measures.

| | | | |
|---|---|---|---|
| 1 gall. | =4 qt. | =8pt. | =32 gills =10lbs. =4.5 litres. |
| 1 pt. | =$1\frac{1}{4}$ lb. | =588 c.c. | =20 fl. oz. |
| 1 litre | =0.22 gall. | =1.76pt. | =35.2 fl. oz. |
| 1 metre | =3.3 ft. | =39.37 in. | |
| 1 yard | =91.44 cm. | | |
| 1 in. | =2.54 cm. | | |

---

| | | |
|---|---|---|
| Mercury =135.9 lb. gallon | | Turpentine =8.7 lb. gallon. |
| Sperm oil =8.8 ,, | | Alcohol =8 ,, |
| Kerosine =8 ,, | | Petrol =$7\frac{1}{2}$ ,, |

1 Gallon of Milk weighs approximately $10\frac{1}{2}$ lbs.

---

## Hydraulic Equivalents.

| | | |
|---|---|---|
| One Imperial Gallon | =277.274 | Cubic inches. |
| ,, ,, ,, | = .16 | Cubic foot. |
| ,, ,, ,, | = 10.00 | Lbs. |
| ,, ,, ,, | = 1.2 | U. S. Gallons. |
| ,, ,, ,, | = 4.537 | Litres. |
| ,, U.S. ,, | = 231 | Cubic Inches. |
| ,, ,, ,, | = .133 | Cubic foot. |
| ,, ,, ,, | = 8.33 | Lbs. |

| | | |
|---|---|---|
| One U.S, Gallon | = | .83 Imperial Gallon. |
| ,, ,, ,, | = | 3.8 Litres. |
| One Cubic Inch of Water | = | .0361 Lb. |
| ,, ,, ,, ,, ,, | = | .003607 Imperial Gallon. |
| ,, ,, ,, ,, ,, | = | .00329 U. S. Gallon. |
| ,, ,, Foot of Water | = | 6.23 Imperial Gallons. |
| ,, ,, ,, ,, ,, | = | 7.48 U. S. Gallons. |
| ,, ,, ,, ,, ,, | = | 28.375 Litres. |
| ,, ,, ,, ,, ,, | = | .0283 Cubic Metre. |
| ,, ,, ,, ,, ,, | = | 62.5 Lbs. |
| ,, ,, ,, ,, ,, | = | .557 Cwt. |
| ,, ,, ,, ,, ,, | = | .028 Ton. |
| ,, Lb. of water. | = | 27.72 Cubic Inches. |
| ,, ,, ,, ,, | = | .10 Imperial Gallon. |
| ,, ,, ,, ,, | = | .083 U. S. Gallon. |
| ,, ,, ,, ,, | = | .16 Cubic foot. |
| ,, cwt ,, ,, | = | 11.2 Imperial Gallons. |
| ,, ,, ,, ,, | = | 13.44 U.S. Gallons. |
| ,, ,, ,, ,, | = | 1.8 Cubic feet. |
| ,, Ton of water | = | 35.9 Cubic feet. |
| ,, ,, ,, ,, | = | 224 Imperial Gallons. |
| ,, ,, ,, ,, | = | 268.8 U.S. Gallons. |
| ,, ,, ,, ,, | = | 1000 Litres. (approximately) |
| ,, ,, ,, ,, | = | 1 Cubic Metre ( ,,) |
| ,, Litre ,, ,, ,, | = | .22 Imperial Gallon. |
| ,, ,, ,, ,, | = | .264 U.S. Gallons. |
| ,, ,, ,, ,, | = | 1 Kilogram =2.204 lb. |
| ,, ,, ,, ,, | = | 61 Cubic inches. |
| ,, ,, ,, ,, | = | .0353 Cubic foot. |
| ,, Cubic Metre of water | = | 220 Imperial Gallons. |
| ,, ,, ,, ,, ,, | = | 264 U. S. Gallons. |
| ,, ,, ,, ,, ,, | = | 1.308 Cubic yards. |
| ,, ,, ,, ,, ,, | = | 61028 Cubic Inches. |
| ,, ,, ,, ,, ,, | = | 35.31 Cubic feet. |
| ,, ,, ,, ,, ,, | = | 1000 Kilos. |
| ,, ,, ,, ,, ,, | = | 1 Ton (approximately) |
| ,, ,, ,, ,, ,, | = | 1000 Litres. |

## Hydraulic Memoranda

A cylindrical foot of water weighs 48.96 lbs.
A cylindrical inch of water weighs .0284 lbs.
353 cylindrical inches = 1 gallon.
A column of water 12 in. long 1 in. square weighs .434 lbs.
A column of water 12 in. long 1 in. diameter weighs. .340 lb.
The capacity of a 12 in. cube =6.232 gallons.
The capacity of a 1 in. square 1 ft. long = .0434 gallon.
The capacity of a 1 ft. diameter 1 ft. long = 4.896 gallons.
The capacity of a 1 in. diameter 1ft. long = .034 gallon.
The capacity of a cylindrical inch = .002832 gallon.
The capacity of a cylinder 1 yard long, in gallons = .1 × dia. squared.

The capacity of a cubic inch = .003606 gallon.
The capacity of a sphere 12 in. diameter = 3.263 gallons.
The capacity of a sphere 1 in. diameter = .00188 gallon.

*Water.*

Head in ft. × .4325 = lbs. per sq. in. (fresh water). R =2.3122.
Depth in fathoms × 2.6624 =lbs. per sq. in. (sea water).
Tons water × 224 =gallons; 1 gallon =10 lbs.
Cubic feet per min × 9000 =gallons per 24 hours.
(Inches diam. of pipe)$^2$ =lbs. of water contained per yd.

*Sea Water.*

1c.ft. of sea water = 64.11 lbs.
Wt. of sea water = 1.027 weight of fresh water.
A cubic inch of sea water = .037037 lb.

*Rainfall.*

Inches of rainfall × 2,323,200 =c. ft. per sq. mile.
Inches of rainfall × 14½ =millions of gallons per sq. mile.
1 Inch of rainfall = 22,622 Gallons per Acre 100 Tons (approx).

*Hydraulic Calculations.*

1 foot = 12 inches = .305 metres.
1 metre = 3.28 feet = 39.37 inches.
1 cubic foot = 6.25 gallons = 28.3 litres = .0283 cubic metres
1 cubic metre = 1000 litres = 220 gallons = 35.32 cubic feet.
1 gallon = 277.27 cubic inches = .16 cubic foot = 4.543 litres.
= .004543 cubic metre.
1 litre = .001 cubic metres = .035 cubic feet = .22 gallons.

## Low Boiling—Point Liquids

| Liquid. | Boiling Points. Cent. | Boiling Points. Fahr. | Melting Points. Cent. | Melting Points. Fahr. |
|---|---|---|---|---|
| Ammonia .. .. | —38.5 | —37.3 | —77.34 | —10.72 |
| Carbon Dioxide .. | —78.2 | —121.4 | —65 | —85 |
| Ethyl Chloride .. | —19.5 | —3.1 | —141.6 | —222.9 |
| Liquid Air. .. | —190 | —310 | — | — |
| Liquid Nitrogen .. | —195.5 | —319.9 | —210.5 | —346.9 |
| Liquid Oxygen .. | —182.7 | —296.9 | —227 | —376.6 |
| Sulphur Dioxide .. | —10 | —14 | —76.1 | —105 |

## Measures of Space Angular Measure.

60 Seconds = 1 Minute.
60 Minutes = 1 Degree.
30 Degrees = 1 Sign.
45 Degrees = 1 Octant.
60 Degrees = 1 Sextant.
90 Degrees = Quadrant.
(a Right Angle).
180 Degrees = 1 Semi-circle.
360 Degrees = 1 Circle.

## Useful Fixed Points for Calibrating Thermometers and Pyrometers.

| | °F. | °C. |
|---|---|---|
| Absolute Zero .. .. .. .. .. | —459.4 | 273 |
| Melting Point of Hydrogen .. .. .. | —431 | —237 |
| Boiling Point of Hydrogen .. .. .. | —423 | —253 |
| Do. of Oxygen .. .. .. | —297 | —183 |
| Melting Point of Mercury .. .. .. | —37.8 | —38.8 |
| Do. of Ice .. .. .. .. | 32 | 0 |
| Boiling Point of Alcohol .. .. .. | 173 | 78.3 |
| Do. of Water .. .. .. .. | 212 | 100 |
| Do. of Aniline .. .. .. | 363 | 184.1 |
| Do. of Mercury .. .. .. | 674 | 356.7 |
| Melting Point of Lead.. .. .. .. | 620 | 327 |
| Do. of Zinc .. .. .. .. | 786 | 419 |
| Do. of Aluminium .. .. .. | 1216 | 658 |
| Do. of Sodium Chloride .. .. | 1472 | 800 |
| Do. of Barium Chloride .. .. | 1760 | 960 |
| Do. of Gold .. .. .. .. | 1945 | 1063 |
| Do. of Copper .. .. .. | 1982 | 1083 |
| Do. of Nickel .. .. .. .. | 2645.6 | 1452 |
| Do. of Iron .. .. .. .. | 2744 | 1507 |

## Thermometrical Table.

The following table shows the relative readings of thermometers at various temperatures :—

| | Fahrenheit. | Centigrade. | Réaumur. |
|---|---|---|---|
| Water Boils .. .. .. | 212° | 100° | 80° |
| Alcohol Boils .. .. .. | 173° | 78.3° | 627° |
| Tallow Melts .. .. .. | 127° | 53° | 43° |
| Blood Heat .. .. .. | 98° | 36.7° | 29.3° |
| Fever Heat begins .. .. | 100° | 37.8° | 30.2° |
| Summer Heat .. .. .. | 77° | 25° | 20° |
| Temperature of Spring Water | 50° | 10° | 8° |
| Water Freezes .. .. .. | 32° | 0° | 0° |
| | zero. | —17.7° | —14.2° |
| Healthy Indoor Temperature .. | 55° to 65° | .. | .. |

Degree centigrade ×1.8 +32 =Degrees Fahrenheit.
Degree Fahrenheit ×0.555—32 =Degrees Centigrade.

## Shrinkage of Castings—Per Lineal Ft.

| | Ins. |
|---|---|
| Brass, thin .. .. | $\frac{3}{16}$ |
| Do. thick .. .. | $\frac{1}{6}$ |

**Cast Iron**

| | |
|---|---|
| Girders.. .. .. | $\frac{1}{10}$ |
| Pipes, etc. .. .. | $\frac{1}{8}$ |
| Copper .. .. | $\frac{3}{16}$ |
| Gun Metal .. .. | $\frac{1}{8}$ |
| Lead .. .. .. | $\frac{5}{16}$ |
| Tin .. .. .. | $\frac{1}{4}$ |
| Zinc .. .. .. | $\frac{1}{4}$ |

## ROUND BARS.

WEIGHTS IN LBS. PER LINEAL FOOT.

| Dia. Iron. | Weight | Steel. | Dia | Weight Iron | Steel | Dia. | Weight Iron. | Steel. |
|---|---|---|---|---|---|---|---|---|
| in. | lbs | lbs. | in. | lbs. | lbs. | in | lbs. | lbs. |
| 1/8 | .051 | .052 | 2¼ | 13.25 | 13.52 | 8 | 167.5 | 170.9 |
| 3/16 | .092 | .094 | 2⅜ | 14.77 | 15.06 | 8½ | 189.1 | 192.9 |
| 1/4 | .164 | .167 | 2½ | 16.36 | 16.69 | 9 | 212.1 | 216.3 |
| 5/16 | .256 | .261 | 2⅝ | 18.04 | 18.40 | 9½ | 236.3 | 241.0 |
| 3/8 | .368 | .376 | 2¾ | 19.80 | 20.19 | 10 | 261.8 | 267.0 |
| 7/16 | .501 | .511 | 2⅞ | 21.64 | 22.07 | 10½ | 288.6 | 294.4 |
| 1/2 | .654 | .668 | 3 | 23.56 | 24.03 | 11 | 316.8 | 323.1 |
| 9/16 | .828 | .845 | 3¼ | 27.65 | 28.21 | 11½ | 346.2 | 353.1 |
| 5/8 | 1.023 | 1.043 | 3½ | 32.07 | 32.71 | 12 | 377.0 | 384.5 |
| 11/16 | 1.237 | 1.262 | 3¾ | 36.82 | 37.55 | 12½ | 409.2 | 417.2 |
| 3/4 | 1.473 | 1.502 | 4 | 41.89 | 42.73 | 13 | 442.4 | 451.3 |
| 13/16 | 1.728 | 1.763 | 4¼ | 47.29 | 48.23 | 13½ | 477.1 | 486.7 |
| 7/8 | 2.004 | 2.044 | 4½ | 53.01 | 54.07 | 14 | 513.1 | 523.4 |
| 15/16 | 2.301 | 2.347 | 4¾ | 59.07 | 60.25 | 14½ | 550.4 | 561.4 |
| 1 | 2.618 | 2.670 | 5 | 65.45 | 66.76 | 15 | 589.0 | 600.8 |
| 1⅛ | 3.313 | 3.380 | 5¼ | 72.16 | 73.60 | 16 | 670.2 | 683.6 |
| 1¼ | 4.001 | 4.172 | 5½ | 79.19 | 17 | 17 | 756.6 | 771.7 |
| 1⅜ | 4.950 | 5.049 | 5¾ | 86.56 | 88.29 | 18 | 848.2 | 865.2 |
| 1½ | 5.890 | 6.008 | 6 | 94.25 | 96.13 | 19 | 945.1 | 964.0 |
| 1⅝ | 6.913 | 7.051 | 6¼ | 102.27 | 104.31 | 20 | 1047 | 1068 |
| 1¾ | 8.018 | 8.178 | 6½ | 110.61 | 112.82 | 21 | 1154 | 1178 |
| 1⅞ | 9.204 | 9.388 | 6¾ | 119.28 | 121.67 | 22 | 1267 | 1292 |
| 2 | 10.472 | 10.681 | 7 | 128.28 | 130.85 | 23 | 1385 | 1413 |
| 2⅛ | 11.824 | 12.062 | 7½ | 147.26 | 150.21 | 24 | 1508 | 1538 |

### SQUARE BARS.

## Weights in Lbs. Per Lineal Foot.

| Size. | Weight Iron. | Steel. | Size. | Weight Iron. | Steel | Size | Weight Iron. | Steel |
|---|---|---|---|---|---|---|---|---|
| in. | lbs. | lbs. | in. | lbs. | lbs. | in. | lbs. | lbs. |
| 1/8 | .056 | .058 | 2¼ | 16.87 | 17.21 | 8 | 213.3 | 217.6 |
| 3/16 | .117 | .120 | 2⅜ | 18.80 | 19.18 | 8½ | 240.8 | 245.6 |
| 1/4 | .208 | .213 | 2½ | 20.83 | 21.25 | 9 | 270.0 | 275.4 |
| 5/16 | .326 | .332 | 2⅝ | 22.97 | 23.43 | 9½ | 300.8 | 306.8 |
| 3/8 | .469 | .478 | 2¾ | 25.21 | 25.71 | 10 | 333.3 | 340.0 |
| 7/16 | .638 | .651 | 2⅞ | 27.55 | 28.10 | 10½ | 367.5 | 374.8 |
| 1/2 | .833 | .849 | 3 | 30.00 | 30.60 | 11 | 403.3 | 411.4 |
| 9/16 | 1.005 | 1.076 | 3¼ | 35.21 | 35.91 | 11½ | 440.8 | 449.6 |
| 5/8 | 1.302 | 1.328 | 3½ | 40.83 | 41.65 | 12 | 480.0 | 489.6 |
| 11/16 | 1.576 | 1.607 | 3¾ | 46.87 | 47.81 | 12½ | 520.8 | 535.2 |
| 3/4 | 1.875 | 1.912 | 4 | 53.33 | 54.40 | 13 | 563.2 | 574.4 |
| 13/16 | 2.201 | 2.245 | 4¼ | 60.21 | 61.41 | 13½ | 607.6 | 619.6 |
| 7/8 | 2.552 | 2.603 | 4½ | 67.50 | 68.85 | 14 | 653.2 | 666.4 |
| 15/16 | 2.930 | 2.988 | 4¾ | 75.21 | 76.71 | 14½ | 700.8 | 714.8 |
| 1 | 3.333 | 3.400 | 5 | 83.33 | 85.00 | 15 | 750.0 | 764.8 |
| 1⅛ | 4.219 | 4.303 | 5¼ | 91.87 | 93.71 | 16 | 853.2 | 870.4 |
| 1¼ | 5.208 | 5.312 | 5½ | 100.8 | 102.8 | 17 | 963.2 | 982.4 |
| 1⅜ | 6.302 | 6.428 | 5¾ | 110.2 | 112.4 | 18 | 1080 | 1102 |
| 1½ | 7.500 | 7.650 | 6 | 120.0 | 122.4 | 19 | 1203 | 1227 |
| 1⅝ | 8.802 | 8.978 | 6¼ | 130.2 | 132.8 | 20 | 1333 | 1360 |
| 1¾ | 10.20 | 10.41 | 6½ | 140.8 | 143.6 | 21 | 1470 | 1499 |
| 1⅞ | 11.72 | 11.96 | 6¾ | 151.9 | 154.9 | 22 | 1613 | 1646 |
| 2 | 13.33 | 13.60 | 7 | 163.3 | 166.6 | 23 | 1763 | 1798 |
| 2⅛ | 15.05 | 15.35 | 7½ | 187.5 | 191.2 | 24 | 1920 | 1958 |

## Ready Methods of Calculating Weights of Steel and Cast Iron.

Steel: Cubic inches $\times$ .2833 = Lbs.
(or approx $\frac{2}{7}$)

" " $\times$ .00253 = Cwts.

" " $\div 400 + \frac{1}{100}$ = Cwts.

Cast Iron: Cubic inches $\times$ .263 = Lbs.

" " $\times$ .00235 = Cwts.

" " $\times\ 7 \div 3000$ = Cwts.

*Squares* —

Steel: Side$^2$ $\times$ length $\div 4 \times \frac{1}{10}$ and $\frac{1}{3}$ of the tenth = Lbs.

" Side$^2$ $\times$ length $\div 400 + \frac{1}{100}$ .. .. = Cwts.

Cast Iron: Sise$^2$ $\times 3$ length $\div 10 - \frac{1}{8}$ .. .. = Lbs.

" " $\times 2$ " $+ \frac{1}{6} \div 1000$ .. .. = Cwts.

*Rounds* :—

Steel: Dia.$^2$ $\times 2$ length $\div 9$ .. .. .. = Lbs.

" " $\times 2$ " $\div 1000$ .. .. .. = Cwts.

Cast Iron: Dia.$^2$ $\times$ length $\times$ .206 .. .. .. = Lbs.

" " $\times$ " $\div 9 \div 6 \div 10$ .. .. = Cwts.

*Flats :—*

Steel : Width $\times$thickness $\times$length $\div$ 4
$+\frac{1}{10}$ and $\frac{1}{3}$ of the tenth .. .. =Lbs.
,, Width $\times$thickness $\times$length $\div$ 400 $+\frac{1}{100}$ .. =Cwts.
Cast Iron: Width $\times$thickness $\times$3 length $\div$ 10 — $\frac{1}{8}$ .. =Lbs.
,, ,, Width $\times$thickness $\times$2 length $+\frac{1}{6}\div$ 1000 =Cwts.

*Rings or Cylinders :—*

Steel : Inside dia. + thickness $\times$ thickness.
$\times$8 = length $\div$ 9 .. .. .. =Lbs.
,, Inside dia. + thickness $\times$thickness
$\times$8 length $\div$ 1000 .. .. .. =Cwts.
Cast Iron: Inside dia. + thickness $\times$thickness-
$\times$4 length $\times$ .206 .. .. =Lbs.
Inside dia. + thickness $\times$thickness
$\times$8 length $\div$ 1100 .. .. .. =Cwts.

*Hexagons :—*

Steel : Dia.$^2$ $\times$length $\times$ .249 .. .. .. =Lbs.
,, ,, $\times$ ,, $\times$ .00222 .. .. .. =Cwts.
Cast Iron: Dia.$^2$ $\times$length $\times$ .227 .. .. .. =Lbs.
,, ,, $\times$ ,, $\times$ .00202 .. .. .. =Cwts.

*Octagons :—*

Steel : Dia.$^2$ $\times$length $\times$ .235 .. .. .. =Lbs.
,, ,, $\times$ ,, $\times$ .0021 .. .. .. =Cwts.
Cast Iron: Dia.$^2$ $\times$length $\times$ .217 .. .. .. =Lbs.
,, Dia.$^2$ $\times$ ,, $\times$ .00194 .. .. .. =Cwts.

## Angles of Repose for Various Materials.

| | Angle of Repose. |
|---|---|
| Bituminous coal | 35° |
| Anthracite coal | 27° |
| Slaked coal | 37½° to 45° |
| Ashes | 40° |
| Soft Iron Ore | 35° |
| Earth (loam) | 30° to 45° |
| Sand (dry) | 25° to 35° |
| Sand (moist) | 30° to 45° |
| Sand (Wet) | 15° to 30° |
| Clay | 25° to 45° |
| Gravel | 30° to 40° |
| Cinders | 25° to 40° |

| | Angle of Repose. |
|---|---|
| Coke .. .. .. .. .. .. .. | 30° to 45° |
| Wheat .. .. .. .. .. .. .. | 28° |
| Maize .. .. .. .. .. .. .. | 27° to 30° |
| Barley .. .. .. .. .. .. .. | 27° |
| Oats .. .. .. .. .. .. .. | 28° |
| Cement .. .. .. .. .. .. .. | 17° to 30° |

## SQUARES, SQUARE ROOTS, CUBES AND CUBE ROOTS.

| No. | SQUARE | SQUARE Root | Cube | Cube Root | No. | SQUARE | SQUARE Root | Cube | Cube Root | No. | SQUARE | SQUARE Root | Cube | Cube Root |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ⅛ | .015 | .353 | .0019 | .500 | 3 | 9 | 1·732 | 27 | 1·44 | 7¾ | 60·062 | 2.783 | 465.484 | 1·97 |
| ¼ | .062 | .500 | .0156 | .629 | 3⅛ | 9·765 | 1·767 | 30·517 | 1·46 | 8 | 64 | 2.828 | 512 | 2 |
| ⅜ | .140 | .612 | .0527 | .721 | 3¼ | 10·562 | 1·803 | 34·328 | 1·48 | 8¼ | 68·062 | 2.872 | 561.515 | 2.02 |
| ½ | .250 | .707 | .1250 | .793 | 3⅜ | 11·390 | 1 837 | 38·443 | 1·50 | 8½ | 72·250 | 2.915 | 614.125 | 2·04 |
| ⅝ | .390 | .790 | .244 | .855 | 3½ | 12·250 | 1 870 | 42·875 | 1.51 | 8¾ | 76·562 | 2.958 | 669.021 | 2·06 |
| ¾ | .562 | .866 | .421 | .908 | 3⅝ | 13·150 | 1·903 | 47·634 | 1·53 | 9 | 81 | 3 | 729 | 2·08 |
| ⅞ | .765 | .935 | .669 | .966 | 3¾ | 14·062 | 1 936 | 52·734 | 1·55 | 9¼ | 85·562 | 3.041 | 791.453 | 2·09 |
| 1 | 1 | 1·000 | 1 | 1 | 3⅞ | 15·015 | 1·968 | 58·185 | 1·57 | 9½ | 90.25 | 3.082 | 857.375 | 2·11 |
| 1⅛ | 1.265 | 1·060 | 1.423 | 1.04 | 4 | 16 | 2 | 64 | 1.58 | 9¾ | 95·062 | 3.122 | 926.859 | 2·13 |
| 1¼ | 1.562 | 1·118 | 1.953 | 1.07 | 4¼ | 18·062 | 2.061 | 76·765 | 1·61 | 10 | 100 | 3.162 | 1000 | 2·15 |
| 1⅜ | 1·890 | 1·172 | 2.599 | 1.11 | 4½ | 20·250 | 2 121 | 91·125 | 1·65 | 10¼ | 105 062 | 3.201 | 1076.89 | 2·17 |
| 1½ | 2.250 | 1·224 | 3.375 | 1.14 | 4¾ | 22.562 | 2.179 | 107·171 | 1·68 | 10½ | 110.250 | 3·240 | 1157.625 | 2·18 |
| 1⅝ | 2.610 | 1·274 | 4.291 | 1.17 | 5 | 25 | 2.236 | 125 | 1·71 | 10¾ | 115 562 | 3·278 | 1242.296 | 2·20 |
| 1¾ | 3·062 | 1·322 | 5.359 | 1.20 | 5¼ | 27.562 | 2.291 | 144·703 | 1·73 | 11 | 121 | 3·316 | 1331 | 2·22 |
| 1⅞ | 3.515 | 1·369 | 6.591 | 1.23 | 5½ | 30·250 | 2.345 | 166·375 | 1·76 | 11¼ | 126·562 | 3·354 | 1423.828 | 2·24 |
| 2 | 4 | 1·414 | s | 1·25 | 5¾ | 33.062 | 2·397 | 190·109 | 1·79 | 11½ | 132·250 | 3·391 | 1520.875 | 2·25 |
| 2⅛ | 4.515 | 1·457 | 9.595 | 1·28 | 6 | 36 | 2·449 | 216 | 1·81 | 11¾ | 138·062 | 3.427 | 1622.234 | 2·27 |
| 3¼ | 5·062 | 1·500 | 11.390 | 1·30 | 6¼ | 39.062 | 2·500 | 244·140 | 1·84 | 12 | 144 | 3·464 | 1728 | 2·28 |
| 2⅜ | 5·640 | 1·541 | 13.396 | 1·33 | 6½ | 42·250 | 2·549 | 274·625 | 1·86 | | | | | |
| 2½ | 6·250 | 1·581 | 15.625 | 1.35 | 6¾ | 45·563 | 2·598 | 307·546 | 1·88 | | | | | |
| 2⅝ | 6·890 | 1·620 | 18.087 | 1·37 | 7 | 49 | 2 645 | 343 | 1·91 | | | | | |
| 2¾ | 7·562 | 1.658 | 20·796 | 1·40 | 7¼ | 52·562 | 2·692 | 381·078 | 1·93 | | | | | |
| 2⅞ | 8·265 | 1·695 | 23·763 | 1·42 | 7½ | 56·250 | 2·738 | 421·875 | 1·95 | | | | | |

## PROPORTIONS OF SOLIDS AND VOIDS IN VARIOUS COARSE MATERIALS.

| Aggregates. | Solids | Voids. |
|---|---|---|
| Sand moist, fine, passing 18-mesh sieve (i.e. 324 meshes to the sq. in.) | ·57 | ·43 |
| Sand moist, coarse, not passing 18-mesh sieve. .. .. .. | ·65 | ·35 |
| Sand moist, coarse and fine mixed, ordinary .. .. .. | ·62 | ·38 |
| Stone Screenings and stone dust .. .. .. .. .. | ·58 | ·42 |
| Sand dry, coarse and fine mixed. .. .. .. .. .. | ·70 | ·30 |
| Ballast, ¾ in. and under, 6 per cent. Coarse sand.. .. .. | ·67 | ·33 |
| Broken Stone, 1 inch and under .. .. .. .. .. | ·54 | ·46 |
| Broken Stone 2½ inch and under, dust only Screened out .. | ·59 | ·41 |
| Broken Stone, 2 inch and under, most small stone Screened out. | ·55 | ·45 |

## Mortars Produced with ordinary.

( Fine and Coarse Mixed) Sand.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Parts of Sand mixed with 1 part of cement. .. | 1.0 | 1.15 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 5.0 |
| Volume of Slush mortar .. | 1.4 | 1.78 | 2.17 | 2.55 | 2.98 | 3.39 | 3.82 | 4.65 |
| Volume of dry facing mortar rammed .. .. .. | 1.22 | 1.57 | 1.93 | 2.28 | 2.64 | 2.99 | 3.35 | 4.08 |

## MATERIALS REQUIRED FOR FLOORS, PER SQUARE YARD.

| Proportions. | Materials. | 4 in thick | 4½ in thick | 5 in thick | 5½in thick | 6 in thick | 6½in thick | 7 in thick | 7½ in thick | 8 in thick | 8½ in thick | 9 in thick | 9½ in thick | 10 in thick | 11 in thick | 12 in thick |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 : 2 : 4 | *Cement lb. | 59.3 | 66.75 | 74.16 | 31.58 | 89 | 96.42 | 103.83 | 111.25 | 118.66 | 126.08 | 133.5 | 140.92 | 148.33 | 163.16 | 178 |
| | Sand cu. ft. | 1.32 | 1.485 | 1.65 | 1.82 | 1.93 | 2.15 | 2.31 | 2.48 | 2.64 | 2.81 | 2.97 | 3.14 | 3.3 | 3.63 | 3.96 |
| | Coarse matl cu. ft. | 2.64 | 2.97 | 3.3 | 3.63 | 3.96 | 4.29 | 4.62 | 4.95 | 5.28 | 5.61 | 5.94 | 6.27 | 6.6 | 7.26 | 7.92 |
| 1 : 2½ : 5 | *Cement lb. | 48.9 | 55 | 61.1 | 67.2 | 73.3 | 79.4 | 85.5 | 91.6 | 97.7 | 103.8 | 110 | 116.1 | 122,2 | 134.4 | 146.6 |
| | Sand cu. ft. | 1.35 | 1.52 | 1.69 | 1.86 | 2.03 | 2.19 | 2.36 | 2.53 | 2.7 | 2.87 | 3.04 | 3.21 | 3.38 | 3.71 | 4.05 |
| | Coarse matl cu. ft. | 2.7 | 3.04 | 3.38 | 3.72 | 4.05 | 4.39 | 4.73 | 5.06 | 5.4 | 5.74 | 6.08 | 6.41 | 6.75 | 7.43 | 8.1 |
| 1 : 3 : 6 | *Cement lb. | 41.5 | 46.69 | 51.88 | 57.07 | 62.25 | 67.44 | 72.63 | 77.82 | 83 | 88.19 | 93.38 | 98.57 | 103.76 | 144.14 | 124.5 |
| | Sand cu. ft. | 1.43 | 1.62 | 1.79 | 1.97 | 2.15 | 2.33 | 2.51 | 2.69 | 2.87 | 31.5 | 3.23 | 3.41 | 3.58 | 3.95 | 4.3 |
| | Coarre matl cu. ft. | 2.86 | 3.23 | 3.58 | 3.94 | 4.3 | 4.66 | 5.02 | 5.38 | 5.74 | 60. | 6.46 | 6.82 | 7.16 | 7.9 | 8.6 |

*Based on loose cement weighing 90 lb. per cu. ft.

## MATERIALS FOR 1 CU. YD. OF CONCRETE.

Based on loose cement weighing 90 lb. per cu. ft. and a cu. ft. of loose, moist, coarse sand weighing 89 lb. when dry.

| Proportions. | Coarse Material. | Lb. Portland Cement in 1 cu. yd. | Sand cu. yds. in 1 cu. yd. | Coarse Material cu. yds. in 1 cu. yd |
|---|---|---|---|---|
| 1 : 1 : 2 | Shingle (40 per cent. voids) .. .. .. .. | 869 | .36 | .71 |
| Do. | Broken stone (45 per cent. voids) .. .. | 902 | .37 | .74 |
| 1 : 1½ : 3 | Shingle .. .. .. .. .. .. | 666 | .41 | .82 |
| Do. | Broken stone (45 per cent. voids) .. .. | 697 | .43 | .86 |
| 1 : 1⅔ : 3⅓ | Shingle .. .. .. .. .. .. | 610 | .42 | .84 |
| Do. | Broken stone.. .. .. .. .. | 640 | .44 | .88 |
| 1 : 2 : 4 | Shingle .. .. .. .. .. .. | 520 | .43 | .86 |
| Do. | Broken stone.. .. .. .. .. | 548 | .45 | .90 |
| 1 : 2½ : 5 | Shingle .. .. .. .. .. .. | 430 | .44 | .88 |
| Do. | Broken stone.. .. .. .. .. | 450 | .46 | .92 |
| 1 : 3 : 6 | Shingle .. .. .. .. .. .. | 364 | .45 | .90 |
| Do. | Broken stone.. .. .. .. .. | 383 | .47 | .94 |
| 1 : 4 : 8 | Shingle .. .. .. .. .. .. | 280 | .46 | .92 |
| Do. | Broken stone.. .. .. .. .. | 294 | .48 | .97 |

## Materials used in Textile Machinery Construction.

*Cast Iron*—Used for machine framings, roller beams, roller Stands,

*Cast' Iron*—Used for machine framings, roller beams, roller Stands, bearing pedestals, levers, etc.

*Wrought Iron*—Used for nuts, bolts, washers.

*Mild Steel*—Used in place of wrought iron wherever possible.

*Mild Steel*—Used for shafts, top and bottom rollers, Spindles, flyers, and pressers, and generally where the material has to withstand a torsional stress.

*Malleable Iron*—(castings which are placed in powdered red hoematite, and kept at a bright red heat for varying periods of time according to size of casting). Used for tin roller blocks, knee brakes for ring frame Spindles.

*Tin* (*Alloy*)—Used for ring frame tin rollers for fly frames and ring-frames, pneumatic conveyer pipes for blowing rooms, sliver plates, etc.

*Brass*—Used for roller footsteps, Spindle footsteps and bolsters, bushes for bearings, etc.

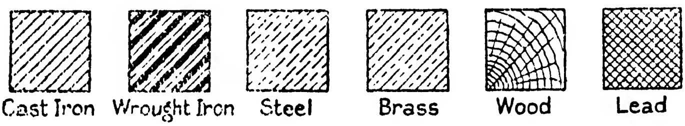
*Sheet Steel*—Used for fly frame casing plates, and machine guards, etc.

*Leather*—Used for lap building motions on openers, belting, etc.

*Wood*—is used for various parts of textile machinery, such as creels for flyer and ring frames, bobbins and skewers, etc.

*Alloys*—An alloy is produced by melting two or more metals together. Copper, tin, zinc, and lead are the principal metals used in the manufacture of alloys. The best known alloy is brass.

SECTIONAL SHADING FOR VARIOUS MATERIALS.




The ingredients of a few well-known alloys are given below :—

*Alluminium Bronze.*

| | |
|---|---|
| Copper .. .. .. .. | 9 parts. |
| Aluminium .. .. .. | 1 part. |

*Bell-Metal.*

| | |
|---|---|
| Copper .. .. .. .. | 3 to 5 parts. |
| Tin .. .. .. .. | 1 part. |

*Brass.*

| | |
|---|---|
| Copper .. .. .. .. | 7 parts. |
| Zinc .. .. .. .. | 3 parts. |

*Bronze.*

| | |
|---|---|
| Copper .. .. .. .. | 90 parts. |
| Tin .. .. .. .. | 6 ,, |
| Lead .. .. .. .. | 1 ,, |

*Gun Metal.*

| | |
|---|---|
| Copper .. .. .. .. | 9 parts. |
| Tin .. .. .. .. | 1 „ |
| Zinc .. .. .. .. | Trace. |

*German Silver.*

| | |
|---|---|
| Copper .. .. .. .. | 23 parts. |
| Nickel .. .. .. .. | 17 „ |
| Zinc .. .. .. .. | 10 „ |

---

## Soft Solder

An excellent soft solder suitable for copper, brass, and bronze is obtained by melting together :—

| | |
|---|---|
| Tin .. .. .. .. | 2 parts. |
| Lead .. .. .. .. | 1 „ |
| Bismuth .. .. .. .. | 1 „ |

*Red Paint.*

| | |
|---|---|
| Red lead (dry) .. .. .. | 25 lbs. |
| Linseed oil .. .. .. | 1 gallon. |

Mix thoroughly and strain. To hasten the drying add 1 gill of good Japan driers.

*White Paint.*

| | |
|---|---|
| White lead in oil .. .. | 7 lbs. |
| Zinc white in oil .. .. | 7 „ |
| Linseed oil (raw) .. .. | 1 quart. |
| Turpentine .. .. .. | 1 „ |
| Japan driers .. .. .. | 1 gill. |

This paint dries with an egg-shell gloss.

**Table shewing pressures of water in pounds per sq. inch. for every foot in height up to 100 feet.**

| Height in Feeit. | Pressure in pounds per sq. inch. | Height in Feet. | Pressure in pounds per sq. inch. | Height in Feet. | Pressure in pounds per sq. inch. | Height in Feet. | Pressure in pounds per sq. inch. | Height in Feet. | Pressure in pounds per sq. inch. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | .43 | 21 | 9.09 | 41 | 17.75 | 61 | 26.42 | 81 | 35.08 |
| 2 | .86 | 22 | 9.53 | 42 | 18.19 | 62 | 26.85 | 82 | 35.52 |
| 3 | 1.30 | 23 | 9.96 | 43 | 18.62 | 63 | 27.29 | 83 | 35.95 |
| 4 | 1.73 | 24 | 10.39 | 44 | 19.05 | 64 | 27.72 | 84 | 36.39 |
| 5 | 2.16 | 25 | 10.82 | 45 | 19.49 | 65 | 28.15 | 85 | 36.82 |
| 6 | 2.59 | 26 | 11.26 | 46 | 19.92 | 66 | 28.58 | 86 | 37.25 |
| 7 | 3.03 | 27 | 11.69 | 47 | 20.35 | 67 | 29.02 | 87 | 37.68 |
| 8 | 3.46 | 28 | 12.12 | 48 | 20.79 | 68 | 29.45 | 88 | 38.12 |
| 9 | 3.89 | 29 | 12.55 | 49 | 21.22 | 69 | 29.88 | 89 | 38.55 |
| 10 | 4.33 | 30 | 12.99 | 50 | 21.65 | 70 | 30.32 | 90 | 38.98 |
| 11 | 4.76 | 31 | 13.42 | 51 | 22.09 | 71 | 30.73 | 91 | 39.42 |
| 12 | 5.20 | 32 | 13.86 | 52 | 22.52 | 72 | 31.18 | 92 | 39.85 |
| 13 | 5.63 | 33 | 14.29 | 53 | 22.95 | 73 | 31.62 | 93 | 40.28 |
| 14 | 6.06 | 34 | 14.72 | 54 | 23.39 | 74 | 32.05 | 94 | 40.72 |
| 15 | 6.49 | 35 | 15.16 | 55 | 23.82 | 75 | 32.48 | 95 | 41.15 |
| 16 | 6.93 | 36 | 15.59 | 56 | 24.26 | 76 | 32.92 | 96 | 41.58 |
| 17 | 7.36 | 37 | 16.02 | 57 | 24.69 | 77 | 33.35 | 97 | 42.01 |
| 18 | 7.79 | 38 | 16.45 | 58 | 25.12 | 78 | 33.78 | 98 | 42.45 |
| 19 | 8.22 | 39 | 16.89 | 59 | 25.55 | 79 | 34.21 | 99 | 42.88 |
| 20 | 8.66 | 40 | 17.32 | 60 | 25.99 | 80 | 34.65 | 100 | 43.31 |

NOTE :—In applying this table the height of the highest Sprinkler above the pressure gauge must be ascertained and the pressure to be allowed for such height will be obtained by reference to the table; for example; if the gauge records a pressure of 60 lbs., and the highest sprinkler is 67 feet above the gauge, there will be a pressure of say 31 lbs. on the highest sprinkler.

## Pulley Diameters for Horse power Ratings.

The normal ratings in the table are based on the use of pulleys no smaller than the following :—

| Horse power | Min. Diam. Pulley. |
|---|---|
| 10 | 6″ |
| 20 | 8″ |
| 30 | 10″ |
| 40 | 11″ |
| 50 | 13″ |
| 75 | 16″ |
| 100 | 18″ |
| 150 | 21″ |
| 200 | 24″ |
| 250 | 27″ |
| 300 | 30″ |

## Horse Power of Gearing.

For every 100 feet Velocity per minute.

| Breadth. | Pitch. | Spur. | Bevel. |
|---|---|---|---|
| | | H.P. | H.P. |
| 4 | $1\frac{1}{2}$ | $1\frac{1}{4}$ | 1 |
| 5 | $1\frac{3}{4}$ | 2 | $1\frac{1}{2}$ |
| 6 | 2 | $3\frac{1}{2}$ | $2\frac{1}{2}$ |
| 7 | $2\frac{1}{4}$ | $4\frac{1}{2}$ | $3\frac{1}{2}$ |
| 8 | $2\frac{1}{2}$ | $6\frac{1}{2}$ | 5 |
| 9 | $2\frac{3}{4}$ | 9 | $6\frac{1}{2}$ |
| 10 | 3 | $11\frac{1}{2}$ | 9 |
| 11 | $3\frac{1}{4}$ | 15 | 12 |
| 12 | $3\frac{1}{2}$ | 20 | 15 |

Mortice wheels transmit about 25 per cent less; helical wheels about 25 per cent more power than above.

## Horse Power of Shafting.

| Dia. of Shaft in inches. | Horse power for every ten revolutions. Iron. | Horse power for every ten revolutions. Steel. | Distan. of bearings apart in feet. |
|---|---|---|---|
| $1\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{5}{8}$ | 5 |
| $1\frac{3}{4}$ | $\frac{3}{4}$ | 1 | 6 |
| 2 | $1\frac{1}{2}$ | $1\frac{1}{2}$ | 7 |
| $2\frac{1}{4}$ | $1\frac{1}{2}$ | $1\frac{7}{8}$ | 8 |
| $2\frac{1}{2}$ | 2 | $2\frac{1}{2}$ | 9 |
| $2\frac{3}{4}$ | $2\frac{1}{2}$ | $3\frac{1}{8}$ | $9\frac{1}{2}$ |
| 3 | 3 | $3\frac{3}{4}$ | 10 |
| $3\frac{1}{2}$ | 5 | $6\frac{1}{4}$ | $10\frac{1}{4}$ |
| 4 | 8 | 10 | 11 |
| $4\frac{1}{2}$ | 11 | $13\frac{3}{4}$ | 12 |
| 5 | 15 | $18\frac{3}{4}$ | 13 |
| $5\frac{1}{2}$ | 20 | 25 | 14 |
| 6 | 27 | $31\frac{3}{4}$ | 15 |

## Engine Department.*

| Type and Class of Engine. | No. | Date. | Maker. | I.H.P. | Remarks. |
|---|---|---|---|---|---|
| Horizontal Steam Engine with Cross compound condensing Corliss Valve | 1 | 1922 | Yates & Thom. | 1500 | |
| Donkey Pump .. .. | 1 | | | | Size according to requirement. |
| Drosophores Pump .. .. | 1 | | | | |
| Welding Plant .. .. | 1 | | | | |

| | |
|---|---|
| Revolution of Engine | =70 per minute. |
| Fly Wheel | =20 feet Dia. |
| Circumferential Speed | =4396 ft. per min. |
| 2nd Motion Wheel | =5 ft. 6 in. |
| Speed of 2nd Motion Shaft | =254. |

## Boilers.*

| Description of Boiler. | No. | Pressure per sq. in. | Remarks |
|---|---|---|---|
| Lancashire Boilers .. .. | 4 | 180 lbs. | Equipped with superheater. |
| Economisers .. .. .. | 288 tubes. | | |

## Hands Employed.

| Description. | No. | Amount. Rs. | Per | |
|---|---|---|---|---|
| Engine Driver .. .. .. .. | 1 | 55 | Month. | |
| Head Oiler .. .. .. .. | 1 | 27 | ,, | |
| Engine Oiler .. .. .. .. | 1 | 20 | ,, | |
| ,, ,, .. .. .. .. | 1 | 15 | ,, | |
| ,, Cleaner .. .. .. .. | 1 | 15 | ,, | |
| Oiler for calendering machine .. .. | 1 | 15 | ,, | |
| Rope Splicer .. .. .. .. | 1 | 28 | ,, | |
| Firemen .. .. .. .. .. | 4 | 20 | ,, | each. |
| Boiler Cleaners .. .. .. .. | 4 | 15 | ,, | ,, |
| Coalmen .. .. .. .. .. | 6 | 15 | ,, | ,, |

* Particulars given here are by way of a guide only.

**Mechanic Department.**

| Kind of Machine. | No. | Date. | Maker. | Size. | | Size of Table. | Remarks. |
|---|---|---|---|---|---|---|---|
| | | | | Length | Centre | | |
| Gap Lathe | 1 | 1941 | | 22′ | 22″ | | |
| ,, ,, | 1 | ,, | | 13′ | 20″ | | |
| ,, ,, | 1 | ,, | | 8′ | 16″ | | |
| Shaping Machine | 1 | ,, | | | | 3′ | |
| Plaining ,, | 1 | ,, | | | | 4′ | |
| Drilling ,, | 1 | ,, | | | | 30″ | |
| Cutting and Dividing Machine | 1 | ,, | | | | | |
| Wheel cutting (small) | 1 | ,, | | | | | |
| Milling Machine | 1 | ,, | | | | 3′×2″ | |
| Screwing ,, | 1 | ,, | | | | | |
| Hack Saw ,, | 1 | ,, | | | | 18″ | Blade |
| Saw Bench | 1 | ,, | | | | 22″ | |
| Emery grinders | 1 | ,, | | | | 16″ | Dia.×2″ thick. |
| Steam Hammer | 1 | ,, | | | | | |
| Coupolas | 2 | ,, | | | | | |
| Fans. | 2 | ,, | | | | | |

**Hands Employed.**

| Designation. | No. | Amount. Rs. | Per | |
|---|---|---|---|---|
| Head Fitter .. .. .. .. .. | 1 | 43 | Month. | |
| Workshop Mistry .. .. .. .. | 1 | 37 | ,, | |
| Fitters .. .. .. .. .. | 2 | 35 | ,, | each. |
| Do. .. .. .. .. .. | 2 | 30 | ,, | ,, |
| Turners .. .. .. .. .. | 2 | 40 | ,, | ,, |
| Bandanis or Khalasis .. .. .. | 3 | 18 | ,, | ,, |
| Fitter Coolie .. .. .. .. .. | 3 | 15 | ,, | ,, |
| Blacksmith .. .. .. .. .. | 1 | 24 | ,, | ,, |
| Hammerman .. .. .. .. .. | 1 | 18 | ,, | |
| Blacksmith Coolie .. .. .. .. | 2 | 15 | ,, | each. |
| Tinman .. .. .. .. .. | 1 | 30 | ,, | |
| Do. .. .. .. .. .. | 1 | 28 | ,, | |
| Do. Coolie .. .. .. .. | 1 | 11 | ,, | |
| Carpenters .. .. .. .. .. | 2 | 40 | ,, | each. |
| Do. .. .. .. .. .. | 2 | 30 | ,, | ,, |
| Do. Coolie .. .. .. .. | 1 | 15 | ,, | |
| Hoop Puncher .. .. .. .. | 1 | 15 | ,, | |
| Pump Cleaner .. .. .. .. | 1 | 15 | ,, | |
| Shafting Cleaner .. .. .. .. | 1 | 15 | ,, | |
| Humidifier Mistry .. .. .. .. | 1 | 25 | ,, | |
| Do. Coolie .. .. .. .. | 1 | 18 | ,, | |
| Do. do. .. .. .. .. | 1 | 16 | ,, | |
| Do. do. .. .. .. .. | 2 | 15 | ,, | each. |

## CONSUMPTION OF STORES.

| Description. | Quantity No. | Quantity Lbs. | Per | Remarks. |
|---|---|---|---|---|
| Heavy Engine Oil medium | | 10 | Month | |
| Dark Shafting Oil .. .. | | 372 | ,, | |
| Heavy Engine Oil .. .. | | 189 | ,, | |
| Cylinder Oil .. .. .. | | 205 | ,, | |
| Kerosine Oil .. .. .. | | 24 | ,, | |
| Linseed Oil .. .. .. | | 1 | ,, | |
| Spindle Oil .. .. .. | | 4 oz. | ,, | |
| Castor Oil .. .. .. | | 1 lb. | ,, | |
| Sulphuric Acid .. .. .. | | 27 | ,, | |
| Muriatic Acid .. .. .. | | 1 | ,, | |
| Asbestos Tape .. .. .. | | 1 | ,, | |
| Belting (all sizes) .. .. | | 17 ft. | ,, | |
| Lubricating Glass .. .. | 2 | | ,, | 4¼"×3½" |
| Asbestos Packing .. .. | | 2 lb. | ,, | |
| Diamond Packing.. .. .. | | 11 ,, | ,, | |
| Carbolic Powder .. .. .. | | 1 ,, | ,, | |
| Red C. Jointing .. .. .. | | 4 ,, | ,, | |
| Red Lead Powder .. .. | | 4 ,, | ,, | |
| Manila Rope .. .. .. | | 150 ,, | ,, | |
| Cotton Rope .. .. .. | | 8 ,, | ,, | |
| Rubber Ring .. .. .. | 5 | | ,, | |
| Do. Insertion .. .. .. | | 3 | ,, | ¾' |
| Do. Valve .. .. .. | 4 | | ,, | |
| Do. Sheet .. .. .. | | 10 | ,, | |
| Sand Paper .. .. .. | 2 | | ,, | |
| Soda Ash .. .. .. | | 52 | ,, | |
| Tin Sheets .. .. .. | 7 | | ,, | |
| Whiting Powder .. .. .. | | 1 | ,, | |
| Zinc .. .. .. | | 2 oz. | ,, | |
| Coal .. .. .. | | 350 | ,, | Tons. |
| Caustic Soda .. .. .. | | 2½ lbs. | ,, | |
| Castings .. .. .. | | 7 | ,, | cwt. |
| Copper Ingot .. .. .. | | 22 lbs. | ,, | |
| Block Tin .. .. .. | | 2½ | ,, | |
| White Metal .. .. .. | | 4 | ,, | |
| Bolts & Nuts .. .. .. | | 46 | ,, | |
| Brass Rod .. .. .. | | 4 | ,, | |
| Hard Coke .. .. .. | | 82 | ,, | |
| Hammer Handle .. .. .. | 1 | | ,, | |
| Hack Saw Blade .. .. .. | 6 | | ,, | 12"×14" |
| Lead .. .. .. .. | | 8 ozs. | ,, | |
| Hinges .. .. .. .. | 11 | | ,, | |
| Pump Hide .. .. .. | | 2 ,, | ,, | |
| Wire .. .. .. .. | | 2 lb. | ,, | All sizes. |
| Steel Bar .. .. .. | | 7 ,, | ,, | |
| Wood Screws .. .. .. | 7 doz. | | ,, | All sizes. |
| Set Screws .. .. .. | 3 doz. | | ,, | |
| Washers .. .. .. | | 5 ,, | ,, | |
| Wire Nails .. .. .. | | 2 ,, | ,, | |
| Wire Netting .. .. .. | 38 sq. ins. | | ,, | |
| Broom Sticks .. .. .. | | 5 lb. | ,, | |
| Emery Cloth .. .. .. | 24 | | ,, | |
| Coal Basket .. .. .. | 1 | | ,, | |
| Exol Grease .. .. .. | | 4 lb. | ,, | |
| Files .. .. .. .. | 3 | | ,, | All sizes. |
| Firing Shovel .. .. .. | 2 | | ,, | |
| Gauge Glass .. .. .. | 3 | | ,, | 18½"×3¼" |
| Black Lead .. .. .. | | 12 oz. | ,, | |
| Grease Lubricator .. .. | | 10 lbs. | ,, | |
| Belt Fastener .. .. .. | 1 | | ,, | |
| Bath Brick .. .. .. | 3 | | ,, | |
| Salamoniac .. .. .. | | 2 'bs. | ,, | |

**Electric Department.**

| Description. | No. | Volts. | Amp | Remarks. |
|---|---|---|---|---|
| A. C. Dynamo .. | 1 | 430 | 66 | With an exiter of 110 volts, switch-boards, resistances meters etc. Complete with main going in various Depts to transformers lowering the current to 25 volts. |
| A. C. Dynamo .. | 1 | 110 | 60 | With resistances, switch-boards, etc. complete with mains going to the sizing, folding Depts, and wett room for day lighting and also two mains going to all the Depts. for working a pilot light when necessary. |
| Electric Wiring.. | | | | A complete system of Electric wiring from ten transformers of 430 to 25 Volts in different Depts., to over all the machines where necessary. |

## Lighting.

The importance of light in industry after daylight has ceased to operate is recognised to-day more than it has ever been. At the same time there is a good deal of misconception prevailing as to just what are the fundamentals of good artificial lighting in industry. Whatever kind of lighting is chosen for industrial premises there are certain standards at which it is necessary to aim. The lighting must be planned, no matter whether it is daylight or artificial, to increase production, to avoid waste and mistakes, to cut down accidents to the minimum, and to promote the comfort and well-being of work people. Light stimulates the eye and gives a sense of vision, which is essential to the accuracy demanded in industrial operations. The iris of the eye contracts or opens relative to the amount of light present. The Speed of seeing is regulated by the illumination.

In designing a lighting scheme for any Indian mills there are two limiting factors to be considered. First, the total lighting load must not exceed a given maximum, and secondly, the foot—candle intensity must not be high.

India has not received the same education in better lighting as has Europe or America.

The bulk of machinery in a cotton mill is small and the roof is supported on iron columns which, following standard practice, are spread 22ft. by 11 ft. apart; floor to ceiling height is 14 ft.

Moderately good lighting is required in the weaving shed to enable the weavers to observe the broken threads.

In general, a system of general lighting is suitable, such as 100, 200, and 300 watt. lamps with dispersive type reflectors, and 40 watt. lamps with extensive type reflectors for local lighting.

The intensities vary between 2 and 4 foot-candles with an average of 2.8 foot-candles.

The total flux emitted from a uniform light source one—candle is 12.57 lumens. One lumen will light a surface of one square foot to an average illumination of one foot-candle. Regular cleaning of lamps and fittings is essential.

The following example is given to show the actual savings affected by changing over from 16 c.p. of 25 watt. to 200 c.p. of 100 watts. of electric lights in a cotton weaving shed.

| No. of Bulbs. | Candle Power. | Watts. | Area. | Maximum Illuminations. | Remarks. |
|---|---|---|---|---|---|
| 166 | 16 | 25 | 5 ft.= 4 Looms | .05 | |
| 20 | 200 | 100 | 21 ft.=20 Looms. | .20 | |

166×25=4150
20×100=2000

2150 Dift: saving in Power Consumption.

## Essentials of Good Lighting.

In the spinning room as well as in the weaving shed, good illumination is of the first importance because it is in the former that the yarn is spun and in the latter, the cloth is actually made. The lighting of a new shed is comparatively simple, since it can be designed on scientific lines.

In connection with lighting the following points should be observed :—

(1) Give adequate illumination; poor lighting impedes production and causes eye trouble.

Every detail of the work must be plainly visible without the slightest need for the operator to strain or peer.

(2) Eliminate glare which is apt to rack the nerve of the operatives if it comes from badly placed light sources. This particular evil is extremely trying and is, no doubt, responsible for many faults in material to-gether with irreparable damage to the operatives' eyes.

To promote well—being among operatives, light must not only be sufficient–well directed and properly distributed but light of a nature which is cheerful, steady, and sufficiently diffused to enable the general surroundings to be seen without strain.

(3) Minimise shadows. Their presence may cause serious accident due to shadows being mistaken for solid objects and objects for shadows with disastrous results.

(4) Use quality lamps and fittings. The use of cheap lighting equipment is a false economy. Ultimately its effect will be shown in high maintenance costs.

The use of reliable lamps is strongly recomended. Any electric lamp is useless except as a converter of energy into light which is its sole function. Its quality, therefore, must be judged by the answer to the question "How much light will this lamp give me for a certain stated amount of electricity ? " The higher the quality of the lamp, the less current it will consume to provide the amount of light which is required.

A good lamp should not lose more than 10 per cent. of its light throughout its useful life. There are cheap lamps on the market which lose considerably more than this. It is thus possible to save a little on the initial cost of the lamp, but loss considerably due to a general reduction in the light available, which must in turn affect production. It will be clear, too, that only a fraction of one per cent. loss in production will be a much heavier loss, and cannot be compensated for by the Slight Saving in lamp renewals.

(5) Poor workmanship in the weaving shed results in more financial loss than in any other part of the mill. The illumination should be well balanced as to horizontal and vertical values, the horizontal illumination being requisite for cloth inspection and the vertical essential for such processes as the threading of a broken warp. In addition to the resulting effects of good lighting on

production, it must be remembered that the appearance of a shed has a direct reaction on operatives. Badly lit premises, abounding with glare and harsh shadow, invariably detract from a weaver's efficiency whilst a bright cheery atmosphere has a beneficial pychological effect. Better work less fatigue and depression and eyes troubles as experienced in those mills where executive are sufficiently alive to the advantages of the installation of modern lighting.

The following schedule gives the details of a light installation for a Spinning and weaving mills.

### Mixing and Blow Room.

Fittings of 100 C. P. should be so arranged in this department that a good general light is obtained at 7 ft. 6 in. from the floor level to the reflector.

### Carding Department.

100 C. P. fittings should be fixed to serve six carding machines, erected in alleys 7 ft. from floor level, or alternately 300 C.P. fittings to serve 10 carding machines.

### Drawing Frames.

Six 100 C. P. fittings 7 ft from the floor level serve two complete heads of drawings.

### Slubbing Frames.

Two 100 C. P. fittings, fixed about 15 ft. apart, serving to light up each frame (34 ft. long), are sufficient. These are fixed 7 ft. from the floor to the reflector.

### Intermediate Frames.

Three 100 C. P. fittings are fixed in each alley 7 ft. from the floor, length of frame =40 ft.

### Roving Frames.

These are served in the same manner as the previous frames.

### Ring Spinning Room.

It is usual to use three 100 C. P. fittings about 12ft. each way apart, 7 ft. high, and between the alleys where possible.

### Ring Doubling Frames.

It is usual to use two 100 C. P. fittings about 18ft. apart and staggered 7ft. high.

### Winding Room.

This department is served by 100 C. P. fittings, fixed about 10 ft. apart, directly over the centre of the frames.

### Warping Room.

100 C. P. fittings, fixed directly over the pins of each frame, and 100 C. P. fitting inside each 'V' creel.

### Sizing Room.

One, or sometimes two 100 C. P. fittings are fixed at head—stock of machine, and 100 C. P. fittings over centre at back of machine are all right. The number of fittings here, of course, varies with the number of warper's beams in use.

### Drawing Room.

Adjustable lever pendants, fitted with 100 C. P. inverted burners, are fixed. These are found very suitable for moving about to any desired position.

### Folding Department.

100 C. P. are fitted in this room over the tables, and one to each cloth machine, fixed about 7ft. 6in. from floor level.

### Calendering Department.

Two 100 C. P. are fitted in such a way so that the passage of the cloth is clearly seen both in front and behind the machine.

### Finishing Department.

Two or sometimes three 100 C. P. fittings are fixed both in front and at the back of the machine .

## CONVERSION TABLE.

**Consumption per B. H. P. to consumption per K. W. (Engine-driven Generators)**

| Per B.H.P. | .5 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Efficient % | | | | | | | | | | | | | | | | |
| 95 | .706 | 1.42 | 2.83 | 4.24 | 5.65 | 7.06 | 8.47 | 9.87 | 11.29 | 12.69 | 14.11 | 15.53 | 16.93 | 18.33 | 19.74 | 21.16 |
| 94 | .713 | 1.43 | 2.86 | 4.28 | 5.71 | 7.13 | 8.55 | 9.99 | 11.46 | 12.83 | 14.26 | 15.68 | 17.10 | 18.53 | 19.97 | 21.38 |
| 93 | .721 | 1.44 | 2.89 | 4.33 | 5.77 | 7.21 | 8.65 | 10.09 | 11.53 | 12.97 | 14.41 | 15.85 | 17.29 | 18.72 | 20.17 | 21.61 |
| 92 | .729 | 1.46 | 2.92 | 4.38 | 5.83 | 7.29 | 8.74 | 10.19 | 11.66 | 13.12 | 14.57 | 16.03 | 17.47 | 18.94 | 20.38 | 21.85 |
| 91 | .737 | 1.48 | 2.95 | 4 42 | 5.89 | 7.37 | 8.83 | 10.31 | 11.78 | 13.26 | 14.73 | 16.20 | 17.66 | 19.14 | 20.61 | 22.09 |
| 90 | .745 | 1.49 | 2.98 | 4.47 | 5.96 | 7'45 | 8.93 | 10.42 | 11.91 | 13.42 | 14.89 | 16.38 | 17.86 | 19.35 | 20.84 | 22.34 |
| 89 | .753 | 1.51 | 3.02 | 4.52 | 6.03 | 7.53 | 9.03 | 10.54 | 12.04 | 13.55 | 15.06 | 16.57 | 18.06 | 19.57 | 21.08 | 22.58 |
| 88 | .762 | 1.53 | 3.05 | 4.57 | 6.09 | 7.62 | 9.14 | 10.67 | 12.19 | 13.71 | 15.23 | 16.76 | 18.27 | 19.78 | 21.33 | 22.84 |
| 87 | .770 | 1.54 | 3.08 | 4.62 | 6.16 | 7.70 | 9.24 | 10.78 | 12.33 | 13.87 | 15.40 | 16.94 | 18.48 | 20.02 | 21.56 | 23.11 |
| 86 | .779 | 1.56 | 3.12 | 4.68 | 6.24 | 7.79 | 9.35 | 10.91 | 12.47 | 14.03 | 15.58 | 17.14 | 18.70 | 20.25 | 21.82 | 23.37 |
| 85 | .788 | 1.58 | 3.16 | 4.73 | 6.31 | 7.88 | 9.46 | 11.04 | 12.61 | 14.19 | 15.77 | 17.35 | 18.91 | 20.49 | 22.07 | 23.64 |
| 84 | .798 | 1.60 | 3.19 | 4.79 | 6.38 | 7.98 | 9.57 | 11.17 | 12.76 | 14.36 | 15.96 | 17.55 | 19.14 | 20.73 | 22.33 | 23.92 |
| 83 | .808 | 1.62 | 3.23 | 4.85 | 6.46 | 8.08 | 9.69 | 11.30 | 12.92 | 14.53 | 16.15 | 17.76 | 19.37 | 20.99 | 22.60 | 24.22 |
| 82 | .818 | 1.64 | 3.27 | 4.91 | 6.54 | 8.18 | 9.81 | 11.44 | 13.08 | 14.71 | 16.25 | 17.98 | 19.61 | 21.24 | 22.88 | 24.51 |
| 81 | .828 | 1.66 | 3.31 | 4.97 | 6.62 | 8.28 | 9.93 | 11.58 | 13.24 | 14.89 | 16.55 | 18.21 | 19.85 | 21.51 | 23.16 | 24.81 |
| 80 | .838 | 1.68 | 3.35 | 5.03 | 6.70 | 8.38 | 10.05 | 11.73 | 13.41 | 15.08 | 16.76 | 18.43 | 20.10 | 21.78 | 23.45 | 25.13 |

# COMPARISON TABLE FOR WIRES AND CABLES.

| NEW STANDARD. | | | Approx. Equivalents OLD STANDARD. | | MINIMUM WEIGHT OF CONDUCTOR. | | | MAX. RESISTANCE IN STANDARD OHMS, AT 60° F. | | | CARRYING CAP. IN AMPERES. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. & Diam. of Wire forming Conductor. | Nomial Area. Sq. In. | Nomial Area. Sq. M/m. | No. and Diam. of Wires forming Conductor. | Area in Sq. Ins. | Per Mile Lbs. | Per 1,000 yds. Lbs. | Per Kilometer Lbs. | Per Mile. | Per 1,000 Yds. | Per Kilometre | At 1,000 per Sq. In. | At I.E.E Stand. (V.I.R. Insul.) |
| 1/.036 | ·0010 | ·66 | 1/20 S.W.G. | ·0010 | 20·10 | 11·42 | 12·49 | 42·75 | 24·29 | 26·56 | 1 | 4·1 |
| 1/.044 | ·0015 | ·98 | 1/18 ,, | ·0018 | 30·03 | 17·06 | 18·66 | 28·62 | 16·26 | 17·78 | 1·5 | 6 1 |
| 3/.029 | ·0020 | 1·25 | 3/22 ,, | ·0018 | 40·32 | 22·91 | 25·05 | 22·18 | 12·61 | 13·79 | 2·0 | 7·8 |
| 3/.036 | ·0030 | 1·93 | 3/20 ,, | ·0030 | 62·13 | 35·30 | 38·61 | 14·40 | 8 180 | 1·946 | 3·0 | 12·0 |
| 1/.064 | ·0030 | 2·08 | 1/16 ,, | ·0032 | 63·52 | 36·09 | 39·47 | 13·53 | 7·687 | 8·407 | 3·0 | 12·9 |
| 7/.029 | .0045 | 2·93 | 7/22 ,, | ·0042 | 93·81 | 53·30 | 58·29 | 9·481 | 5·387 | 5·891 | 4·5 | 18·2 |
| 7/.036 | ·0070 | 4·52 | 7/20 ,, | ·0070 | 144·6 | 82·14 | 89·83 | 6·153 | 3·496 | 5·823 | 7·0 | 24·0 |
| 7/.044 | ·0100 | 6·75 | 7/18 ,, | ·0125 | 215·9 | 122·7 | 134·2 | 4.118 | 2 340 | 2·559 | 10·0 | 31·0 |
| 7/.052 | ·0145 | 9·43 | 7/17 ,, | ·0170 | 301·7 | 171·4 | 187·4 | 2·948 | 1·675 | 1·832 | 14·5 | 37·0 |
| 7/.064 | ·0225 | 14·3 | 7/16 ,, | ·0221 | 456·9 | 259·6 | 283·9 | 1.947 | 1·106 | 1·209 | 22·5 | 46·0 |
| 19/.052 | ·0100 | 25·5 | 19/17 ,, | ·0459 | 820·2 | 466·0 | 509·6 | 1·088 | ·6184 | ·6763 | 40·0 | 64·0 |
| 19/.064 | ·0600 | 38·7 | 19/16 ,, | ·0600 | 1242·0 | 705·9 | 772·0 | ·7148 | ·4082 | ·4464 | 60·0 | 83·0 |
| 19/.072 | ·0750 | 49·0 | 19/15 ,, | ·0750 | 1572·0 | 893·4 | 977·0 | ·5676 | ·3225 | ·3527 | 75·0 | 97·0 |
| 19/.083 | ·1000 | 65·1 | 19/16 ,, | ·0937 | 2089·0 | 1187·0 | 1298·0 | ·4271 | ·2427 | ·2654 | 100·0 | 118·0 |
| 37/.064 | ·1200 | 75·4 | 19/14 ,, | ·1168 | 2420·0 | 1375·0 | 1504·0 | ·3691 | ·2097 | ·2293 | 120·0 | 130·0 |
| 37/.072 | ·1500 | 95·4 | 37/16 ,, | ·1500 | 3064·0 | 1741·0 | 1904·0 | ·2916 | ·1657 | ·1812 | 150·0 | 152·0 |
| 37/.083 | ·2000 | 127·0 | 37/15 ,, | ·1820 | 4071·0 | 2313·0 | 2529·0 | ·2195 | ·1247 | ·1364 | 200·0 | 184·0 |
| 37/.093 | ·2500 | 159·0 | 37/14 ,, | ·2500 | 5111·0 | 2904·0 | 3176·0 | ·1748 | ·09933 | ·1086 | 250·0 | 214·0 |
| 37/.103 | ·3000 | 195·0 | 37/13 ,, | ·3000 | 6269·0 | 3562·0 | 3895·0 | ·1425 | ·08098 | ·0886 | 300·0 | 240·0 |
| 61/.093 | ·4000 | 262·0 | 37/12 ,, | ·4000 | 8429·0 | 4789·0 | 5237·0 | ·1061 | ·06026 | ·0659 | 400·0 | 288·0 |
| 61/.103 | ·5000 | 322·0 | 61/12 ,, | ·5000 | 10338·0 | 5874·0 | 6424·0 | .0865 | ·04913 | ·0537 | 500·0 | 332·2 |
| 91/.093 | ·6000 | 391·0 | 61/·112ins. | ·6000 | 12573·0 | 7144·0 | 7813·0 | ·0711 | ·04040 | ·0442 | 600·0 | 384·0 |
| 91/.103 | ·7500 | 480·0 | 91/·101 ,, | ·7500 | 15423·0 | 8763·0 | 9583·0 | ·0580 | ·03294 | ·0360 | 750·0 | 461·0 |
| 127/.103 | 1·0000 | 669·0 | 127/-101 ,, | 1·0000 | 21527·0 | 12231·0 | 13376·0 | ·0415 | ·02260 | ·0258 | 1000·0 | 595·0 |

## DIAMETERS OF COPPER, LEAD AND TIN WIRES WHICH ARE FUSED BY VARIOUS CURRENTS.

| Current in. Amps. | Copper | | Lead. | | Tin. | |
|---|---|---|---|---|---|---|
| | Diameter (in.) | Nearest (larger) S.W.G. | Diameter (in.) | Nearest (larger) S.W.G. | Diameter (in.) | Nearest (larger) S.W.G. |
| 1 | 0.0021 | 46 | 0.0081 | 35 | 0.0072 | 36 |
| 2 | 0.0034 | 43 | 0.0128 | 29 | 0.0113 | 31 |
| 3 | 0.0044 | 41 | 0.0168 | 26 | 0.0149 | 27 |
| 4 | 0.0053 | 38 | 0.0203 | 24 | 0.0181 | 25 |
| 5 | 0.0062 | 37 | 0.0236 | 23 | 0.0210 | 24 |
| 10 | 0.0098 | 33 | 0.0375 | 19 | 0.0334 | 20 |
| 15 | 0.0129 | 29 | 0.0491 | 17 | 0.0437 | 18 |
| 20 | 0.0156 | 27 | 0.0595 | 16 | 0.0529 | 17 |
| 25 | 0.0181 | 25 | 0.0690 | 15 | 0.0614 | 16 |
| 30 | 0.0205 | 24 | 0.0779 | 14 | 0.0694 | 15 |
| 35 | 0.0227 | 23 | 0.0864 | 13 | 0.0769 | 14 |
| 40 | 0.0248 | 22 | 0.0944 | 12 | 0.0840 | 13 |
| 45 | 0.0268 | 22 | 0.1021 | 12 | 0.0909 | 13 |
| 50 | 0.0288 | 21 | 0.1095 | 11 | 0.0975 | 12 |
| 60 | 0.0325 | 20 | 0.1237 | 10 | 0.1101 | 11 |
| 70 | 0.0360 | 20 | 0.1371 | 9 | 0.1220 | 10 |
| 80 | 0.0394 | 19 | 0.1499 | 8 | 0.1334 | 9 |
| 90 | 0.0426 | 18 | 0.1621 | 7 | 0.1443 | |
| 100 | 0.0457 | 18 | 0.1739 | 7 | 0.1548 | 8 |
| 120 | 0.0516 | 17 | 0.1964 | .. | 0.1748 | 7 |
| 140 | 0.0572 | 16 | 0.2176 | .. | 0.1937 | .. |
| 160 | 0.0625 | 16 | 0.2370 | .. | 0.2118 | .. |
| 180 | 0.6766 | 15 | 0.2573 | .. | 0.2291 | .. |
| 200 | 0.0725 | 14 | 0.2760 | .. | 0.2457 | .. |
| 225 | 0.0784 | 14 | 0.2986 | .. | 0.2658 | .. |
| 250 | 0.0841 | 13 | 0.3203 | .. | 0.2851 | .. |
| 275 | 0.0897 | 13 | 0.3413 | .. | 0.3038 | .. |
| 300 | 0.0950 | 12 | 0.3617 | .. | 0.3220 | .. |

## CAPACITY OF CONDUITS (Heavy Gauge)

For the Drawing-in of Conductors (250-volt grade).

FROM I. E. E. WIRING RULES.

| External Diameter of Conduit .. | $\frac{5}{8}''$ | $\frac{3}{4}''$ | $\frac{7}{8}''$ | $1''$ | $1\frac{1}{4}''$ | $1\frac{1}{2}''$ | $2''$ |
|---|---|---|---|---|---|---|---|
| Internal Diameter of Conduit .. | 0.497 in. | 0.606 in. | 0.731 in. | 0.856 in. | 1.106 in. | 1.34 in. | 1.816 in. |
| 1 Size of Conductor | Approximate Overall Diameter of Conductor | NUMBER OF CONDUCTORS | | | | | |
| | Inches. | | | | | | |
| 1/.044 | 0.179 | 4 | 5 | 6 | — | — | — |
| 3/.029 | 0.193 | 2 | 3 | 6 | 6 | — | — | — |
| 3/.036 | 0.215 | 2 | 3 | 4 | 6 | — | — | — |
| 7/.029 | 0.221 | — | 2 | 4 | 5 | — | — | — |
| 7/.036 | 0.294 | — | — | 2 | 4 | 6 | — | — |
| 7/.044 | 0.336 | — | — | 2 | 3 | 5 | — | — |
| 7/.064 | 0.394 | — | — | — | 2 | 3 | 4 | — |
| 19/.044 | 0.452 | — | — | — | — | — | 2 | 4 |
| 19/.064 | 0.548 | — | — | — | — | — | 2 | 3 |
| 19/.083 | 0.644 | — | — | — | — | — | 2 | 2 |

NOTE:—The external diameter is that by which the size of the conduit is known.

## BARE COPPER WIRES.

HARD DRAWN HIGH CONDUCTIVITY FOR ELECTRIC LIGHT AND POWER TRANSMISSION LINES, TELEPHONES, &c.

| Size. | Cur'nt at 1,000 Amperes per sq. in. | Diameter | | Sectional Area of Copper | | Approx Resistance. | | Approx. Weight. | | Size. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Inch | m/m. | Sq. in | Sq. m/m | Per 1,000 yards. | Per mile. | Per 1,000 yards. | Per mile. | |
| S.W.G. | | | | | | Ohms. | Ohms. | lbs. | lbs. | S.W.G. |
| 10 | 12.868 | .128 | 3.251 | .0129 | 8.303 | 1.868 | 3.288 | 148.8 | 261.9 | 10 |
| 8 | 20. | .160 | 4.064 | .0201 | 12.970 | 1.195 | 2.104 | 232.5 | 409.2 | 8 |
| 7 | 24. | .176 | 4.470 | .0243 | 15.700 | .9881 | 1.739 | 281.3 | 495.1 | 7 |
| 6 | 29. | .192 | 4.877 | .0290 | 18.68 | .8307 | 1.462 | 334.7 | 589.1 | 6 |
| 5 | 35. | .212 | 5.385 | .0353 | 22.77 | .6813 | 1.199 | 408.2 | 718.4 | 5 |
| 4 | 42. | .232 | 5.893 | .0423 | 27.27 | .5688 | 1.001 | 488.8 | 860.2 | 4 |
| 3 | 50. | .252 | 6.401 | .0499 | 32.18 | .4821 | .8484 | 576.7 | 1015 | 3 |
| 2 | 60. | .276 | 7.010 | .0598 | 38.6 | .4019 | .7073 | 692.0 | 1218 | 2 |
| 1 | 70. | .300 | 7.620 | .0707 | 45.6 | .3402 | .5987 | 817.6 | 1439 | 1 |
| 0 | 82. | .324 | 8.230 | .0824 | 53.19 | .2917 | .5133 | 953.4 | 1678 | 0 |
| 00 | 95. | .348 | 8.839 | .0051 | 61.36 | .2528 | .4450 | 1099.0 | 1835 | 00 |
| 000 | 108. | .372 | 9.449 | .1087 | 70.23 | .2212 | .3893 | 1257.0 | 2212 | 000 |
| 0000 | 125. | .400 | 10.160 | .1257 | 81.07 | .1913 | — | 1453.0 | — | 0000 |

## Comparison of Wire Gauges

| Size. | B W G | | | | | |
|---|---|---|---|---|---|---|
| | Diameter | | Area. | | Weight lbs. per 1000 ft. | Resist, Ohms per 1000ft. |
| | in. | mm | sq. in. | sq. mm | | |
| 0000 | 0.454 | 11.53 | 0.1618 | 104.44 | 623.92 | 0.050 |
| 000 | 0.425 | 10.80 | 0.1419 | 91.52 | 546.76 | 0.057 |
| 00 | 0.380 | 9.65 | 0.1134 | 73.165 | 437.10 | 0.071 |
| 0 | 0.340 | 8.64 | 0.0908 | 58.573 | 349.93 | 0.089 |
| 1 | 0.300 | 7.62 | 0.0707 | 45.60 | 272.43 | 0.115 |
| 2 | 0.284 | 7.21 | 0.0633 | 40.87 | 244.15 | 0.128 |
| 3 | 0.259 | 6.58 | 0.0527 | 33.99 | 203.06 | 0.154 |
| 4 | 0.238 | 6.05 | 0.0445 | 28.70 | 171.46 | 0.182 |
| 5 | 0.220 | 5.59 | 5.0380 | 24.52 | 146.51 | 0.213 |
| 6 | 0.203 | 5.16 | 0.0324 | 20.88 | 124.74 | 0.250 |
| 7 | 0.180 | 4.57 | 0.0254 | 16.42 | 98.08 | 0.319 |
| 8 | 0.165 | 4.19 | 0.0214 | 13.79 | 82.41 | 0.379 |
| 9 | 0.148 | 3.76 | 0.0172 | 11.10 | 66.30 | 0.471 |
| 10 | 0.134 | 3.40 | 0.0141 | 9.098 | 54.35 | 0.575 |
| 11 | 0.120 | 3.05 | 0.0113 | 7.296 | 43.59 | 0.717 |
| 12 | 0.109 | 2.77 | 0.0093 | 6.020 | 35.96 | 0.869 |
| 13 | 0.095 | 2.41 | 0.0071 | 4.573 | 27.32 | 1.144 |
| 14 | 0.083 | 2.11 | 0.0054 | 3.491 | 20.85 | 1.498 |
| 15 | 0.072 | 1.83 | 0.0041 | 2.486 | 15.69 | 1.991 |
| 16 | 0.065 | 1.65 | 0.0033 | 2.141 | 12.79 | 2.443 |
| 17 | 0.058 | 1.47 | 0.0026 | 1.704 | 10.18 | 3.069 |
| 18 | 0.019 | 1.24 | 0.0019 | 1.217 | 7.27 | 4.299 |
| 19 | 0.042 | 1.07 | 0.0014 | 0.894 | 5.34 | 5.852 |
| 20 | 0.035 | 0.89 | 0.0010 | 0.621 | 3.71 | 8.427 |
| 21 | 0.032 | 0.81 | 0.0008 | 0.519 | 3.10 | 10.081 |
| 22 | 0.028 | 0.71 | 0.0006 | 0.397 | 2.37 | 13.167 |
| 23 | 0.025 | 0.64 | 0.0005 | 0.317 | 1.89 | 16.517 |
| 24 | 0.022 | 0.56 | 0.0004 | 0.215 | 1.46 | 21.829 |
| 25 | 0.020 | 0.51 | 0.0003 | 0.203 | 1.21 | 25.808 |

## Comparison of Wire Gauges.

| Size | Continental | | | |
|---|---|---|---|---|
| | Diam. mm | Area. sq. mm | Weight kg 1000 m | Resist. Ohms 1000 m |
| 0000 | 19/2.85 | 120 | 1105 | 0.145 |
| 000 | 19/2.52 | 95 | 876 | 0.184 |
| 00 | 19/2.17 | 70 | 646 | 0.250 |
| 0, 1 | 7.98 | 50 | 445 | 0.349 |
| 2 | 6.68 | 35 | 311.5 | 0.499 |
| 3, 4 | 5.65 | 25 | 225.5 | 0.698 |
| 5, 6 | 4.52 | 16 | 142.4 | 1.090 |
| 7, 8 | 3.57 | 10 | 89.0 | 1.745 |
| 9, 10 | 2.77 | 6 | 53.4 | 2.91 |
| 11, 12 | 2.26 | 4 | 35.6 | 4.36 |
| 13, 14 | 1.79 | 2.5 | 22.25 | 6.98 |
| 15, 16 | 1.38 | 1.5 | 13.35 | 11.63 |
| 17, 18 | 1.13 | 1 | 8.90 | 17.45 |
| 19 | 1.00 | 0.75 | 6.68 | 23.26 |
| 20 | 0.80 | 0.5 | 4.45 | 34.90 |

## Tseful Cable Formule

To find the current to be transmitted.

Given the B. H. P. of a motor and efficiency :—

(1) Direct Current $C = \dfrac{746 \times \text{B.H.P.}}{\text{Volts} \times \text{Efficiency.}}$

(2) Single Phase $C = \dfrac{746 \times \text{B.H.P.}}{\text{Volts} \times \text{Efficy.} \times \text{Power Factor}}$

(3) Three Phase $C = \dfrac{746 \times \text{B.H.P.}}{\text{Volts} \times \text{Efficy.} \times \text{P.F.} \times 1.73}$

Given the power to be transmitted :—

(1) Direct Current $C = \dfrac{1000 \times K.W.}{Volts.}$

(2) Single Phase $C = \dfrac{1000 \times K.W.}{Volts \times P.F.}$ or $\dfrac{1000 \times K.V.A.}{Volts.}$

(3) Three—Phase $C = \dfrac{1000 \times K.W.}{Volts \times 1.73 \times P.F.}$ or $\dfrac{1000 \times K.V.A.}{Volts \times 1.73}$

*Note*—If the power factor is not given, take 0.8 for motor load

Volt Drop $= C \times R \times 2$

In a Three—Phase Circuit :—

Volt Drop $= C \times R \times 1.73$.

## USEFUL CABLE FORMULÆ

A=Area of cable in square inches.
B=B.H.P. of motor at end of line.
C=Current to be carried.
D=Distance one-way in yd.
E=Voltage at end of line.
F=Power Factor.
N=Efficiency of Motor.
V=Volts drop allowable in line.

| To find. | Given. | Formulæ |
|---|---|---|
| Area of cable=A | Current.<br>Volts drop in line.<br>Length of line. | $A = \dfrac{C \times 2D}{V \times 38.5 \times 1{,}000}$ |
| Area of cable =A | B. H. P. of motor (direct current).<br>Volts at Motor.<br>Volts drop in line.<br>Length of line.<br>Efficiency of motor. | $A = \dfrac{B \times D \times 1.5}{E \times V \times N \times 38.5}$ |
| Area of cable=A | B. H. P. of motor (three-phase.)<br>Volts at motor.<br>Volts drop in line.<br>Length of line.<br>Efficiency of motor.<br>Power-factor. | $A = \dfrac{B \times D \times .75}{E \times V \times N \times F \times 38.5}$ |
| Drop in volts=V | Area of cable.<br>Current.<br>Length of line. | $V = \dfrac{C \times 2D}{A \times 38.5 \times 1{,}000}$ |
| Amperes per phase in these-phase balanced system. | KW. in system.<br>Voltage.<br>Power-factor. | $\text{Amperes} = \dfrac{KW \times 1{,}000}{E \times F \times 1.73}$ |
| Total power in three-phase balanced system. | Amperes per phase.<br>Voltage.<br>Power factor. | $\text{Power} = \text{Amps} \times E \times F \times 1.73$ |
| Frequency=$f$. | Revolutions per minute-$r$.<br>Number of magnet poles-$m$ | $f = \dfrac{r \times m}{120}$ |
| Weight of copper Wire in lb. per yard .. .. W | Area of cable. | $W = A \times 11.56$ |

# APPROXIMATE CURRENT TAKEN BY MOTORS OF AVERAGE EFFICIENCY

| H. P. | Direct current | | | | | Single phase | | | | Two phase | | | | Three phase | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 110v. | 220v. | 440v. | 460v. | 500v. | 200v. | 346v. | 400v. | 500v. | 200v. | 346v. | 400v. | 500v. | 200v. | 346v. | 400v. | 500v. |
| | Amp. | Amp. | Amp. | Amp. | Amp. | Amp. | Amp. | Amp. | Amp. | Amp. | Amp. | Amp. | Amp. | Amp. | Amp. | Amp. | Amp. |
| 1 | 9 | 5 | 2 | 2 | 2 | 7 | 4 | 4 | 3 | 4 | 2 | 2 | 2 | 4 | 2 | 2 | 2 |
| 2 | 18 | 9 | 5 | 4 | 4 | 15 | 8 | 7 | 6 | 7 | 4 | 4 | 3 | 8 | 4 | 4 | 3 |
| 3 | 27 | 14 | 7 | 7 | 6 | 22 | 13 | 11 | 9 | 11 | 6 | 5 | 4 | 11 | 7 | 6 | 5 |
| 4 | 36 | 18 | 9 | 9 | 8 | 29 | 17 | 15 | 12 | 14 | 8 | 7 | 6 | 15 | 9 | 7 | 6 |
| 5 | 41 | 21 | 10 | 10 | 9 | 29 | 17 | 15 | 12 | 15 | 9 | 8 | 8 | 17 | 10 | 8 | 7 |
| 6 | 49 | 25 | 13 | 12 | 11 | 34 | 20 | 17 | 14 | 18 | 11 | 9 | 7 | 20 | 12 | 10 | 8 |
| 7½ | 62 | 30 | 16 | 15 | 14 | 43 | 25 | 22 | 17 | 23 | 13 | 11 | 9 | 25 | 14 | 13 | 10 |
| 10 | 79 | 40 | 20 | 19 | 18 | 55 | 32 | 28 | 22 | 64 | 37 | 32 | 11 | 30 | 17 | 15 | 10 |
| 12 | 95 | 48 | 24 | 23 | 21 | 62 | 38 | 33 | 27 | 27 | 16 | 14 | 18 | 36 | 21 | 18 | 15 |
| 15 | 119 | 59 | 30 | 29 | 26 | 82 | 48 | 41 | 33 | 33 | 19 | 16 | 16 | 57 | 33 | 28 | 18 |
| 20 | 154 | 77 | 39 | 37 | 34 | 107 | 62 | 54 | 43 | 41 | 24 | 21 | 21 | 45 | 26 | 23 | 23 |
| 25 | 193 | 97 | 48 | 46 | 43 | 134 | 78 | 67 | 54 | 51 | 30 | 26 | 26 | 71 | 41 | 35 | 28 |
| 30 | 231 | 116 | 58 | 56 | 51 | 161 | 93 | 80 | 64 | 77 | 45 | 38 | 31 | 85 | 49 | 42 | 34 |
| 35 | 270 | 135 | 68 | 65 | 60 | 187 | 108 | 94 | 75 | 89 | 52 | 45 | 36 | 99 | 57 | 49 | 40 |
| 40 | 308 | 154 | 77 | 74 | 68 | 214 | 124 | 107 | 86 | 102 | 59 | 51 | 41 | 113 | 65 | 57 | 45 |
| 45 | 553 | 277 | 138 | 132 | 122 | 241 | 139 | 121 | 97 | 115 | 67 | 58 | 46 | 127 | 73 | 64 | 51 |
| 50 | 590 | 295 | 148 | 141 | 130 | 265 | 153 | 132 | 106 | 118 | 68 | 59 | 47 | 130 | 75 | 65 | 52 |
| 60 | 664 | 332 | 166 | 159 | 146 | 317 | 184 | 159 | 127 | 141 | 82 | 71 | 57 | 156 | 90 | 78 | 63 |
| 70 | 737 | 369 | 184 | 176 | 162 | 370 | 214 | 185 | 148 | 165 | 96 | 83 | 66 | 182 | 105 | 91 | 73 |
| 75 | 347 | 174 | 87 | 88 | 77 | 392 | 227 | 196 | 157 | 175 | 101 | 88 | 70 | 198 | 112 | 97 | 77 |
| 80 | 377 | 189 | 94 | 90 | 83 | 471 | 242 | 209 | 167 | 186 | 108 | 93 | 75 | 206 | 119 | 103 | 83 |
| 90 | 452 | 226 | 113 | 108 | 100 | 418 | 272 | 235 | 188 | 210 | 121 | 105 | 84 | 232 | 134 | 116 | 93 |
| 100 | 527 | 264 | 132 | 126 | 116 | 523 | 302 | 262 | 200 | 233 | 135 | 117 | 93 | 258 | 149 | 129 | 103 |

## Chapter XIII.

# POWER DRIVERS FOR COTTON MILLS.

The various forms of 'drives' which are to-day considered standard drives for cotton mills, may be classified into three principal groups, namely: (I) belt and rope drives, (II) direct drives (prime movers coupled direct to a main line of shafting), (III) electric drives. Each of these has its advantages and its disadvantages.

## Belt Drives.

It is the usual practice to adopt belt drives for small powers, especially for individual drives from pulleys and line shafting to machines. To a limited extent this form of drive is also used as a link between reciprocating prime movers of small outputs and shafting, or machines, dynamos, etc, whilst with leather or cotton belts it is efficient and quite practicable to transmit powers up to some hundreds of horse-power, it has only rarely found favour with larger installations.

## Rope Drives.

This is the most favoured form of cotton mill drive. All the foregoing drives have the disadvantages of a loss of power between the prime mover and the driven pulley. This loss is expressed by the term "efficiency of the drive," and signifies, if expressed as percentage, the horse power available in the driven pulley for every hundred horse power produced by the engine. Thus, if a rope or belt efficiency of 95 per cent is obtained, the driven pulley transmits 95 b.h.p. to the shafting for every 100 b.h.p. of engine output. The difference between ropes and belts with regard to material and manufacture, as well as the great variation in driving arrangement rest, tension, atmospheric conditions, etc., make it impossible to lay down any hard and fast rule. The commercial efficiency for a well-designed, well-executed and well-kept rope or belt drive may be assumed to be 90 to 95 per cent.

## Direct Drives.

Economically, direct driving is to be preferred to any other. It obviates the disadvantages of belts and ropes and requires the least floor space.

## If Belt runs badly.

The alignment of pulleys and or shafting may be faulty. One or both of the pulleys may be badly balanced. If steam is coming irregulary to the engine, a wave motion will be imparted to the slack side of the belt. A heated bearing—the result of failure to lubricate—will have this effect. An overloaded belt will cause it to slide from side to side on the pulley.

## If Belt Slips.

Slip is evidenced by the pulley faces becoming polished. A few drops of leather dressing applied to the face of one of the pulleys or to the driving face of the belt by means of a rag will probably cure this, but if the belt is still found to slip it should be shortened. Slip may be due to the belt being overloaded. The belt may be too heavy for the small pulley. The pulley centres may be too short, belt contact with the pulleys being lost thereby. If a longer drive cannot be arranged, a Jockey pulley or Lennix Idler may be installed with advantage. The belt may be too narrow for their work. A broad thin belt is always preferable to a narrow thick belt.

## If Belt leaves the pulley.

It may be running at an excessively high speed. The alignment of the pulleys may be at fault. It may be overloaded.

## If Belt frays at the edges.

Flanged pulleys may be the cause. They serve no useful purpose and should be discarded. If the shifter is being forced over instead of being eased over it will not only fray the edges but buckle the belt. Use roller forks wherever possible. If metal fasteners are used to join a belt running on a fork drive, they will strike and barb the forks if they are too close to the edge of the belt. The forks in turn will fray and cut the belt edge.

## If Belt is out of condition.

In certain unventilated rooms in which large numbers of people work, all belts are apt to suffer from a chemical action caused by bad air. An occasional light application of leather dressing on outside of the belt will be found a good preservative.

## If Belt is tight.

A tight belt makes hot bearings, and requires more power to drive, and runs the machine no quicker. A large quantity of coal can be saved by running the belts at a right tension. Tight belts ruin the bearings, cost more to run, and do not increase production.

**Care of Belting.**—To accomplish the reduction of operating expense most effectively and simply, and to increase production, place the care of belting under one man, who, from practical experience, is thoroughly acquainted with its use.

## Facts Influencing the Efficiency of Drive.

The most efficient drive is obtained, of course, when (1) the pulleys are of equal diameter, (2) the distance between pulleys is liberal, so as to allow a fair amount of sag; and (3) the bottom side is the driving one. The larger the pulley diameter, the better for the belt—as the bending stresses in it are then less severe. As far as is practicable, use a diameter preferably not less than 35 to 40 times the belt thickness. That is, say as a minimum, 6 to 7 inches for a $\frac{3}{16}$ —inch belt.

All machines should be inspected and the conditions noted at regular intervals say weekly or fortnightly to find out whether (*a*) a belt is too greasy, (*b*) too dry, (*c*) too slack, or (*d*) if it is not running in the centre of the pulleys and is rubbing its edges on a part of the machine, or is in a condition to cause trouble in the near future. The necessary repairs ought to be made as soon as possible. By so doing the following advantages are to be gained.

(1) Increased production ;

(2) Lower belting cost ;

(3) Lower maintenance cost ;

(4) Lower manufacturing cost.

Belting cost is really an appreciable item in the overhead expenses of a mill, and to neglect them is to incur a two-fold loss—

(*a*) Waste of power due to the inefficiency of the belts,

(*b*) Increased cost occasioned by frequent belt renewals.

A belt if looked after well will last 12 years, on the other hand if neglected will be useless after 3 or 4 years' service, if not less than that.

The belt should never be cleaned with a piece of card clothing, as this affects the smooth surface of the belt and the grip upon the face of the loom pulley. It may be cleaned by the use of a fairly stiff bristled brush, or hard waste. To assist brushing if the belts are very dirty use paraffin or petrol. To soften belt rub occasionally the back of it with pure beaf tallow, mixed with castor oil in equal parts. Before applying the dressing the belt should be thoroughly cleaned with wet cloth. Resin should never be used.

While a belt should never be allowed to become dry, hard or too stiff the too liberal use of dressings shortens its life. Many so-called belt dressings on the present day market are in reality belt destroyers. The hair side of a belt should be put next to the pulley.

The following simple formula can be used for calculating the Horse Power Capacity of Leather Belting on normal drives.

## For Single Belting.

$$\frac{\text{width (thickness} \times 10) \times \text{speed, in ft. per min.}}{33000} = \text{H. P. transmitted.}$$

in m.m.

Thus a 4-in. wide belt 6 m.m. thick, travelling at 2500 ft. per min. would transmit.

$$\frac{4\ (6 \times 10)\ \times 2500}{33000} = \frac{60000}{33000} = 18 \text{ H. P.}$$

## For Double Belting.

Use the formula for the single ply (half thickness of the double belt) and multiply the result by 1.6.

## Belt conveyors, power required for.

$$\text{H.P.} = \frac{(0.15\ b + 0.07\ \text{W1})\ \text{V} + h\ \text{W2}}{33.000},$$

when

| | |
|---|---|
| $b$ | =Weight of belt. |
| H.P. | =Horse power required. |
| W1 | =Maximum weight of material on the belt at any one time. |
| W2 | =Weight of material delivered per minute. |
| V | =Speed of belt in feet per minute. |
| $h$ | =Height of elevation in feet. |

## Belt conveyors, power transmitted by.

$$H.P. = \frac{(T-t)\,v}{33{,}000},$$

when

| | |
|---|---|
| H.P. | =Horse power transmitted. |
| T | =Tension in pounds on pulling side. |
| $t$ | =Tension in pounds on slack side. |
| $v$ | =Speed of belt in feet per minute. |

To Find the Horse Power that a single belt will carry from one pully to another.

*Rule* :—Reduce the width of belt to inches and then multiply it by 45 and by the feet the belt travels per minute, and divide the quotient by 33000.

Width of Belt = 12″

Belt travels =1500 feet.

$$\frac{12 \times 45 \times 1500}{33000} = 24.54 \text{ Horse Power.}$$

To Find the Horse Power that a Double Belt will carry from one pulley to another.

*Rule* :—Reduce the width of belt to inches and then multiply it by 75 and by the feet the belt travels per minute, and divide the quotient by 33000.

Width of Belt =12″.

Belt travels =1500 feet.

$$\frac{12 \times 75 \times 1500}{33000} = 40.90 \text{ Horse Power.}$$

To Find a Single Belt required to give a certain Horse Power.

Horse Power required =27

Belt travels per minute =2000 feet.

$$\frac{27 \times 33000}{2000 \times 45} = \frac{99}{10} = 10\text{-inch single belt practically.}$$

Widths of Beltings pertaining to various Machinery.

1″ =Reeling and Weaving.

$1\frac{1}{2}$″ =Blow Room, Carding, Frame, Reeling, Weaving.

$1\frac{3}{4}$″ =Weaving.

2″ =Blow Room, Carding, Frame, Winding, Warping and Weaving.

$2\frac{1}{2}$″ =Frame, Mule.

3″ =Blow Room, Carding, Frame, Ring.

$3\frac{1}{2}$″ =Blow Room, Ring.

4″ =Blow Room, Sizing and Dyeing.

5″ =Blow Room, Mule, Winding and Sizing.

6″ =Engineering.

Diameters of Rope pertaining to various departments.

$1\frac{3}{4}$″——Engine——Rope ally.

$1\frac{1}{2}$″——Calendering department.

$1\frac{1}{4}$″——Pumps.

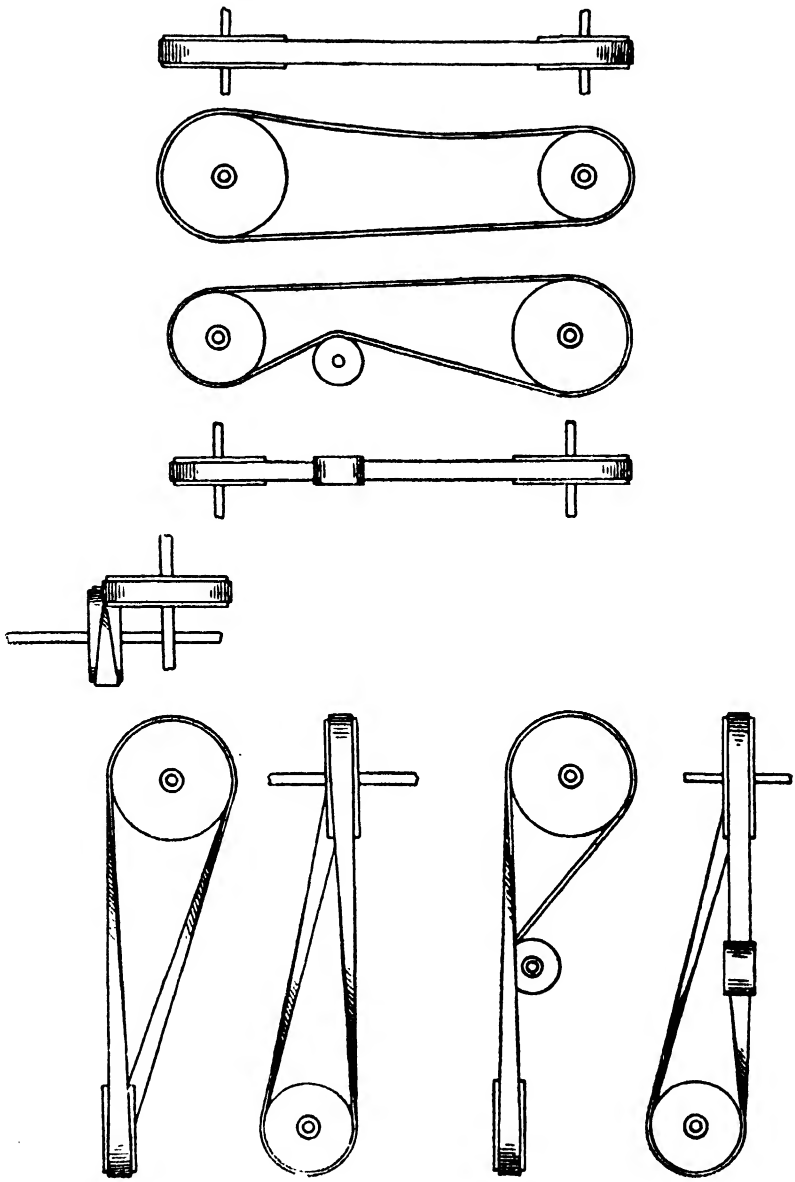
1″ ——Black Smith Shop.

$\frac{7}{8}$″, $\frac{3}{4}$″, $\frac{1}{2}$″—Mule.

$\frac{3}{8}$″ ——Blow Room.

5*16″——Card Room.

# Application of Belt Drives



## Approximate Horse Power transmitted by Leather Belts.

*Single Belting.*

| Speed in ft. per minute. | Width of Belt in Inches. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 |
| 1000 | 4 | 6 | 8 | 10 | 12 | 16 | 20 | 24 | 28 | 32 | 36 | 40 |
| 1200 | 4 | 7 | 9 | 12 | 14 | 19 | 24 | 28 | 33 | 38 | 43 | 48 |
| 1500 | 6 | 9 | 12 | 14 | 19 | 24 | 30 | 36 | 42 | 48 | 54 | 60 |
| 1800 | 7 | 10 | 14 | 18 | 21 | 28 | 36 | 43 | 50 | 57 | 64 | 72 |
| 2000 | 8 | 12 | 16 | 20 | 24 | 32 | 40 | 48 | 56 | 64 | 72 | 80 |
| 2400 | 9 | 14 | 19 | 24 | 28 | 38 | 48 | 57 | 67 | 76 | 86 | 96 |
| 2800 | 11 | 16 | 23 | 28 | 33 | 44 | 56 | 67 | 78 | 89 | 100 | 112 |
| 3000 | 12 | 18 | 24 | 30 | 36 | 48 | 60 | 72 | 84 | 96 | 108 | 120 |
| 3500 | 14 | 21 | 28 | 35 | 42 | 56 | 70 | 84 | 98 | 112 | 126 | 140 |
| 4000 | 16 | 24 | 32 | 40 | 40 | 64 | 80 | 96 | 112 | 122 | 144 | 160 |

*Double Belting.*

| Speed in ft. per minute. | Width of Belt in Inches. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 1000 | 10 | 16 | 21 | 26 | 32 | 37 | 42 | 48 | 53 | 58 | 64 |
| 1200 | 12 | 19 | 25 | 32 | 38 | 44 | 51 | 57 | 64 | 70 | 76 |
| 1500 | 16 | 24 | 32 | 40 | 48 | 56 | 64 | 72 | 80 | 87 | 95 |
| 1800 | 18 | 28 | 38 | 48 | 57 | 66 | 76 | 86 | 96 | 105 | 115 |
| 2000 | 21 | 32 | 42 | 53 | 64 | 74 | 85 | 96 | 106 | 117 | 128 |
| 2400 | 25 | 38 | 50 | 64 | 76 | 89 | 102 | 114 | 128 | 140 | 153 |
| 2800 | 29 | 44 | 58 | 74 | 89 | 103 | 119 | 133 | 149 | 163 | 178 |
| 3000 | 32 | 48 | 64 | 80 | 96 | 112 | 128 | 144 | 160 | 175 | 192 |
| 3500 | 37 | 56 | 74 | 93 | 112 | 130 | 149 | 168 | 186 | 204 | 224 |
| 4000 | 42 | 64 | 85 | 106 | 128 | 148 | 170 | 192 | 212 | 234 | 256 |

It must be understood the above tables of horse powers are submitted only in a general sense. They can be relied upon for favourable drives.

*Rope Driving.*

Tables of the horse power of transmission rope. The working strain is 800 lbs. for a 2-inch diameter rope and is the same at all speeds, due allowance having been made for loss by centrifugal force.

| Diam. Rope Inches. | Speed of the Rope in Feet per minute. | | | | | | | | | Smallest Diam. Pulley Inches |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1500 | 2,000 | 2,500 | 3,000 | 3,500 | 4,000 | 4,500 | 5,000 | 6,000 | 7,000 | |
| ¾ | 3·3 | 4·3 | 5·2 | 5·8 | 6·7 | 7·2 | 7·7 | 7·7 | 7·1 | 4·9 | 30 |
| ⅞ | 4·5 | 5·9 | 7·0 | 8·2 | 9·1 | 9·8 | 10.8 | 10.8 | 9·3 | 6.5 | 36 |
| 1 | 5·8 | 7·7 | 9·2 | 10.7 | 11.9 | 12.8 | 13.6 | 13.6 | 12.5 | 8.8 | 42 |
| 1¼ | 9.2 | 12.1 | 14·3 | 16.8 | 18.6 | 20.0 | 21.2 | 21.2 | 19.5 | 13·8 | 54 |
| 1½ | 13·1 | 17·4 | 20.7 | 23·1 | 26.8 | 28.8 | 30.6 | 30.8 | 28.2 | 19.8 | 60 |
| 1¾ | 18.0 | 23·7 | 28.2 | 32.8 | 36.4 | 39·2 | 41·5 | 41·8 | 37·4 | 27.6 | 72 |
| 2 | 23.1 | 30.8 | 36.8 | 42.8 | 47.6 | 51.2 | 54·4 | 54·8 | 50.0 | 35.2 | 84 |

## A Few Hints.

(1) Never use for driving purposes an ordinary 3 or 4—— Strand rope. A rope without the proper lubrication and construction for transmission of power will always fail to give good results.

(2) When using Driving rope, avoid contact with anything stationary—chafing injures rope quickley. If it is necessary to use small pulleys, use small ropes; increase the number as resistance to bending decreases with the smaller ropes.

(3) Economical speed is rated at 4500 feet per minute; slow speed increase durability.

(4) Avoid overloading; either use larger rope, if grooves permit, or put in additional ropes.

(5) Put only enough weight on tension carriage to allow rope to run without vibration and slippage in grooves.

(6) Rope sheaves should have the same pitch line in every groove, otherwise rope will rip. Any roughness in the surface of grooves will rapidly injure the rope.

(7) Examine all grooves occassionally, and clean out any accumulation of dirt from bottom of grooves—this dirt bed is a very frequent cause of ropes slipping.

(8) Keep water away from ropes; dampness causes initial contraction, but ultimate extension.

## Horse-Power of Rope—Gearing.

To find the number of indicated horse—power transmitted by rope—gearing.

*Rule ;*—Multiply 8 times the square of the circumference of one rope by the number of ropes, and by the circumferential velocity of the driving pulley in feet per minute; and divide the product by 33,000.

## White Hemp—Ropes.

The breaking strength of the untarred or white hemp–ropes used for rope–belts, varies from 6,400 lbs. to 1,100 lbs per square inch; the average breaking strength being 8700 lbs. per square inch. The working strength is one—sixth of the breaking strength or 1,450 lbs. per square inch,

## CIRCUMFERENCE OF CIRCLES.

FOR DIAMETERS IN INCHES AND $\frac{1}{8}$ ths.

| Dia. in ins. | .0 in. | .$\frac{1}{8}$ in. | .$\frac{1}{4}$ in. | .$\frac{3}{8}$ in. | .$\frac{1}{2}$ in. | .$\frac{5}{8}$ in. | .$\frac{3}{4}$ in. | .$\frac{7}{8}$ in. | Dia. in ins. |
|---|---|---|---|---|---|---|---|---|---|
| 0 | .0 | .3927 | .7854 | 1.178 | 1.570 | 1.963 | 2.356 | 2.748 | 0 |
| 1 | 3.141 | 3.534 | 3.927 | 4.319 | 4.712 | 5.105 | 5.497 | 5.890 | 1 |
| 2 | 6.283 | 6.675 | 7.068 | 7.461 | 7.854 | 8.246 | 8.639 | 9.032 | 2 |
| 3 | 9.424 | 9.817 | 10.21 | 10.60 | 10.99 | 11.38 | 11.78 | 12.17 | 3 |
| 4 | 12.56 | 12.95 | 13.35 | 13.74 | 14.13 | 14.52 | 14.92 | 15.31 | 4 |
| 5 | 15.70 | 16.10 | 16.49 | 16.88 | 17.27 | 17.67 | 18.06 | 18.45 | 5 |
| 6 | 18.84 | 19.24 | 19.63 | 20.02 | 20.42 | 20.81 | 21.20 | 21.59 | 6 |
| 7 | 21.99 | 22.38 | 22.77 | 23.16 | 23.56 | 23.95 | 24.34 | 24.74 | 7 |
| 8 | 25.13 | 25.52 | 25.91 | 26.31 | 26.70 | 27.09 | 27.48 | 27.88 | 8 |
| 9 | 28.27 | 28.66 | 29.05 | 29.45 | 29.84 | 30.23 | 30.63 | 31.02 | 9 |
| 10 | 31.41 | 31.80 | 32.20 | 32.59 | 32.98 | 33.37 | 33.77 | 34.16 | 10 |
| 11 | 34.55 | 34.95 | 35.34 | 35.73 | 36.12 | 36.52 | 36.91 | 37.30 | 11 |
| 12 | 37.69 | 38.09 | 38.48 | 38.87 | 39.27 | 39.66 | 40.05 | 40.44 | 12 |
| 13 | 40.84 | 41.23 | 41.62 | 42.01 | 42.41 | 42.80 | 43.19 | 43.58 | 13 |
| 14 | 43.98 | 44.37 | 44.76 | 45.16 | 45.55 | 45.94 | 46.33 | 46.73 | 14 |
| 15 | 47.12 | 47.51 | 47.90 | 48.30 | 48.69 | 49.08 | 49.48 | 49.87 | 15 |
| 16 | 50.26 | 50.65 | 51.05 | 51.44 | 51.83 | 52.22 | 52.62 | 53.01 | 16 |
| 17 | 53.40 | 53.79 | 54.19 | 54.58 | 54.97 | 55.37 | 55.76 | 56.15 | 17 |
| 18 | 55.54 | 56.94 | 57.33 | 57.72 | 58.11 | 58.51 | 58.90 | 59.29 | 18 |
| 19 | 59.69 | 60.08 | 60.47 | 60.86 | 61–26 | 61.65 | 62.04 | 62.43 | 19 |
| 20 | 62.83 | 63.22 | 63.61 | 64.01 | 64.40 | 64.79 | 65.18 | 65.58 | 20 |
| 21 | 65.97 | 66.36 | 66.75 | 67.15 | 67.54 | 67.93 | 68.32 | 68.72 | 21 |
| 22 | 69.11 | 69.50 | 69.90 | 70.29 | 71.07 | 71.47 | 71.47 | 71.86 | 22 |
| 23 | 72.25 | 72.64 | 73.04 | 73.43 | 73.82 | 74.22 | 74.61 | 75.00 | 23 |
| 24 | 75.39 | 75.79 | 76.18 | 76.57 | 76.96 | 77.36 | 77.75 | 78.14 | 24 |
| 25 | 78.54 | 78.93 | 79.32 | 79.71 | 80.10 | 80.50 | 80.89 | 81.28 | 25 |
| 26 | 81.68 | 82.07 | 82.46 | 82.85 | 83.25 | 83.64 | 84.03 | 84.43 | 26 |
| 27 | 84.82 | 85.21 | 85.60 | 86.00 | 86.39 | 86.78 | 87.17 | 87.57 | 27 |
| 28 | 87.96 | 88.35 | 88.75 | 89.14 | 89.53 | 89.92 | 90.32 | 90.71 | 28 |
| 29 | 91.10 | 91.49 | 91.89 | 92.28 | 92.67 | 93.06 | 93.46 | 93.85 | 29 |
| 30 | 94.24 | 94.64 | 95.03 | 95.42 | 95.81 | 96.21 | 96.60 | 96.99 | 30 |
| 31 | 97.4 | 97.8 | 98.2 | 98.6 | 99.0 | 99.4 | 99.7 | 100.1 | 31 |
| 32 | 100.5 | 100.9 | 101.3 | 101.7 | 102.1 | 102.5 | 102.9 | 103.3 | 32 |
| 33 | 103.7 | 104.1 | 104.5 | 104.9 | 105.2 | 105.6 | 106.0 | 106.4 | 33 |
| 34 | 106.8 | 107.2 | 107.6 | 108.0 | 108.4 | 108.8 | 109.2 | 109.6 | 34 |
| 35 | 110.0 | 110.3 | 110.7 | 111.1 | 111.5 | 111.9 | 112.3 | 112.7 | 35 |
| 36 | 113.1 | 113.5 | 113.9 | 114.3 | 114.7 | 115.1 | 115.5 | 115.8 | 36 |
| 37 | 116.2 | 116.6 | 117.0 | 117.4 | 117.8 | 118.2 | 118.6 | 119.0 | 37 |
| 38 | 119.4 | 119.8 | 120.2 | 120.6 | 121.0 | 121.3 | 121.7 | 122.1 | 38 |
| 39 | 122.5 | 122.9 | 123.3 | 123.7 | 124.1 | 124.5 | 124.9 | 125.3 | 39 |
| 40 | 125.7 | 126.1 | 126.4 | 126.8 | 127.2 | 127.6 | 128.0 | 128.4 | 40 |
| 41 | 128.8 | 129.2 | 129.6 | 130.0 | 130.4 | 130.8 | 131.2 | 131.6 | 41 |
| 42 | 131.9 | 132.3 | 132.7 | 133.1 | 133.5 | 133.9 | 134.3 | 134.7 | 42 |
| 43 | 135.1 | 135.5 | 135.9 | 136.3 | 136.7 | 137.1 | 137.4 | 137.8 | 43 |
| 44 | 138.2 | 138.6 | 139.0 | 139.4 | 139.8 | 140.2 | 140.6 | 141.0 | 44 |
| 45 | 141.4 | 141.8 | 142.2 | 142.6 | 142.9 | 143.3 | 143.7 | 144.1 | 45 |
| 46 | 144.5 | 144.9 | 145.3 | 145.7 | 146.1 | 146.5 | 146.9 | 147.3 | 46 |
| 47 | 147.7 | 148.0 | 148.4 | 148.8 | 149.2 | 149.6 | 150.0 | 150.4 | 47 |
| 48 | 150.8 | 151.2 | 151.6 | 152.0 | 152.4 | 152.8 | 153.2 | 153.5 | 48 |
| 49 | 153.9 | 154.3 | 154.7 | 155.1 | 155.5 | 155.9 | 156.3 | 156.7 | 49 |
| 50 | 157.1 | 157.5 | 157.9 | 158.3 | 158.7 | 159.0 | 159.4 | 159.8 | 50 |
| 51 | 160.2 | 160.6 | 161.0 | 161.4 | 161.8 | 162.2 | 162.6 | 163.0 | 51 |
| 52 | 163.4 | 163.8 | 164.1 | 164.5 | 164.9 | 165.3 | 165.7 | 166.1 | 52 |
| 53 | 166.5 | 166.9 | 167.3 | 167.7 | 168.1 | 168.5 | 168.9 | 169.3 | 53 |
| 54 | 169.6 | 170.0 | 170.4 | 170.8 | 174.2 | 171.6 | 172.0 | 172.4 | 54 |
| 55 | 172.8 | 173.2 | 173.6 | 174.0 | 174.4 | 174.8 | 175.1 | 175.5 | 55 |
| 56 | 175.9 | 176.3 | 176.7 | 177.1 | 177.5 | 177.9 | 178.3 | 178.7 | 56 |
| 57 | 179.1 | 179.5 | 179.9 | 180.2 | 180.6 | 181.0 | 181.4 | 181.8 | 57 |
| 58 | 182.2 | 182.6 | 183.0 | 183.4 | 183.8 | 184.2 | 184.6 | 185.0 | 58 |
| 59 | 185.4 | 185.7 | 185.1 | 186.5 | 186.9 | 187.3 | 187.7 | 188.1 | 59 |
| 60 | 188.5 | 188.9 | 189.3 | 189.7 | 190.1 | 190.5 | 190.9 | 191.2 | 60 |

## AREAS OF CIRCLES.

FOR DIAMETERS IN INCHES AND ⅛ths.

| Dia. in ins. | .o in. | .⅛ in. | .¼ in. | .⅜ in. | .½ in. | .⅝ in. | .¾ in. | .⅞ in. | Dia. in ins. |
|---|---|---|---|---|---|---|---|---|---|
| 0 | .o | .0122 | 0.490 | .1104 | .1963 | .3068 | .4417 | 6.013 | 0 |
| 1 | .7854 | .9940 | 1.277 | 1.484 | 1.767 | 7.073 | 2.405 | 2.761 | 1 |
| 2 | 3.141 | 3.546 | 3.976 | 4.430 | 4.908 | 5.441 | 5.939 | 6.491 | 2 |
| 3 | 7.068 | 7.669 | 8.295 | 8.946 | 9.621 | 10.32 | 1.04 | 11.79 | 3 |
| 4 | 12.56 | 13.36 | 14.18 | 15.03 | 15.90 | 16.80 | 17.72 | 18.66 | 4 |
| 5 | 19.63 | 20.62 | 21.64 | 22.69 | 23.75 | 24.85 | 25.96 | 27.10 | 5 |
| 6 | 28.27 | 29.46 | 30.67 | 31.91 | 33.18 | 34.47 | 35.78 | 37.12 | 6 |
| 7 | 38.48 | 39.87 | 41.28 | 42.71 | 44.17 | 45.66 | 47.17 | 48.70 | 7 |
| 8 | 50.26 | 51.84 | 53.45 | 55.08 | 56.74 | 58.42 | 60.13 | 61.86 | 8 |
| 9 | 63.61 | 65.39 | 67.20 | 69.02 | 70.88 | 72.75 | 74.66 | 76.58 | 9 |
| 10 | 78.54 | 80.51 | 82.51 | 84.54 | 86.59 | 88.66 | 90.76 | 92.88 | 10 |
| 11 | 95.03 | 97.20 | 99.40 | 101.6 | 103.8 | 106.1 | 108.4 | 110.7 | 11 |
| 12 | 113.0 | 115.4 | 117.8 | 120.2 | 122.7 | 125.1 | 127.6 | 130.1 | 12 |
| 13 | 132.7 | 135.2 | 137.8 | 140.5 | 143.1 | 145.8 | 148.4 | 145.2 | 13 |
| 14 | 153.9 | 156.6 | 159.4 | 162.2 | 165.1 | 167.9 | 170.8 | 173.7 | 14 |
| 15 | 176.7 | 179.6 | 182.6 | 185.6 | 188.6 | 191.7 | 194.8 | 197.9 | 15 |
| 16 | 201.0 | 204.2 | 207.3 | 210.5 | 213.8 | 217.0 | 220.3 | 223.6 | 16 |
| 17 | 226.9 | 230.3 | 233.7 | 237.1 | 240.5 | 243.9 | 247.4 | 250.9 | 17 |
| 18 | 254.4 | 258.0 | 261.5 | 265.1 | 268.8 | 272.4 | 276.1 | 279.8 | 18 |
| 19 | 283.5 | 287.2 | 291.0 | 294.8 | 298.6 | 302.4 | 306.3 | 310.2 | 19 |
| 20 | 314.1 | 318.1 | 322.0 | 326.0 | 330.0 | 334.1 | 338.1 | 344.2 | 20 |
| 21 | 346.3 | 350.4 | 354.6 | 358.8 | 363.0 | 367.2 | 371.5 | 375.8 | 21 |
| 22 | 380.1 | 384.4 | 388.8 | 393.2 | 397.6 | 402.0 | 406.4 | 410.9 | 22 |
| 23 | 415.4 | 420.0 | 414.5 | 429.1 | 433.7 | 438.3 | 443.0 | 447.7 | 23 |
| 24 | 452.3 | 457.1 | 461.8 | 466.6 | 471.4 | 476.2 | 481.1 | 485.9 | 24 |
| 25 | 490.8 | 495.7 | 500.7 | 505.7 | 510.7 | 515.7 | 520.7 | 525.8 | 25 |
| •26 | 530.9 | 536.0 | 541.1 | 546.3 | 551.5 | 556.7 | 562.0 | 567.2 | 26 |
| 27 | 572.5 | 577.8 | 583.2 | 588.5 | 593.9 | 599.3 | 604.8 | 610.2 | 27 |
| 28 | 615.7 | 621.2 | 626.7 | 632.3 | 637.9 | 643.5 | 649.1 | 654.8 | 28 |
| 29 | 660.5 | 666.2 | 671.9 | 677.7 | 683.4 | 689.2 | 695.1 | 700.9 | 29 |
| 30 | 706.8 | 712.7 | 718.6 | 724.0 | 730.6 | 736.6 | 742.6 | 748.6 | 30 |
| 31 | 754.8 | 760.9 | 767.0 | 773.1 | 779.3 | 785.5 | 791.7 | 798.0 | 31 |
| 32 | 804.2 | 810.5 | 816.9 | 823.2 | 829.6 | 836.0 | 842.4 | 848.8 | 32 |
| 33 | 855.3 | 861.8 | 868.3 | 874.8 | 881.4 | 888.0 | 894.6 | 901.3 | 33 |
| 34 | 907.9 | 914.6 | 921.3 | 928.1 | 934.8 | 941.6 | 948.4 | 955.3 | 34 |
| 35 | 962.1 | 969.0 | 975.9 | 982.8 | 989.8 | 996.8 | 1003.8 | 1010.8 | 35 |
| 36 | 1017.9 | 1025.0 | 1032.1 | 1039.2 | 1046.4 | 1053.5 | 1060.7 | 1068.0 | 36 |
| 37 | 1075.2 | 1082.5 | 1089.8 | 1097.1 | 1104.5 | 1111.8 | 1119.2 | 1126.7 | 37 |
| 38 | 1134.1 | 1141.6 | 1149.1 | 1156.6 | 1164.2 | 1171.7 | 1179.3 | 1186.9 | 38 |
| 39 | 1194.6 | 1202.3 | 1210.0 | 1217.7 | 1225.4 | 1233.2 | 1241.0 | 1248.8 | 39 |
| 40 | 1256.6 | 1264.5 | 1272.4 | 1280.3 | 1288.3 | 1296.2 | 1304.2 | 1312.2 | 40 |
| 41 | 1320.3 | 1328.3 | 1336.4 | 1344.5 | 1352.7 | 1360.8 | 1369.0 | 1377.2 | 41 |
| 42 | 1385.4 | 1393.7 | 1401.9 | 1410.2 | 1418.6 | 1426.9 | 1435.3 | 1443.7 | 42 |
| 43 | 1452.2 | 1460.6 | 1469.1 | 1477.6 | 1486.1 | 1494.7 | 1503.3 | 1511.9 | 43 |
| 44 | 1520.5 | 1529.1 | 1537.8 | 1546.5 | 1555.2 | 1564.0 | 1572.8 | 1581.6 | 44 |
| 45 | 1590.4 | 1599.2 | 1608.1 | 1617.0 | 1626.0 | 1634.9 | 1643.8 | 1652.8 | 45 |
| 46 | 1661.9 | 1670.9 | 1680.0 | 1689.1 | 1698.2 | 1707.2 | 1716.5 | 1725.7 | 46 |
| 47 | 1734.9 | 1744.1 | 1753.4 | 1762.7 | 1772.0 | 1781.3 | 1790.7 | 1800.1 | 47 |
| 48 | 1809.5 | 1818.9 | 1828.4 | 1837.9 | 1847.4 | 1856.9 | 1866.5 | 1876.1 | 48 |
| 49 | 1885.7 | 1895.3 | 1905.0 | 1914.7 | 1924.4 | 1934.1 | 1943.9 | 1953.6 | 49 |
| 50 | 1963.5 | 1973.3 | 1983.1 | 1993.0 | 2002.9 | 2012.8 | 2022.8 | 2032.8 | 50 |
| 51 | 2042.8 | 2052.8 | 2062.9 | 2072.9 | 2083.0 | 2093.2 | 2103.3 | 2113.5 | 51 |
| 52 | 2123.7 | 2133.9 | 2144.1 | 2154.4 | 2164.7 | 2175.0 | 2185.4 | 2195.7 | 52 |
| 53 | 2206.1 | 2216.6 | 2227.0 | 2237.5 | 2248.0 | 2258.5 | 2269.0 | 2279.6 | 53 |
| 54 | 2290.2 | 2300.8 | 2311.4 | 2322.1 | 2332.8 | 2343.5 | 2354.2 | 2365.0 | 54 |
| 55 | 2375.8 | 2386.6 | 2397.4 | 2408.3 | 2419.2 | 2430.1 | 2441.0 | 2452.0 | 55 |
| 56 | 2463.0 | 2474.0 | 2485.0 | 2496.1 | 2507.1 | 2518.2 | 2529.4 | 2540.5 | 56 |
| 57 | 2551.7 | 2562.9 | 2574.1 | 2585.4 | 2596.7 | 2608.0 | 2619.3 | 2630.7 | 57 |
| 58 | 2642.0 | 2653.4 | 2664.9 | 2676.3 | 26.878 | 2699.3 | 2710.8 | 2722.4 | 58 |
| 59 | 2733.9 | 2745.5 | 2757.1 | 2768.8 | 2780.5 | 2799.2 | 2803.9 | 2815.6 | 59 |
| 60 | 2827.4 | 2839.2 | 2851.0 | 2862.8 | 2874.7 | 2886.6 | 2898.5 | 2910.5 | 60 |

# CHAPTER XIV.

## LUBRICANTS AND LUBRICATION.

One very expensive factor in the cost of running the cotton industry is the generation and application of power. The price of the fuel, the water-rights, the interest and depreciation on the cost of boilers, engine, gearing, shafting, machines, belting, and general maintenance is no small matter; but the amount in money value can easily be ascertained, and, therefore, although expensive, it is a known quantity. The item, however, which probably is the more important because the least about it is known, may be, is friction..

Anywhere between 20 per cent to 30 per cent of the total horse power shown by the indicator diagrams is absorbed by the friction of the moving parts of driving arrangements, before any actual production is registered. Added to this is the wear and tear upon the engines, shaftings, bearings, etc., and the costs of oils and greases used, to alleviate as far as possible the friction load generally. The following notes on friction will give some idea of its causes. The various losses that may accrue are tabulated and many of the usual methods adopted in preparing to meet and overcome the power stealer are set forth.

### Friction.

In the first place friction is a negative force or resistance, occurring when two bodies are at rest, sliding or rolling, one in contact with the other. Friction at rest is termed static friction, while friction in motion is termed kinetic. The relation between the pressure required to move a body from its state of rest and the weight of the body being moved, is termed the co-efficient of friction. A 7 lb. force required to move a 28 lb. body, is expressed as $\frac{7}{28} = .25$, the co-efficient in that case being .25. The lower this co-efficient the less is the weight required to move a body ; thus by reducing the friction between the two surfaces in contact,economy of power applied is obtained, as is also economy by reduction of wear and tear of surfaces in contact. The amount of friction present is directly related to the pressure acting between the metals in contact, the class of metal and under certain conditions, in part degree to the velocity of moving surfaces. Friction between machine parts lowers the mechanical efficiency or ratio of power obtained to power applied. Thus the mechanical efficiency of an engine is the ratio between the indicated horse power or total power required to drive the engine and the brake horse power, or total power given out at the fly wheel, the loss of power shown between the two being given up in overcoming friction of the engine parts.

B.H.P./I.H.P. =M.E. and for good working with all in correct adjustments, the mechanical efficiency may be .95, but for poor conditions it can fall as low as .75. Multiplying these two factors by 100, we get the mechanical efficiency expressed as 95 per cent and 75 per cent respectively. The efficiency of other everyday items, belts, ropes, etc., are approximately :—

| | Per cent |
|---|---|
| Ropes | 99 |
| Belts | 98 |
| Chains | 97 |
| Cast Teeth and Bearings | 93 |
| Cut Teeth of Bevel Gears | 95 |
| Ordinary Bearings | 94 |
| Ball Bearings | 99 |
| Roller Bearings | 98 |

## Bearings.

Bearings, then, in order to function to the best advantage, should be so designed as to allow of the maximum safety pressure and the minimum co-efficient of friction. The metals used for this purpose may be composed of alloys of tin, antimony, zinc and lead, the proportion of each being different, depending upon the speeds and pressures which obtain in their particular instance. Usually, the composition approximates the following proportions :—

Bearings for high pressures :
Tin 90, antimony 7, copper 3 per cent.
Bearings for high pressures and fast speeds :
Tin 85, antimony, 12, copper 3 per cent.
Bearings for medium pressures and fast speed :
Tin 30, antimony 20, lead 50 per cent.
Bearing for medium pressures and low speed :
Tin 15, antimony 25, lead 60 per cent.
Bearings for low pressures and medium speed :
Tin, 8, antimony 20, lead 72 per cent.
Bearings for shaftings :
Antimony 10, lead 90 per cent.

The design and composition of these bearings is such as to minimise as far as possible the amount of friction created. The presence of friction in bearings causes a rise in temperature of from 10 deg. to 100 deg. Fahrenheit, usually averaging a rise of 30 deg. above the heat of room. This rise in temperature will continue until the heat, generated by the friction of metals in contact, is balanced by the heat radiated, thus the efficient radiation of heat from a bearing will keep it cooler than it otherwise would be. Friction being directly due to pressure, a certain standard is arranged for in the construction of friction bearing surfaces. Shaftings are constructed for average pressures of 25 lb. per sq. inch; dynamos, 30 lb.; main bearing for high speed engines, 60 lb.; main bearings for slow speed engines, 80 lb.;crank pins, 800 lb.; main bearings for gas engines; 500 lb.; gas engine crank pins, 1,500 lb.; and heavy line shafts, 100 lb. per sq. inch.

## Lubrication.

In addition to the special composition and construction of bearings to reduce friction to a minimum, another most important item is necessary, *viz.;* efficient lubrication. Lubrication is the interposing of a medium between two friction surfaces, the interposed body having particles which adapt themselves to varying pressures, adhering to the friction surfaces and protecting them: for this purpose solid, semi-solid and liquid, bodies are used. The substance applied forms a film between the bearing surfaces and holds them apart, of shafts and journals

Space is left primarily to take up the expansion of the journal.

| | | |
|---|---|---|
| 1 | Inch shafts have allowances of | 2-1000ths in. |
| 2 | ,, ,, ,, | 3-1000ths ,, |
| 4 | ,, ,, ,, | 5-1000ths ,, |
| 6 | ,, ,, ,, | 9-1000ths ,, |
| 8 | ,, ,, ,, | 12-1000ths ,, |
| 10 | ,, ,, ,, | 14-1000ths ,, |
| 12 | ,, ,, ,, | 16-1000ths ,, |
| 14 | ,, ,, ,, | 18-1000ths ,, |
| 16 | ,, ,, ,, | 20-1000ths ,, |

Lubricants, therefore, are used in order to reduce the co-efficient of friction, increasing the energy put out in relation to that put in, preventing also abrasion and seizing of the metals. Different materials are used for lubrication, these having different chemical and physical properties, lending themselves to the different conditions which obtain in the occurrence of friction. Two first essentials are, however, required in all lubricants, *viz.*, viscosity and oiliness.

Viscosity is a physical property of the lubricant and determines its ability to form and retain an efficient buffer film under heat and pressure; the greater the heat and pressure between the friction bearing surfaces the greater viscosity is required of the lubricant employed to prevent thinning and squeezing out of film.

Oiliness is a chemical property more or less, being the readiness of the unsaturated hydro-carbon compound in the lubricant, to form a physicochemical union with the metals and creating a friction compound surface. The more perfect this union of lubricant and metals, the more perfect spreading and resistance to disruption of the oil film created by the lubricant's viscosity. From 20 per cent to 40 per cent of the hydro-carbons are unsaturated, the more the better to certain limits for the oiliness and metal union.

## Methods of application.

The method of applying lubricants generally depends upon the bearing or surface for which it is required and the particular conditions appertaining. Where perfect retention of an anti-friction film is needed, a bath of the lubricant is required, the bearings being constantly immersed. This is essential for high speeds under certain conditions, as in high speed engine crank shafts, dynamos, ring spindles and beater bearings in blowing rooms. For better distribution of the lubricant, splash rings may be used with this method as in Mohler bearings on operners and scutchers and ring oilers for shafts.

Forced lubrication of combined pump and reservoir, containing feed pipes to the bearing surfaces, is used to ensure that high speeds are efficiently catered for where rings cannot be utilised with bath: this method is also adopted for certain types of lubricant under altered conditions, it being a very satisfactory method for some engine parts, big necks and shafts. Mechanical force feed lubrications may be employed in the oiling of internal parts of steam engines, in conjunction with an atomiser. The lubricant in this case is raised from tank through water container, and upon emerging, is blown along with the steam to all internal parts. Thus the steam is charged with lubricating properties and all the parts with which it comes in contact are efficiently lubricated. Wick lubrication may be employed satisfactorily on engine bearings where slow but steady feed of oil is needed, the wick suspended from oil container, absorbing the liquid and distributing same to the journals.

The portion immersed should always be shorter than that part which is suspended over the bearings, a jamming of the wick will prevent air pressure from acting correctly and feed of lubricant will cease. Bottle lubrication employed on high speed shaftings or shafts which run at medium speeds, is quite efficient. The hanging needle in contact with the revolving shaft vibrating and allowing air bubbles within the bottle container, displace the lubricant therein, allowing it to enter past the needle into the bearing. Semi-solid lubricants are best applied to slow speed parts with heavy pressures, a cup or box containing the lubricant, which latter is in contact with the moving parts: thus the shaft can constantly take round with it a film, the heat of friction set up, partially liquefying the lubricant used.

## Types of Lubricants.

Many types of lubricants are in daily use for purposes of reducing friction and a general classification of these lubricants is as follows :—

Fats and Liquid Waxes; Mineral Oils; Blended Oils; Greases and Solid Lubricants.

The fats produce oils which are commercially known as fixed oils and are so termed because they are not volatile without decomposition. This latter fact is a most important consideration when deciding upon the use of a fixed oil for certain lubricating purposes. At decomposition these oils give off acrolein. Fixed oils may be of either animal or vegetable origin and are mixtures of organic compounds termed glycerides. The animal oils are obtained from the tissues of certain animals by boiling and heating, vegetable oils being obtained from fruits and seeds, the extraction being performed by either crushing or the use of ether as a solvent.

The best known animal oils in general use are: Tallow oil, lard oil, and neatsfoot oil. The vegetable oils in use mostly are: Olive oil, rape oil, Cocoanut oil, and castor oil.

Liquid waxes produce among others the well known sperm oil, this latter possessing splendid properties of oiliness and its viscosity not being over-affected by rise in temperatures.

Mixed oils may be artificially thickened by the action of forced air current on heated oils, causing partial oxidisation, increasing their density and viscosity ; such oils are then termed blown oils.

Mineral oils are derived from petroleum, lignite, and shale; they consist of saturated and unsaturated hydro-carbons of methane, ethane, etc., with a boiling point of over 300 deg. Fahrenheit.

The hydro-carbons may be obtained by a process of distillation, the saturated hydro-carbons being carbon molecules, saturated absolutely with hydrogen and not capable of union with anything else; thus the importance of having in an oil the unsaturated molecules, to unite with the metals and form the antifriction compound.

## Mineral Oils.

Mineral oils are commercially classed as pale and dark and have a very wide range of viscosity. The fundamental diffrence between mineral and fixed oils is centred round their behaviour towards oxygen. Mineral oils are indifferent while fixed oils will unite, gumming and generating heat. This is another important factor when using any particular oil, especially for internal lubrication of a steam engine, where gumming is detrimental. Mineral oils with a specific gravity up to .9 are known as distilation products, those with S.G. higher than .9 are reduced oils, distilled by steam in vacuum.

Compounded oils, the next type in the general classification, are composed of mixtures of fixed oils and mineral oils. Mineral oils are so mixed with fixed oils in varying proportions, depending upon subsequent use. The resultant lubricant is good for general purposes, the oiliness and viscosity of mineral oils being improved and any disadvantage of the pure fixed oil being neutralised. These mixtures may be from 10 per cent to 25 per cent of fixed oil with from 90 per cent to 75 per cent mineral oil.

Greases are composed of mixtures of mineral oils with soaps, aluminium, fatty acids, resins and water ; lime soap and mineral oils dissolved are used for heavy machines and cold mineral oils with hot potash soap (neutral) for engine grease.

Solid lubricants are composed of graphite, soap-stone, french chalk and mica ; the lubricating properties of greases depend upon the shearing property or resistance of components to be separated.

## Properties of Lubricants.

The properties of both mineral and fixed oils are very similar although their respective characteristics differ. These properties are utilised in the lubrication of machine parts, bearings, internal cylinders and sliding surfaces. The characteristic of an oil are reckoned primarily upon the following traits: specific gravity, viscosity, oiliness, flash point, fire point, setting point, volatility, neutrality, and finally colour. The above features are the determining factors in an oil's use as a lubricant under appertaining conditions.

Specific gravity is the relation between the weights of an equal volume of oil and volume of water, at a temperature of 39.2 degrees Fah. Mineral oils have a specific gravity of from .860 to .940. Fixed oils are usually between .879 to .968. No relation as a rule exists between an oil's specific gravity and its lubricating properties, but as a rule mineral oils with lower specific gravity are more oily. Viscosity is really the adhesive and film forming capacity of an oil, its fluidity of flowing capacity and this property varies at different heats and in different oils. The more viscous an oil is, the greater the load or pressure in bearings it will sustain without squeezing out. Oiliness is the capacity of an oil for the retention of an unbroken film during use sustained by its viscosity.

The unsaturated hydro-carbons form a friction decreasing surface with the metals of shaft and journal, the more unsaturated hydro-carbons, the more the oiliness present the less is the co-efficient of friction. Flash point is the peak of heat or point of temperature at which an oil will give off an explosive vapour mixture in the atmosphere. Good oils do not flash until they are heated to about 500 degrees. The flashing point really depends upon the liberation of hydro-carbons which join with the oxygen of the atmosphere and form combustion, from this it follows that the more unsaturated hydro-carbons, the less the flashing point, therefore, the higher the flashing point of an oil, the oily it is. Volatility is the temperature resisting capacity of an oil, before it commences to give off its constituent hydro-carbon. For oil to be used in cases of internal lubrication, withstanding 160 lbs. steam pressure, the volatility should be such that no loss is sustained before a temperature of 370 degrees is attained.

Depending upon an oil's volatility is closely related to the tendency of an oil to gum or resinfry. This gumming is due to decomposition owing to heat: mineral oils which gum have had their lighter constituents evaporated and formed as tars by precipitation.

## Fixed Oils.

Fixed oils are not volatile without decomposition thus, under heavy steam pressures and attendant high temperatures, they are hydrolysed to glyceral and fatty acids, forming metallic soaps on the metals with which they come in contact and leaving carbonaceous deposits. It may here be stated that fixed oils are either drying or non-drying, the drying oils being linseed, hemp, poppy and walnut; the non-drying section includes olive oil, almond and colza; castor oil forms a link between the two. Drying oils absorb oxygen and if in contact with cotton or wool, generates heat causing spontaneous combustion.

'Setting point' is the term used to denote the cold test of an oil and is the temperature at which an oil ceases to flow, being totally opposite to the fire point, which is that degree of heat at which an oil is totally consumed as vapour.

Colour as a characteristic is not of very much practically assistance; animal oils, however, are either colourless or yellow; vegetable oils are yellow or green; mineral oils being pale or dark. Pale mineral oils are transparent and tinged with yellow and red shades, dark oils being opaque, greenish brown, and black. Neutrality of an oil is the term used to denote its freedom from acids. Animal oils contain stearic and vegetable oils, oleic, acids, other fatty acids such as capric are also present. These fatty acids when liberated mix with oxygen and cause corrosion in pipes or deposits in boilers.

## Testing of Oils.

Oils can be tested for degree of characteristics in the laboratory but the best testing method for lubricating properties is a try out under actual working conditions. To test for the specific gravity of an oil, a graduated hydrometer is used, the weighted tube being immersed in the oil and its depth of sinking denotes the specific gravity as marked off, along the hydrometer. This test will denote the presence of any solid impurities in an oil of known specific gravity foreign matter present, showing a heavier specific gravity than natural. Another method of determining impure solid matter is to add to the oil being tested an equal quantity of kerosene, after mixing filter the whole through good filtering paper. The solid matter will show clearly on the surface of the filter.

The viscosity of an oil can be tested in various ways, the principle of the test being the length of time taken for a given quantity of oil to flow out of a given aperture, the temperature of oil being especially noted. The result obtained is then checked off against the time taken by a standard oil, say rape, to flow out of the same aperture, the same temperature obtaining. Redwood's apparatus can be used for this test, the oil in a container is surmounted by a liquid bath, this bath being heated to the required temperature of test; the length of time then taken for the oil to run from a 50 c.c. capacity pipette denotes the oil's viscosity. Rape oil at 60 degs. Fahr. takes 500 seconds of flow out: this can be taken as a standard. The longer the flow the higher the viscosity. An increase of temperature always decreases the viscosity, and again, too great a viscosity of an oil will increase the friction of the oil itself. The ball and cup method of testing for viscosity is also much used. Oiliness can be tested for by using a machine which denotes the co-efficient of friction of the oil itself. This is performed by use of revolving discs the oil having been smeared between, one disc being positively driven the other frictionally driven from first disc. A good ready method of testing thus is to allow oils being tested, to run along surface of slightly inclined glass plate, the oil which runs farthest in a given time being best for general lubricating purposes. The flash and fire tests are carried out usually in a closed cylinder. From a liquid container bath heated, the cylinder holding the oil receives heat and a thermometer inserted in the cylinder shows rise in temperatures. For every rise of 1 degree, a flame is automatically inserted in the oil cylinder until a blue flash is registered, and the temperature noted at flashing. For fire test, the heating is continued until combustion takes place.

## Volatility testing.

For volatility testing the above method can be utilised, the temperature being noted when the oil commences to smoke, this being the volatility temperature. Also, the examination of deposits at varying temperatures is a ready guide. Heating a quantity of oil in a shallow container, for 60 minutes, by passing current of hot air through it, will give an idea of volatile property. After this test, the oil should not have lost more than .5 per cent in weight. The crusting of a thin film of oil, exposed to the air for 7 days denotes gumming and this tendency increases at higher temperatures: for setting point testing, the oils are subjected to cooling or freezing mediums. Finally, with regard to colours, dark oils, if not adulterated, are best. By heating oil to 480 degrees, a good cylinder oil can be determined; the colour in this case should not change but low grades darken.

An oil can be tested for neutrality by means of litmus paper, blue litmus turning red, denoting presence of acids. Adding chlorine to animal oil causes colour to change to brown, while vegetable oils will turn white.

## Selection of Oils.

The factors which should determine the use of any particular oil for lubricating purposes are: The pressure in the bearing; velocity of moving parts; heat in which they work; method of application and conditions prevailing which would tend to neutralise or intensify any particular characteristic. Mineral oils are not as proficient in lubricating properties as a fixed oil, but fixed oils have certain definite disadvantages, thus a blending of the two is beneficial. Fixed oils possess oiliness to a greater extent than mineral oils, but the fatty acids present are liable to decompose under heat and cause gumming or corrosive action on some metals. This is detrimental to their use in high pressure bearings or internal cylinder lubrication, fixed oils in steam are hydrolysed to glyceral and form metallic soaps, such oils getting into the boilers through feed water, form a crust which is more impervious to heat than ordinary scale and causes collapse of furnace or buckling of plates.

The viscosity of a mineral oil is due to its proportionate possession of paraffin wax and its oiliness attributable to the proportion of unsaturated hydro-carbons, thus this type of lubricant is much better for internal cylinder lubrication. Reckoning high pressures over 80 lb. per square inch, then for exceedingly high pressures greases are best used. For moderate high pressures where normal heat appertains a good fixed oil can be applied. When considering the velocity, usually 120 feet per minute are accounted as high speeds. For low speeds a viscous oil is best applied, and thinner oils at higher speeds. Mineral oils are best for heat resisting, but a bath or forced pump lubrication should be used. Light loads and moderate speeds require mineral oils, the increase of load requiring a proportionate increase of fixed oil addition. For ordinary speeds and pressures of 250 lb. viscosity is the chief point. Often in the case of light pressures and high speeds a mineral oil of 350 degrees flash point is used in conjunction with sperm oil. For ordinary machine bearings, a mineral oil of 350 flash point, mixed with tallow oil is used. For the high speeds of armature bearings and ring spindles thin oils are best, the mixture used being a mineral oil of 360 flash point and neatsfoot oil.

The proportionate mixture for machine bearings may be 80 per cent mineral and 20 per cent fixed, for spindles on ring frames, 90 per cent mineral and 10 per cent fixed. For dynamos and motors with ring or bath lubrication, pure mineral oils are best, and assuming the standard as rape oil for viscosity (500 secs.), the viscosity in this case should be about 1,500. Ball bearings require a neutral oil, either fixed or a fairly viscous mineral oil; chains run best in a bath of sperm oil. The chief point in ball and roller bearing lubrication is to prevent rusting. For high speed delicate machinery high speed winding, etc., a good mixture is 20 per cent sperm and 80 per cent mineral with a relative viscosity of 150. For lubrication of turbines with forced pump method, a pure mnieral oil, five times viscosity of rape oil is best. High speed engines are efficiently lubricated by pure mineral oils of 2.5 times viscosity of rape. For steam engine cylinders with super-heated steam a pure heavy mineral oil suits, for ordinary steam pressures 80 per cent mineral and 20 per cent rape oil is often used, but in this respect animal oils are less liable to gum than vegetable.

Bearings in hot temperatures are best lubricated by 80 per cent mineral and 20 per cent blown oils. Oils for gas engine lubrication can be had from a mixture of 90 per cent mineral and 10 per cent neutral oil, the viscosity being about that of rape oils. The best oil in this respect is, however, a pure hydro-carbon oil of high vapourising point 260 deg. and a flash point of 500, with fire test at 600. These oils should lose very little of their constituents under heat in cylinders and should not decompose to form carbon.

## Steam Engine Lubrication.

The parts requiring efficient lubrication on an engine of the above type are: internal, slides, eccentrics, crank pins, and main bearings. The choice of oils used depends upon the steam pressure, degree of superheat, wet or dry steam, vertical or horizontal engine, valve type, piston speed and condensing or non-condensing engine. The best method is to use an atomiser for oil distribution in H.P. and a mechanical feed to the L.P. cylinders. Super-heated steam requires an oil of high grade, sparingly fed and applied in the main range. The oil should have no tendency to carbonise and should be of high flash point. A good cylinder oil is non-gumming and free from acids with great viscosity at high temperatures the flashing point should be 500 degrees and vaporising point high with corresponding low loss. The specific gravity at 60 deg. should be about .9, and taking tallow as a standard for viscosity at 180 degrees, a good cylinder oil should be 3.5 times as viscous; equal at 280 degs., and $\frac{7}{10}$th as viscous at 360 degs. For super-heated steam, a pure mineral oil is best with flashing point 550 deg. Oil in boilers can often be traced to use of surface condensers or open feed water heaters, jet condensing minimises this risk.

Oil separators can be advantageously used, a mechanical separator working efficiently for oils with a flash point below 400 degrees, above this point, the light deposits are not capable of extraction mechanically, the same applying to oils with more than 8 per cent organic compounds present. Chemical separators are then used to free the water passing back to boilers from oil deposit. The chemical action causes the globules to be suspended, saturated, and pulled down into receptacle; the mechanical separator baffles the steam in pipes and causes the suspended oil to fall into receiver. Trouble can be experienced with the large D slide valves, when using super-heated steam of over 50 degrees, and corliss valves will sometimes groan with super-heated steam of 120. Drop valves with no friction surface are best in this respect.

## High Speed Engines and Turbines.

In the case of lubricating a combined H.S.E. and Turbine, the highest possible grade oil should be used in order to pass as little as possible through to the turbine. The impinging steam, if loaded with oil particles, may deposit these on the blades and setting up extra friction reduce the propulsive efficiency. In the case of the H.S.E. itself the oil should be fed sparingly under pressure to all the bearings and then a good draining system should pass the oil back to suction chamber. Badly fitting glands may allow water to get to crank chamber and on this account the oil used should especially resist water and air exposure effects. A pump of ample capacity should be used and is best situated in a separate chamber where the oil can drain from crank case itself, leaving the water behind.

Presence of water in the oil will cause a thickening, and increased friction will be set up; slightly super-heated steam will always reduce the tendency, of condensation and minimise the aforementioned risks. The use of castor oil in some systems of crank splash lubrication increases the frictional heat, causes decomposition and formation of fatty acids which attack the bearing metals. In this latter respect, different oils affect metals used in bearings to different degrees, mineral and sperm oils affect lead most, while copper is most affected by rape, tallow, and lard oil. For direct lubrication of turbine, it is a good system to pass the expended oil to a separate filtration chamber before repumping into crank and bearings. By this method the oil can be heated, separated, and filtered, then forced through an efficient oil cooler to crank.

## Gas Engine Lubrication.

The peculiar conditions prevailing in the engine cylinder, calls for especial qualities, not possessed by all oils. The first stroke, drawing in charge of gas and air, operates with pressure just below that of atmosphere ; second stroke, causing compression of mixture, works with pressure of from to 50 to 200 lbs. At the third or ignition stroke, there is a rapid increase of pressure to 550 lbs; while at the exhaust the pressure drops to just above 15 lbs. From the above can be seen the condition under which the oil must function and as the explosion temperatures are from 1,200 to 2,000 degrees centigrade, the effect of the explosion on the oil film on cylinder walls, is to cause partial evaporation and burning. A high flash point is therefore needed, but care should be taken not to use oils with too high a flash point owing to the influence of the cooling water in cylinder jackets. This cooling effect on oils of high flashing point lends to thicken them increasing the friction of oil itself.

On the other hand, an oil with too low flash point, evaporates quickly and is extremely detrimental. The oil film temperature itself, along cylinder walls, is from 180 to 300 degrees Fahr. and viscosity is an essential on this account. Carbon deposits can be traced to use of oil with too low a flash point, excess of fixed oil proportion or in most cases to excessive oil feed.

## Practical Considerations.

Continued friction in or on a bearing causes heat to be generated, which heat the bearing metals will absorb to a limited extent. Where, however, the generated heat exceeds that capable of being radiated, the metals expand until they bind or seize By the application of suitable lubricants, this tendency is minimised, the viscosity of the oil keeping the metals apart and the oiliness retaining the film by physico-chemical union with metals; the evaporation of the lubricant radiates the heat as it is generated and keeps the bearing cool.

Hot bearings, then, may be directly attributable to the absence of one or more of the three essentials for efficient lubrication. In the case of viscosity, this is dependent upon pressure obtaining and heat of surrounding parts. As regards pressure, a light oil pressure with subsequent lighter viscosity required is about 50 lb., while heavy oil pressures may be reckned as 1,000 lbs.

If the viscosity of film forming capacity is not correct, the oil squeezes out and causes non-lubrication. Steady loads as in a fly-wheel allow of pressures of about 500 lbs. and the oil film is more easily broken than in a variable load such as a crank pin or wrist pin, the former standing twice and the latter three times as much pressure than a steady load without danger of disrupting the oil film.

The incorrect design of bearing may cause abnormal pressure and destroy the oil film as quickly as if the oil used was not viscous enough; the incorrect application can also create a hot bearing or neck, and the all essential oil film can readily be broken with subsequent overheating by the presence of grit or a surface crack in the metal. Pressure can be minimised by slightly slackening the top cap and the hot bearing cooled by applying a fatty oil whose viscosity is not affected over much by temperature; olive and rape oils are good in this respect, though tallow is perhaps the most readily applied. Persistent heating is best neutralised by applying a steam of water on bearings of secondary importance, the water should be soapy and mixed with plumbago or thick oil; white lead and oil may help in some cases where a bearing is running in itself. Where the oiliness of the lubricant is at fault, heating may not take place to any marked degree, but friction can be considerably lessened by changing to a more suitable lubricant.

Often a bearing will heat by reason of insufficient radiation allowing the generated heat to be absorbed by the metals instead of being carried away. Constant application of oil by pump is best to cure this fault and if the bearing is already fed by pump, the latter should be speeded up to pass more oil through per minute, no more oil is used but fresh and cooler applications of the same.

## Testing Fresh Oils.

To try out a fresh type of oil and note its effect of application as friction reducing agent as against an oil in use, calls for much care and observation. From actual noted conditions it has been found that by changing from grease lubrication to good oil, has lessened friction by 20 per cent and heating of parts by over 30 per cent. An oil cannot be judged just by examination of lubricated shaft or machine parts; scars, ridges, or worn parts cannot be put down to use of unsuitable oils but by non-application or too little application of oil being used. Often, too, the above results come from mixing graphite, silica, or other solid lubricants with the oil. Solid lubricants merely fill in the metallic pores and produce a smoothness which while perhaps improving the metal surface cannot possibly carry away the frictional heat being constantly generated. Bad engine packings, overheated in vulcanising may eventually become brittle and contaminate the oil being used. Changing over from a poor oil to a good one may cause dislodging of gummy deposits from the previously used oil and can thus lead to incorrect judgment. It is advisable to run in fresh oil gradually, say over a period of one month, using 25 per cent new oil first week, 50 per cent second week, and so on; further it is an advantage to use a little more of the new oil than necessary until all necks are clean again.

When changing from one oil to another in the case of an engine, often the cleaning out of sight feed lubricators by steam, dislodges fatty acids and deposits, causing subsequent drag and groaning; benzine is best to use for cleaning the oil feed parts. The amount of oil used and price paid over a given period should be first checked, as should also the cost of producing the power generated over that period. A friction diagram can be taken with engine and shafting running, temperature of rooms and temperature of bearings being also noted. After running in the new oils and letting them settle down for about two months, a friction diagram under similar conditions can then be recorded and differences, if any, noted; if the fresh oils are better than it is readily seen. If the difference is in favour of the fresh oil used as indicated by engine diagrams, then they may be used until comparative costing figures can be obtained as against the cost figures of old oils. One actual test resulted as follows :—

| | |
|---|---|
| Light engine load with previous oil .. .. .. | 94.2 i.h.p. |
| Light engine load with new oil .. .. .. | 41.4 i.h.p. |

Reduction in power was 56 per cent; the temperature of slides above room heat was reduced from 33 degrees to 12.5 degrees, being a reduction of 63 per cent. Cost of lubrication was reduced by 19 per cent.

Electric motor drive tests should record horse power of motor, direct or alternating current, voltage and revolutions, temperature and humidity of rooms, temperature of shaft and bearings; the current used in each case can be recorded by interposition of special meter in circuit.

Gas engine testing should record brake horse power of engine, producer or town gas, engine revolution, shafting revolutions, explosions and meter readings; temperature of bearings can be recorded by piece of putty on bearing holding thermoneter.

## Preparation of Lubricating Oils.

Finally, it may not be out of place to give a general outline of the derivation and preparation of oils used for lubricating purposes. Oil is the name given to fluids which remain liquid at very wide temperatures and lubricant is of latin origin, meaning slippery.

Dealing briefly with fixed oils first, their lubricating properties depend upon the presence of olec and palmitic acid fats, the stearic acid fats being unable to vapourise by frictional heat and are left as gumming deposits. Lard oil is obtained from the hog and contains the three essential fats in varying proportions. Tallow oils are obtained from sheep and oxen and contain 70 per cent of stearic and palmitic acid fats with 30 per cent of olein. Neatsfoot oils are obtained from the feet of cows and horses and in use deposits stearin. Sperm oils from the sperm whale contain ceticelaic acids, stearic, and myristic. Castor oil is obtained from the castor oil plant and consists of ricinoleic and stearic acids. It will not mix with mineral oils pure and becomes thick and gummy when in use. Rape oil is from the turnip, the first pressing of the seeds yielding colza oil, the second pressing yielding rape.

In the preparation of those oils, the fatty acids can be precipitated by the action of heat rendering, pressing, or using a solvent; they are subsequently treated with sulphuric acid, caustic soda, and magnesia, Mineral oils are obtained from certain crudes, lignite, shales, and petroleum, their viscosity depending upon quality of paraffin wax, and lubricating properties upon possession of unsaturated hydro-carbons.

Certain crudes are best for certain uses, Franklin county oils being best for use on refrigerating machinery; Russian crudes containing no paraffin wax, produce inferior lubricating oils. After selection of crude, distillation takes place at a very high temperature, uncondensable gases passing over and then a series of light hydro-carbon compounds termed benzines. Burning oils are then collected and the residum form basis for lubricating oils; the destructive process of distillation is employed to obtain a large amount of paraffin, the lubricating oils being regarded as a by-product. The high temperatures decompose the lubricating oils partially and destroy the essential hydro-carbons. These oils or the mineral oil residum are treated with sulphuric acid and then washed with caustic soda to neutralise.

The best process of distillation is where the residum left after burning oils are liberated is collected into tall vessels surrounded by steam. The impurities liberated by scorching influence of oil against heated stills, are allowed to settle and the natural hydro-carbons are uninjured. The distillation products of this, the vacuum system, are lighter in colour and are best for steam cylinder lubrication.

**Suggested Consumption of Oils for Textile Machinery.**

| Departments. | Oiling Period. | Quantity Required ozs. | Maximum Estimated consumption per machine per month lbs. | Remarks. |
|---|---|---|---|---|
| **"Blow Room"** | | | | |
| 1. Bale Breaker with elevating lattice | Daily | 1½ | 2½ | |
| 1. Hopper Feeder Combined with porcupine | ,, | 3 | 5 | |
| 1. Mixing Lattice, 40 ft. long | Weekly | 4 | 6½ | |
| 1. Exhaust opener with lap. | Daily. | 3 | 5 | |
| 1. Crighton opener with Dust Trunk | ,, | 5 | 8⅛ | |
| 1. Scutcher | ,, | 3 | 5 | |
| 1. Roving waste opener | ,, | 1 | 1⅝ | |
| 1. Thread Extractor | ,, | 1 | 1⅝ | |
| 1. Willow Machine | ,, | 2 | 3¼ | |
| **"Card Department"** | | | | |
| Comb Box | Daily | (average) 1 | 1⅝ | |
| Licker-in Card cylinder & doffer cylinder bearings. | ,, | ½ | ozs 13 | |
| Licker-in card cylinder & doffer cylinder bearings | Weekly | as required | about 12 ozs. | |
| Other slow-running bearings | Twice weekly | 1 | ozs. 8 | |
| Cam gear for one card | Weekly | ½ | ,, 2 | |
| **"Frame Department"** | | | | |
| Drawing Frame of three heads and 8 deliveries. Engine parts—main shaft bearings | | | | |
| Coiler shaft bearings, calender roller bearings, spur and meter bevel studs | Daily | 4 | 6½ | |
| Saddle hooks roller necks | ,, | 2½ | 4 | |
| Can gear sliver guide plate bearings Oscillating shaft bearing, clearer Cloth roller bearings & flats | Weekly | 10 | 2½ | |
| Loose bose arbors | alternate days. | 2 | 1⅝ | |
| Grease for gearing | Fortnightly | ½ | ozs. 1 | |
| **"Slubbing Department"** | | | | |
| Engine parts except gear teeth | Daily | 2 | 3¼ | |
| Saddle hooks, roller necks | Alternate days. | 2½ | 2 | |
| Spindle Shaft bearing, bobbin shaft bearing and lifter shaft bearings. | Fortnightly | 3 | ozs. 6 | |
| Balance weight slides, Balance weight pulleys, starting handle pins Sliver guide plate bearings | Weekly | 3 | ozs. 12 | |
| Long collar bobbin wheels | Weekly | 4 | 1 | |
| Footstep bearings | Fortnightly | 5 | ozs. 10 | |
| Loose boss arbors | Twice a week | 1½ | ozs 12 | |
| Grease for gearing | Fortnightly | 2½ | ozs 5 | |

**"Suggested Consumption of oils for Textile Machine."**

| Departments. | Oiling Period. | Quantity Required ozs. | Meximum Estimated consumption per machine per month lbs. | Remarks. |
|---|---|---|---|---|
| **"Intermediate Frame."** | | | | |
| Engine parts, except gear teeth | Daily | 2 | 3¼ | |
| Saddle hooks roller necks | Alternate days. | 2½ | 2 | |
| Spindle shaft bearings, bobbin Shaft bearings, lifter shaft bearings | Fortnightly | 3 | ozs. 6 | |
| Balance weight slides, Balance weight pulleys, starting handle pins, Sliver guide plate bearings | Weekly | 3 | ozs. 12 | |
| Long collars bobbin wheels | Weekly | 4 | 1 | |
| Footstep bearings | Fortnightly | 5 | ozs. 10 | |
| Loose boss arbors | Twice a week | 1½ | ozs. 12 | |
| Grease for Gearing | Fortnightly | 2½ | ozs. 5 | |
| **"Roving Frame"** | | | | |
| Engine parts except gear teeth | Daily | 2 | 3¼ | |
| Saddle hooks roller necks | Alternate days | 2½ | 2 | |
| Spindle shaft bearings, bobbin shaft bearings, lifter shaft bearings | Fortnightly | 3 | ozs. 6 | |
| Balance weight slides, balance weight pulleys, starting handle pins sliver guide plate bearings | Weekly | 3 | ozs 12 | |
| Long collar bobbin wheel | Weekly | 4 | 1 | |
| Footstep bearings | Fortnightly | 5 | ozs. 10 | |
| Loose boss arbors | Weekly | 1½ | ozs. 6 | |
| Grease for gearing | Fortnightly | 2½ | ozs. 5 | |
| **"Ring Frame"** | | | | |
| Frame end | Daily | ½ | ozs. 13 | |
| Middle tin-roller bearings | Alternate days | 1½ | 1¼ | |
| Saddle hooks roller necks | Weekly | 4 | 1 | |
| Loose boss arbors | Weekly | 1½ | ozs. 6 | |
| Gallows pulleys bearings | Varies with types. | | about 1 | |
| Grease for gearing | Fortnightly | 2 | ozs 4 | |
| Filling 1000 spindles bolsters after pumping | once in 3 months. | .14 | | per spindle. |
| Oiling 1000 Spindles bolsters between pumping | once in 4 weeks | .07 | | per spindle. |
| **"Grey Winding"** | | | | |
| General Lubrication | Twice weekly | 2½ | 1¼ | |
| Spindles. | once in 3 months | .07 | | per spindle. |
| **"Universal Winding"** | | | | |
| Transmission shaft. | Twice weekly. | 1½ | ozs. 12 | |
| Spindle mechanism boxes | as required | | | |

**" Suggested Consumption of oils for Textile Machinery "**

| Departments. | Oiling Period | Quantity Required ozs. | Maximum Estimated consumption per machine per month lbs. | Remarks. |
|---|---|---|---|---|
| **" Warping Machine "** | | | | |
| Slow Speed machine | Alternate days | 1 | ozs. 12 | |
| High Speed machine | Daily | 1 | 1¾ | |
| **" Sizing Machine "** | | | | |
| General oiling | Daily | 4 | 9 | depending on method of application |
| Steam heated drum bearings | | | 1 | depending on method of application |
| **" Loom "** | | | | |
| Lubrication of important bearings Crankshaft and Tappet shaft | Daily | ¾ | 1⅜ | |
| After cleaning complete lubrication | Weekly | 1½ | ozs. 6 | |
| General lubrication when beam is removed. | Fortnightly | 1½ | ozs. 3 | |
| Grease pure mineral for beam ruffles | Fortnightly | ½ | ozs. 1 | |
| Loom Spindle | Hourly | 1 per week | ozs. 4 | |
| **" Finishing "** | | | | |
| 21 Cylinder Finishing Machine | Daily | 3 lbs. | 78 | |
| Calendering (general lubrication) | Daily | 4 | 6½ | |
| Damping ( ,, ,, ) | ,, | 2 | 3¼ | |
| Plaiting ( ,, ,, ) | ,, | 1½ | 2½ | |
| Stamping ( ,, ,, ) | ,, | 1 | 1¾ | |
| Baling Press Pump ( ,, ,, ) | ,, | 6 | 9¾ | |
| Press Ram | Monthly | 8 | ozs. 8 | |

All the above consumption figures and periods of oiling are based on a 26 day working month, 9 hours per day. The figures are to be considered as maximum and should not be exceeded when using high quality oils.

Under average operating conditions, with a good quality compounded cylinder oil (suitable for the conditions, e.g. pressure, temperature, steam quality, load etc.) consumption should not exceed 1 lb. per do day of 9 hours. For main bearings 180 to 200 pounds for an engine of 800 to 1000 H.P.

For Shaftings—Ring oil 1 gallon per bearing per year.

## Horse Power, of Cotton Spinning and Manufacturing Machinery.

Horse Power required in the process of cotton manufacturing may be taken approximately as follows :—

Horse power depends upon the following factors (*a*) Speed (*b*) Load (*c*) Friction.

In the case of frictions the following points must be given due considerations.

(*a*) Design of machine (*b*) Nature of work (*c*) Kind of metal (*d*) weight of metal (*e*) change of load (*f*) wear and tear of machine (*g*) Drive whether ball bearing or otherwise.

The H.P. losses in a new and up to date mill due to friction, (power absorbed by main and counter shafts) may be taken as 15 per cent. But in an old mill it will be found to vary from 18 to 35 per cent. If the machine is motor driven an allowance of 20 per cent should be made for starting torque and motor efficiency.

| Kind of Machinery. | No. of Spindles or Drums. | I.H.P. | Remarks. |
|---|---|---|---|
| Single cylinder seed coton opener .. .. | | 2 | |
| Double cylinder seed cotton opener .. .. | | 3½ | |
| Single action McCarthy Gin. .. .. .. | | 2½ | |
| Double action McCarthy Gin. .. .. .. | | 2 | |
| Double Roller Cotton Gin. .. .. .. | | 3 | |
| Cotton Baling Press. .. ... .. .. | | 80 to 100 | |
| Roving waste opener .. .. .. .. | | 3 | |
| Thread Extractor. .. .. .. .. .. | | 1 | |
| Willow Machine. .. .. .. .. .. | | 3 | |
| Hopper Bale Breaker or Bale opener. .. .. | | 3 | |
| Mixing Lattices for each 90 to 100 ft. .. .. | | 1 | |
| Automatic Dust Trunk .. .. .. .. | | ¼ | |
| Automatic Feeding Machine .. .. .. | | 1 | |
| Hopper Feeder .. .. .. .. .. | | 2 | |
| Porcupine Opener .. .. .. .. .. | | 2 | |
| Vertical Beater (creighton) Opener with improved cotton feeding machine .. .. | | 6 | |
| Double Creighton opener .. .. .. .. | | 8.5 | |
| Double Creighton opener with Scutcher and Lap Machine .. .. .. .. .. | | 11.5 | |
| Single Creighton opener with Scutcher and Lap machine .. .. .. .. .. | | 9 | |
| Single Creighton opener with mouth piece delivery .. .. .. .. .. | | 3.5 | |

| Kind of Machinery | No. of Spindles or Drums. | I.H.P. | Remarks. |
|---|---|---|---|
| Single Creight opener without improved feeding machine .. .. .. .. .. | | 4 | |
| Exhaust Opener and Lap machine .. .. | | 8 | |
| Exhaust opener with Scutcher and Lap Machine. .. .. .. .. .. .. | | 10.5 | |
| Exhaust opener with Traverse Beater and 2 Dust cages and Lattise delivery | | 5.5 | |
| Horizontal cylinder (Buckley) and Lap Machine | | $9\frac{1}{2}$ to $13\frac{1}{2}$ | |
| Single Scutcher (Single Beater) 3 Bladed .. .. | | 4 | |
| Double Scutcher (Double Beater) 3 Bladed | | $7\frac{1}{2}$ | |
| The Flat Carding Engine- cylinder 50" .. .. | | $\frac{2}{3}$ to 1 | |
| Sliver Lap Machine. .. .. .. .. | | $\frac{1}{2}$ | |
| Ribbon Lap Machine. .. .. .. .. | | 1 | |
| Comber-- 6 heads. .. .. .. .. | | $\frac{3}{4}$ | |
| D×6 heads. .. .. .. .. | | $\frac{3}{4}$ | |
| D×8 heads. .. .. .. .. | | $\frac{7}{8}$ | |
| Drawing Frame 3 heads 10 deliveries .. .. | | 1 per 14 deliveries | $18\frac{1}{8}$" Staff |
| Slubbing Frame. .. .. .. .. .. | 104 | 1 | |
| Intermediate Frame .. .. .. .. | 142 | 1 | |
| Roving Frame. .. .. .. .. .. | 176 | 1 | |
| Fine Jack Frame. .. .. .. .. .. | 176 | 1 | per 70 spindles. |
| Ring Spinning Fram - 5" Lift. .. .. .. | 400 | 1 | " 35 " |
| Ring Doubler.. .. .. .. .. .. | 300 | 1 | |
| S. A. Mule 17" spindle $1\frac{3}{8}$" gauge .. .. .. | 175 | 1 | |
| Cop reels (for 8 reels.) .. .. .. .. | 60/100 | 1 | |
| Yarn Bundling Press .. .. .. .. | | $\frac{1}{2}$ | |
| Hydraulic Press 14" Ram .. .. .. | | 10 | |
| Tubular Banding Machine .. .. .. .. | | $\frac{1}{2}$ | |
| Zig Zag Willow. .. .. .. .. .. | | 6 | |
| Hard waste Breaking-up machine .. .. | | 5 to 6 | per cylinder |
| The Tatham Preparing Machine .. .. .. | | 12 to 18 | |
| Saw Tooth Hard waste opener .. .. .. | | 5 | |
| Soft waste opening machine .. .. .. | | 3 | |
| The Super grid Area Porcupine Opener with Shirley Patent High Speed Dust Extracting Cage .. .. | | 3 to 4 | |
| Derby Doubler .. .. .. .. .. | | $\frac{1}{2}$ to $\frac{3}{4}$ | |
| Finisher Card for waste .. .. .. .. | | 2 | |
| Breaker card for waste .. .. .. .. | | 4 | |
| Mule for waste .. .. .. .. .. | 720 | 7.5 | |
| Gassing Frame .. .. .. .. .. | 80 | $\frac{1}{2}$ | |
| Winding Frame (Grey) .. .. .. .. | 300 | 1 | |
| Drum Winding Frame (Colour) .. .. .. | 60 | $\frac{1}{2}$ | |
| Pirn Winding Frame (Leesona) .. .. .. | 10 | $\frac{1}{4}$ | |
| Cheese Winding Frame .. .. .. .. | | $\frac{1}{2}$ | |
| Warping Machine for six- .. .. .. | | 1 | |
| Slashing machine 72"×48" cylinder .. .. | | $1\frac{1}{2}$ | |
| Flour Sq. Beck .. .. .. .. .. | | $\frac{1}{2}$ | |
| Size Sq. Beck. .. .. .. .. .. | | $\frac{1}{2}$ | |
| Clay circular Pan .. .. .. .. .. | | $\frac{1}{4}$ | |
| Loom (plain) 50" R. S. ( 3 to 4 — .. .. | | 1 | |
| Do (Drop Box) 50" R.S. 3 - .. .. | | 1 | |
| Do (Jacquard) 72" 2 to 3 -- .. .. | | 1 | |
| Cloth Inspecting Table .. .. .. .. | | $\frac{1}{8}$ | |
| Cloth Folding Machine .. .. .. .. | | $\frac{1}{2}$ | |
| Shearing & Brushing machine .. .. .. | | 3 | |

| Kind of Machinery. | No. of Spindles or Drums. | I.H.P. | Remarks. |
|---|---|---|---|
| Sewing Machine .. .. .. .. .. | | ¼ | |
| Damping Machine .. .. .. .. .. | | 2 | |
| Calendar Machine (7 Bowl) .. .. .. | | 56 | |
| Do do (5 ,, Friction) .. .. | | 60 | |
| Do Do (4 Bowl) .. .. .. | | 48 | |
| Do Do (3 Bowl Friction) .. .. | | 48 | |
| Cylinder Finishing Machine .. .. .. | | 10 | |
| Stentering Range .. .. .. .. .. | | 5 | |
| Cloth Bundling Press 4″ Ram .. .. .. | | 1½ | |
| Stamping Machine .. .. .. .. .. | | 1 | |
| Cloth Press Hydraulic 14″ Ram .. .. .. | | 10 | |
| Humidifier Pump (Vortex) 1 covers 500 to 600 Sq. ft. -- 12 looms .. .. .. | | 65 | |
| Compresser Supplying 50 heads at 50 lbs. per sq. inch. .. .. .. .. | | 3·5 | |
| Gutter Spray pump .. .. .. .. | | 9 | |
| Gutter air pump .. .. .. .. .. | | 6 | |
| Singing Machine .. .. .. .. .. | | 8 | |
| Kier .. .. .. .. .. .. | | 5 | |
| Chlorine Dissolver .. .. .. .. .. | | 1 | |
| Slack Washing Machine .. .. .. .. | | 10 | |
| Bleachers Liming, Chemicing, Souring, .. .. and Washing machine .. .. .. .. | | 4 | |
| Hydro Extractor .. .. .. .. .. | | 8 | |
| Dye Jiggers .. .. .. .. .. .. | | ¾ | |
| Padding Machine .. .. .. .. .. | | 3 | |
| Mercerising of Piece goods .. .. .. | | 16 | |

**Cotton Spinning Machinery Horse Power Transmitted.**

| Type of Machine | Pulley Driver | Pulley Driven | Belt | Revolutions Driver | Belt speed Feet per Minute. | Horse Power Transmitted. |
|---|---|---|---|---|---|---|
| Bale Breaker | 21½″ | 36″ | L 4″ | 250 | 1407 | 7·44 |
| ,, ,, | 36″ | 17″ | ,, 4″ | 149 | 1402 | 7·44 |
| Hopper Feeder | 30″ | 20″ | ,, 4″ | 250 | 1962 | 10.00 |
| ,, ,, | 10″ | 20″ | ,, 3″ | 375 | 978 | 3·90 |
| Vertical Opener | 28″ | 12″ | R ¾″ | 375 | 2748 | 13·40 |
| Porcupine | 35″ | 13″ | L 4″ | 375 | 3455 | 15·20 |
| Hopper Feeder | 29″ | 18″ | ,, 4″ | 250 | 1895 | 9.8 |
| Combined with opener | 36″ | 10″ | ,, 4″ | 402 | 3782 | 16.0 |
| Scutchers | 30″ | 20″ | ,,4½″ | 250 | 1962 | 11.25 |
| ,, | 35″ | 13″ | ,,4½″ | 375 | 3435 | 15·60 |
| ,, | 30″ | 20″ | ,,4½″ | 250 | 1962 | 11.25 |
| ,, | 40″ | 13″ | ,, 4″ | 375 | 5922 | 16.80 |
| ,, | 35″ | 13″ | ,, 4″ | 375 | 3435 | 15·60 |
| Rove Breaker | 24″ | 16″ | ,, 5″ | 250 | 1570 | 15·00 |
| ,, ,, | ,, | 11¾″ | ,, 5″ | 375 | 2355 | 21.00 |
| Thread Extractor | 10¼″ | 12″ | ,, 3″ | 250 | 670 | 2.70 |
| ,, ,, | 15″ | 8″ | ,, 3″ | 250 | 980 | 4.00 |
| Willow Machine | 20″ | 16″ | ,, 4″ | 250 | 1312 | 6.90 |
| Hard Waste | 32″ | 18″ | ,, 5″ | 250 | 2092 | 18.50 |
| Breaker 6 cylinders | 26¾″ | 14″ | ,, 5″ | 441 | 3108 | 28.00 |
| Breaker card | 14″ | 22″ | ,, 3″ | 130 | 476 | 1.8 |
| ,, ,, | 14″ | 20″ | ,, 3″ | 130 | 476 | 1.8 |
| Derby Doubler | 28″ | 12¼″ | ,, 2″ | 130 | 950 | 2.6 |
| Roving | 40″ | 22″ | ,, 6″ | 130 | 1359 | 13.6 |
| ,, | 28″ | 14″ | ,, 3″ | 236 | 1729 | 6.69 |
| Ring Frames | 31½″ | 17″ | R 1″ | 130 | 1072 | 9.00 |
| ,, ,, | 36″ | 15½″ | L 3½″ | 242 | 2277 | 10.50 |
| Flat card | 13″ | 19″ | ,, 3″ | 250 | 852 | 3·30 |
| Drawing | 22″ | 14″ | ,, 3″ | 250 | 1427 | 5·50 |
| Slubbing | 22″ | 13½″ | ,, 3″ | 250 | 1437 | 5·58 |
| Inter | 22″ | 11″ | L 3½″ | 250 | 1437 | 7·44 |
| Roving | 22″ | 12″ | L 3½″ | 250 | 1437 | 7·44 |
| Ring Frames | 40″ | varying | ,, 3″ | 250 | 2615 | 11.25 |

**Cloth Manufacturing Machinery Horse Power Transmitted.**

| Type of Machinery | Pulleys Driver | Pulleys Driven | Belt | Revolutions Driver. | Belt speed Feet per Minute. | Horse Power Transmitted |
|---|---|---|---|---|---|---|
| Winding | 12″ | 11″ | L 2½″ | 165 | 518 | 1.36 |
| Universal Winding | 22″ | 8″ | ,, 3″ | 165 | 950 | 3.9 |
| Warping | 11″ | 16″ | L 2″ | 67 | 190 | 0.50 |
| Sizing | 18″ | 16″ | ,, 3″ | 165 | 775 | 3.00 |
| Looms | 14″ | varying | ,, 2″ | 165 | 600 | 1.60 |
| Plaiting | 16″ | 13¾″ | ,, 2″ | 165 | 690 | 1.60 |
| Damper | 11″ | 15″ | ,, 3″ | 165 | 475 | 1.80 |
| Hydraulic Press Pump | 30″ | 30″ | ,, 6″ | 206 | 1590 | 12.60 |
| Calender | 63″ | 60″ | R 1″ | 165 | 2700 | 45 |

# CHAPTER XIV.

## COTTON.

There is perhaps no other single commodity that has had such a determining effect on the world's history. It has helped to bring civilization and prosperity to many peoples. Its importance has spread into every corner of the modern world. It has opened the channels of International trade and laid the foundation of modern industry.

The conception of cotton as a form of wool survives in the German name for cotton, which is 'Baumwolle', or tree wool. The Arabs, who were the great cotton goods traders of ancient times, and who introduced the cultivation of cotton and manufacture of cotton cloths into the Levant and Europe, called it 'qutum,' from which the word cotton is derived.

Opinions as to the origin of cotton are as numerous as they are contradictory. Cotton having now become one of the world's most important products, Scientist of every country have attempted, by analysis of historical documents, to throw some light on the mystery which surrounds the birth of this fibre and its early developments.

Cotton, the 'wool tree' of the ancients, the 'gossypium' of botany, appears to have had a double origin in Africa and Asia. Reliable historians, such as Herodotus, testify to the existence of cotton plantations in India, the shores of the Persian Gulf and in Arabia, as far back as the fifth century B.C., while in the fourth century B.C. Theophrastus, another ancient historian, gives the first description of the methods of cotton cultivation in those regions.

Between 80 and 90 per cent of the cotton fibre is pure cellulose. The remainder is made up of water, nitrogen—free extract, protein and a vegetable fat known as 'cotton wax.'

If one were to perceive the cotton fibres under a microscope, he, would simply wonder at the similarity of one fibre to another and the construction of the fibre which resembles minature cork-screws. It is well for the trade that they do, otherwise they would be of little use commercially when twisted together the fibres lock by virtue of the spiral character of their construction, ripe fibre having more turns than the unripe. The length of the cotton fibre varies considerably, in Sea Island cotton it reaches nearly 2¼ inches, but in Indian cottons it is often met with under an inch in length. The diameter is small, and ranges from 0.00046 to 0.001 of an inch.

The cotton fibre will support a weight from 75 to 300 grains, the fibres having the largest diameters being usually the Strongest.

The three countries where cotton is grown in a large bulk are as follows.

| | |
|---|---|
| U. S. A. .. .. .. .. .. | 55 per cent. |
| India .. .. .. .. .. | 20 ,, ,, |
| Egypt .. .. .. .. .. | 9 ,, ,, |
| Other Countries .. .. .. .. | 16 ,, ,, |
| | 100 per cent. |

Raw cotton is a staple product and the markets for it are very highly organised and it is grown in the United States of America, India, Egypt, China, Corea and South America.

India ranks next to America as the second largest cotton producing country in the world so far as quality is concerned, the quantity raised being 50,00,000 to 60,00,000 bales annually, whereas the worlds' production is estimated at 27 million bales.

The World's consumption is annually about 24 million bales, out of which America contributes about 14 million bales. In addition to India, Egypt and Africa, particular y Uganda, Nigeria, and Sudan—are looked upon as the future sources for British supply the only difficulty being the opening of the interior and the shortage of labour.

The Egyptian crop is comparatively small, amounting to around 1,500,000 bales; but most of it is long staple cotton of fine quality. The gradual extension of irrigation will probably increase the size of the crop as time goes on.

No other country gives more attention to the raising of the standard of its cotton, its purity, clean ginning and proper baling than Egypt. Many mills in England have replaced American and other staple cottons by Egyptian Uppers and Zagora because of their physical advantages, their greater strength, absence of neps, higher production per Spindle, uniformity in quality, better baling. The increased takings of U.S.A. and other countries is a striking proof of the superiority of Egyptian cotton.

**Cotton in China**—Cotton was introduced into China from India in early times, but there are no records shewing the exact date. At present several million bales are produced and consumed annually. Since a larger part of this cotton is used in the home and does not reach the market, it is impossible to get any reliable data on the amount produced.

**Japan**—Japan proper produces very little cotton, but she has become a great manufacturing country, her mills containing more than 9,000,000 spindles and consuming annually more than 3,500,000 bales of cotton. The major portion of this yield comes from India and the United States.

Of late years, energetic efforts are also made by France, Italy, and Belgium, to stimulate cotton-growing in their Colonies.

America being the largest producer and consumer of cotton in the world, and still supplying more than half of the world's consumption, is able to dictate the prices, and all the cotton markets of the world are guided by the New York rates. To some extent the fluctuation of prices depend upon the acreage of cotton grown; but cotton is as susceptible to weather condition and epidemics of insect pests that considerable variation in the size of crop from year to year cannot well be avoided.

## Yield of Cotton per Acre of Land.

The yield per acre in India is about 90 lbs. of Lint Cotton. Whereas in America it is 200 lbs of Lint Cotton per acre and in Egypt it is 400 lbs. of lint cotton per acre. In Egypt during the year 1937 the average yield per feddan in cantars was about 5.57.

In India out of a total cultivated area of about 300 million acres, no less than 25 million acres, or some 8 per cent. are sown under cotton.

Much of this area consists of very fertile land, but the climate is not so favourable as that prevailing in American Cotton Belt. A part of the area has scanty rainfall, whereas other parts have too much—as much as 500 inches per annum in some places. The

Deccan or central India, is the great cotton section in the country. It is an elevated tableland, with splendid fertile soil which holds moisture well.

Nearly half of the cotton produced is utilised in India's 365 mills which employ about 4,15,000 hands, the remainder is exported to foreign countries such as England, Japan, Germany, and Italy.

For the surplus, which India exports, Japan is one of the best customers, but at the same time Japanese mills are the fiercest competitors of the Indian textile industry. At one moment this state of affairs threatened to lead to an economic war between the two countries, but mutual interest has brought about an understanding, by which the Japanese are allowed to export to India a certain quota of the country's consumption in cotton goods, binding themselves on the other hand to purchase cotton for approximately the equivalent amount.

## Uses of Cotton.

The many uses to which the cotton fibre is now applied have enormously enhanced its commercial value. To regard cotton only as the raw material for the clothing of mankind would be a serious misconception. The bulk of the world's cotton crop is used for this purpose, but its employment does not end here. Cotton is used in mechanical appliances; also cotton is a powerful explosive. Air craft for its structure draws upon the best qualities of cotton; as well as types for Motor Vehicles. Cotton is also extensively used in surgery; it is used as a covering for electric and telephone wires, even dwelling homes are largely furnished with it. Cotton is a very adaptable material, and therefore a commodity of the greatest value.

Whether we look to the agricultural, the trade or the industrial side, a large number of people in India earn their livelihood by work on cotton and their welfare depends entirely upon the condition of the crop and the prosperity of the cotton trade and industry. Cotton is easily the foremost organised industry in India.

Between the finest and poorest classes of cotton, there is a considerable difference. The length of the cotton fibres, fineness, regularity and strength vary very considerably. The reasons are carelessness in cultivation, faulty ginning, sand and dust mixed in the cotton, and negligence in picking and storing the crops.

Indian cotton is the cheapest, but needs continual attention. Left to itself it deteriorates in quality owing to the mixing of seeds in the fields and the ginneries which gives rise to undesirable hybrids. Moreover, it is not only highly susceptible to climatic and environment but also falls an easy prey to a host of pests and diseases. The cotton growers have to be, therefore untiring in their efforts to evolve improved varieties, which, in a given area, could resist the onslaught of pests and diseases, give a higher yield and ginning out-turn or should mark an improvement in staple over the already established cotton.

## Varieties of World's Cotton and Their Classification.

The best cotton of all is the Sea Island, grown on the Islands off Charelston, South Carolina, and also in the West Indies. It is 2″ and more in staple. The fibre is fine, soft, silky, long, and regular. The American Variety of Sea Island cotton is the best. The Fiji and Tahiti varieties of this cotton are uncertain in their staple.

The total quantity of Sea Island crop is very small, viz., about 10,000 bales of Sea Island, America, and 5000 bales of West Indies, but their value is very high. The best Sea Island can be spun as high as 300.

Next in grade is that grown in Georgia and Florida, and the best Egyptian grade Sakel.

Egyptian is next to Sea Island for the spinning of fine yarns. It is silky, strong, and tough.

The brown Egyptian is generally soft, whilst the white Egyptian is hard and harsh. The staple of Egyptian cottons ranges from $1\frac{1}{8}$ to $1\frac{1}{2}$ inches.

Several varieties of Egyptian cotton are known to the market, the most familiar being Sakellaridis, Mitafifi, Ashmouni and Abassi. The bulk of the Egyptian crop is Sakellaridis, while more than half the remainder is Ashmouni. Mitafifi used to be the most important of Egyptian varieties, but it has become of comparatively little importance in recent years. The total crop averages over 1,000,000, bales. Egyptian cotton is mostly used for autombile tires, lace fine hosiery and knited underwear, nainsooks, voiles, organdies and muslins.

In the third grade comes Peruvian and some of the best African cotton. The great bulk of the World's cotton—supply consists of the ordinary American Upland Crop, amounting to about 55 per cent. of the whole world's supply.

**"Finally, Indian and Chinese Cotton."**....The cotton is produced as far North as Peshawar and as far South as Tuticorin; the Westerly limit is the sea, the eastern—most the chinese frontier. Cotton production is mainly limited to that portion of India which lies west of a line drawn through Madras and Lucknow and the greatest concentration is in the famous black-cotton soil area at the head of the Peninsula. The diversity of sowing and picking times is as great. Cotton is being sown in some part of India in every month from March to December and pickings are taking place in one district or another in every month in the year. It is possible, however, to recognise three main sowing periods, viz., the premonsoon sowing with irrigation in Northern India commencing at the end of March and reaching a height in May, the monsoon sowing in all except the Southern areas depending on the advent of the monsoon but ranging approximately from mid -June to the end of July and the Southerns Sowing from August to December. The main crop is Northern India is picked between September and January; Broachs, Surats and Dholleras from January to April and Southerns from February to July. The range of varieties is almost as great.

In Southern India some growers commence picking at day-break with a view to minmizing brittleness accentuated by the Sun. It is very strange to say that cotton gathered during the early hours of the day would almost certainly be cleaner, since dew and moisture in the cooler air must keep down the dust which in some part of India is really appalling, if not a menace.

## Cultivation of the Cotton Plant in India.

The cultivation of the cotton plant in India is not only conducted on every primitive lines but is not favoured by climatic condition so much as is the case in the other part of the world. The high temperature forces the plant to maturity too early and there is in general a lack of sufficient moisture to sustain the growth properly. The result is a fibre of inferior quality. The land is prepared by hand before the break of the monsoon and in most districts planting begins 3 or 4 weeks later, that is, after the breaking of the monsoon which travels from south to north.

The immature fibre is transparent and has glossy appearance so that when it exists in any quantity in a bale of cotton, it can readily be detected with the naked eye. It has the feature of not taking dye so readily as ripened cotton. Immature and dead fibres are due to insufficient nourishment from the rest of the plant. If the fibre is examined under a very powerful microscope, the cotton fibre is found to consist of four distinct membranes or layers of matter. Ignoring the removable foreign matter contained in raw cotton such as sand and other mineral substances, leaf, pieces of boll or stalk, and considering the fibre as being entirely cleared of this, it is found to be composed of cellulose, which is the largest constituent of the cotton fibre and retainer of moisture, permeated by a small amount of mineral matter and each fibre is surrounded by soluble substances present to the extent of from 1 to 2 per cent. The small amount of mineral matter may be liberated by burning the fibre. The inorganic matter remaining as an ash retaining more or less the formation of the fibre and having about 1% of the original weight that make up the complete fibre. Another test may be made by burning a small portion of the yarn or fibre. Cotton will be found to burn with a flash leaving a very light ash, while animal fibre such as silk and wool burn more slowly emitting an offensive odour and leaving a curled bead or globule of carbonised matter. Chemical tests may also be made by which the nature of the fibre can be determined without any doubt.

There is associated with the seed of the cotton fibre, and also to some extent with the fibre itself, a waxy oil, the quantity of which varies with the season and ripeness of the boll, varying between about 0.2 to 0.6 per cent. The presence of this oily wax to a greater or less extent resting upon the surface of the fibres and also in the cells, probably explains to some extent why we have to get a somewhat high temperature in cotton spinning room, which plays an exceedingly important part in many processes to which cotton is subjected in the manufacture of fabrics.

This, it is well known, is more essential for fine spinning than in the case of lower numbers. It will be readily conceived that with a low temperature the oil tends to solidify and become gummy, and hinders the perfect drawing of the fibre. Its presence in a liquefied form assists the natural moisture of the cotton fibre in making the latter more pliable and elastic, and rendering it more subject to the process of cotton manufacture. The diameter of a cotton fibre varies from .00046 to .001 inch and the length from ½ inch in the case of low Indian cotton to 2¼″ inches in sea island cotton. The strength of individual cotton fibres varies from 75 to 300 grs. according to the kind of cotton whether the cotton is fully matured or not, the distance between the points of suspension in making the test and the portion of the fibres selected for the test; usually the long fine fibres break with least strain and the short coarse fibres stand the greatest strain. The approximate breaking strains of four types of cotton fibres are as follows :—

| | | |
|---|---|---|
| East Indian or Surat's.. .. .. .. | 142 | grains |
| American .. .. .. .. .. | 127 | do. |
| Egyptian .. .. .. .. .. | 123 | do. |
| Sea Island .. .. .. .. .. | 85 | do. |

Single yarn is generally kept in a cold moist place where the natural oil becomes stiffened and dry after the high temperature to which it has been subjected in spinning and in the case of yarns for doubling purposes by subjecting them to a high temperature under steam pressure before the process of the doubling of threads, and also in the case of yarn for reeling for export or for sale.

## Ginning.

The first mechanical process to which the cotton is subjected is that of ginning. Cotton is picked by hand, it being quite impossible to pick the cotton without the seed, and it is left to the fairly brutal process of ginning to effect this separation of fibres.

Roller ginning is almost universally adopted in India. It may be added here that the modern Saw Gin, particularly with air blast instead of brush for stripping the saws, would give a cleaner lint and would not crush the seed and leaf to the extent that exists in the lint from the Roller Gin. The entire American Crop is saw—ginned.

The compressed bales of cotton received at a mill contain the bolls of the cotton plant, which have already been freed (by ginning) before baling of most of the seeds etc.

The proportion of seed to cotton fibre in Egyptian and Americans is 2 to 1, while in Indian cotton it is as high as 3 to 1 but in purified cotton it is 2 to 1 .

## Variety in the Indian Weights.

Variety in weights in different districts is an obstacle to the smooth working of the cotton trade. In the Bombay Presidency for the most part cotton is bought and sold on the basis of a Candy of 784 pounds.

In the South of the Presidency, the unit is the 'Nag' of 336 pounds. In Khandesh, the candy varies from 160 to 250 pounds, and the weight of the Maund varies from 42 pounds at Bodwad to 144 pounds at Dhulia and Amalner.

The Madras Candy is only 500 pounds, but in the 'Westerns' district, cotton is sold by the 'Nag' of 312 pounds.

In the United Provinces, the standard 'Maund' (generally used as Railway Maund) of $82\frac{2}{7}$ pounds is used for Kapas.

In the Punjab and Sind, both Kapas and Lint are sold per maund of $82\frac{2}{7}$ pounds.

In Nagpur, the Candy is of 784 pounds of Kapas. *As a rule the seed constitutes about two—thirds of the gross weight of seed cotton. The remainder is cotton lint. The proportion of lint to the gross weight of seed cotton is known as the 'ginning out—turn.'*

Weights

784 Pounds = 1 Kandy.
28 Pounds = 1 Maund.
4 Maunds = 1 Cwt.
7 Cwts = 1 Kandy or 2 Bales.
1 Bale weighs $3\frac{1}{2}$ cwt.

| | |
|---|---|
| 1 Kandy of Kapas | = 7 Maunds. |
| 1 Kapas Maund | = 168 pounds. |
| 1 Kapas Kandy | = 1176 pounds. |
| 1 Bale of cotton | = $\frac{1}{2}$ Kandy or 392 pounds. |
| 2 Bale of cotton | = 1 Kandy or 784 pounds. |

The percentage of seeds in 1 Kandy of Kapas = 40 to 60 per cent.

| | | |
|---|---|---|
| 11.65 pounds of Pressed cotton | = | 1 cubit ft. |
| 10 cubit ft. | = | 1 cwt. |
| 8.87 pounds of Loose ginned cotton | = | 1 cubit ft. |
| 12.6 cubit ft. | = | 1 cwt. |

---

Bengal Maund (or Railway Maund) is taken as standard weight i.e.,

| | | |
|---|---|---|
| 1 Maund | = | 40 Seers. |
| 1 Seer | = | 80 Tolas or 16 chataks. |
| 1 Tola (standard) | = | 180 Grains Troy. |
| 1 Seer | = | 2.057 pounds. |
| 1 Maund | = | 82.28 pounds. |

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Hoops of one bale weigh about 6½ pounds. Gunny (or Bardan) or wrapper of one bale weighs 1½ pounds. Hence the Tare of one bale is generally taken as 8 pounds approximately.

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The standard of weights for many countries in Europe is based on the Metric System, and calculations are made in Kilograms (kilos).

| | | |
|---|---|---|
| ¼ Kilo | = | 0.55 lb. |
| 1 Kilo | = | 2.20 lb. |
| 1 lb. | = | 0.45 Kilo. |
| 100 lbs. | = | 45.35 Kilos. |

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Lengths for cotton staple are in Millimetres, which are abbreviated as m/m.

A Metre being about 39.37 inches, a m/m equals 1000th part of it, i.e., about .04 inch. Thus, 28 m/m means 1.12 inches, equal to about 1⅛ inches.

EGYPT......One Feddan = 1.038 Acres.
One Cantar of ginned cotton = 99.05 lb.

**Chief Types of World's Cottons.**

| Description. | Spinning Count. | Staple | Dia: | Remarks. |
|---|---|---|---|---|
| South Carolina Island | 300s | 1¾" to 2" | | |
| West Indies .. .. | 300s | 2" and over | .00064 | Best Sea Island. |
| Egyptian : Sakel, Janovitch etc. .. .. | 150s | 1½" to 1¾" | | |
| American, Egyptian, Pinian and Meade .. | 120s | 1 11/16 to 1¾ | | |
| Egyptian: Affifi, Upress etc. .. .. | 70s | 1¼" to 1½" | | |
| Sudan .. .. .. | 100s | 1⅛" | | |
| Perivian .. .. .. | 60s | 1" to 1½" | .00078 | |
| Orleans .. .. .. | 60s | | | |
| East African and Uganda | 50s | 1" to 1¼" | | |
| Brazil .. .. .. | 50s | ¾" to 1¼" | .0008 | |
| American Texas and Upland .. .. | 40s | 1" to 1⅛" | | |
| Russian .. .. .. | 40s | 9/10 to 7⅛" | | |
| West African .. .. | 40s | 1" to 1⅛" | | |
| Indian: Hinginghat .. | | 1 1/16" | 1/1200 | Best, Light golden. |
| Broach.. .. | | ¾" to 1" | ,, | Deep colour, clean. |
| Oomras .. | | ½" to ⅞" | ,, | Dirty, but strong. |
| Dholleras .. | | ¾" to 1" | ,, | Dirty but strong, dull white. |
| Tinnevelly .. | | ⅞" to 1" | ,, | Dull cream, moderately clean |
| Dharwar .. | | ⅞" | ,, | Cream, irregular. |
| Madras .. | | ⅞" | 1/1175 | Dirty, moderately strong. |
| Comptah .. | | ⅞" | ,, | Dirty and weak. |
| Bengal .. | | ⅞" | ,, | Stong, harsh, dirty. |
| Scinde .. .. | | ⅝" | ,, | Dull white, weak. |

**Classification of Sea Island, Egyptian and American cotton.**

| Name of cotton. | Length of Staple in Inches. | Range of counts. |
|---|---|---|
| Sea Island .. .. | 1¼″ to 2¼″ | From 120s and upward, Warp and Weft. |
| Edisto .. .. .. | 1⅜″ to 2¼″ | ,, ,, ,, ,, ,, ,, ,, |
| Fiji .. .. .. | 1⅜″ to 2″ | Upto 200s, ,, ,, ,, |
| Tahiti .. .. .. | 1⅜″ to 2″ | ,, 200s, ,, ,, ,, |
| Florida .. .. .. | 1¼″ to 1⅞″ | [illegible]s, ,, ,, ,, |
| Peruvian S. I. .. .. | 1½″ | 50s, ,, ,, ,, |
| Egyptian .. .. | 1¼″ to 1½″ | ,, 150s, ,, ,, ,, |
| Gallini .. .. .. | 1½″ | ,, 150s, ,, ,, ,, |
| Abbasi .. .. .. | 1¼″ | From 50s to 100s, ,, ,, ,, |
| Brown .. .. .. | 1⅜″ | ,, 50s to 130s, ,, ,, ,, |
| White .. .. .. | 1¼″ | Upto 70s, ,, ,, ,, |
| Brazilian—Cera .. | 1″ to 1⅜″ | ,, 50s, warp. |
| Pernambuco .. .. | 1″ to 1⅜″ | ,, 50s, ,, |
| Pariba .. .. .. | 1″ to 1⅜″ | ,, 50s, ,, |
| Maranham .. .. | 1″ to 1⅜″ | ,, 50s, ,, |
| American—Gulf .. | 1⅛″ to 1½″ | ,, 50s, ,, 100s weft. |
| Upland .. .. .. | ¾″ to 1″ | 40s weft. |
| Mobile .. .. .. | 1⅛″ | Up to 50s warp and 70s weft. |
| Texas .. .. .. | ⅞″ to 1⅛″ | ,, 40s warp and weft. |
| Peruvian—Rough .. | 1⅜″ | ,, 70s warp. |
| ,, —Smooth | 1⅜″ to 1½″ | ,, 70s weft. |

## CLASSIFICATION OF INDIAN COTTON.

| Range of Counts. | Name of cotton. | Staple Length | Colour | Blow Room Loss % | Highest Standard warp Counts | Remarks. |
|---|---|---|---|---|---|---|
| 36s-46s | Punjab American 289F | 1 1/16 | Creamy white | 9 | 46s | Soft silky feel. |
| | Sind-Sudhar 289 F-1 | 1 1/16 | ,, | 9 | 46s | |
| 24s-28s | Surat Farm 1027 ALF | 1" | White Bright | 8 | 32s | Greatly in demand in India. |
| | Jayant .. .. | 1" | Creamy | 14 | 30s | Leafy ,, ,, ,, ,, |
| | Kumpta .. .. | 7/8" | ,, | 14 | 28s | Greatly in demand in India. |
| | Cambodia Co2 .. | 1" | Slightly creamy | 8 | 32s | ,, ,, ,, ,, |
| | Cambodia (ordinary) | 15/16" | Creamy | 10 | 28s | ,, ,, ,, ,, |
| 20s-26s | Western farm .. | 15/16" | creamy white | 10 | 24s | In demand in India |
| | Karungani .. .. | 15/16" | creamy white | 10 | 24s | |
| | Hyderabad Jaorani .. | 7/8" | creamy white | 14 | 24s | Leafy-Largely in demand in India. |
| | Veerum .. .. | 7/8" | white | 7 | 26s | Largely in demand in India and often depreciated by mixing. |
| | Punjab-American 4F | 13/16" | white | 9 | 22 | Often depreciated by mixing. |
| | Sind-American 4F-98 | 7/8" | white | 9 | 24s | ,, ,, ,, ,, |
| 14s-18s | Westerns (ordinary) | 13/16" | creamy | 11 | 18s | |
| | Tinnevellies .. | 13/16" | creamy white | 11 | 18s | |
| | Oomras (C. P. No. 1.) | 11/16 | creamy white | 7 | 14s | |
| | Central India.. .. | 3/4" | white | 13 | 16s | Leafy. |
| | Broach .. .. | 3/4" | white | 9 | 18s | |
| | Dholleras (best) .. | 13/16" | Bluish white | 12 | 16s | Leafy. |
| | Coconadas .. .. | 3/4" | Brown | 11 | 14s | |
| 8s-10s | Oomras (Berars etc.).. | 9/16 | white to creamy white | 10 | 10s | Leafy. |
| | Bengals (Sind) .. | 1/2" | white | 11 | 8s | |
| | Bengals (others) .. | 1/2" | white | 11 | 8s | |
| | Burmas .. .. | 1/2" | white | 11 | 8s | |
| | Comilas .. .. | 1/2" | white or khaki | 11 | 8s | |
| | United Provinces .. | 9/16" | white | 10 | 10s | |
| | Rajputana .. .. | 1/2" | white | 11 | 8s | |

## CLASSIFICATION OF WORLD'S COTTON.

American varieties are classed in four qualities—good ordinary, low middling, middling and good middling.

South American are classed in three—Middling fair, fair, and good fair.

Egyptian two—fair and good fair.

| | | | |
|---|---|---|---|
| Fine——Grade I. —— | Sea Island—$1\frac{1}{2}''$ to $2''$Staple. | | |
| | Egyptian (Sakel, Afifi, etc. | $1\frac{1}{4}''$ to $1\frac{5}{8}''$ | Staple |
| | Sudan | $1\frac{1}{4}''$ to $1\frac{1}{2}''$ | Staple. |
| | Pima | $1\frac{3}{8}''$ to $1\frac{5}{8}''$ | ,, |
| | Egyptian (Ashmunia etc.) | $1\frac{1}{8}''$ to $1\frac{1}{4}''$ | ,, |
| | Seruvian | $1\frac{1}{8}''$ to $1\frac{3}{8}''$ | Staple |
| | Brazilian upto | $1\frac{1}{2}''$ | ,, |
| | American upland long staple | $1\frac{3}{16}''$ to $1\frac{3}{8}''$ | Staple. |
| | Uganda | upto $1\frac{1}{4}''$ | Staple. |
| Medium—Grade II—— | U.S.A. | $1''$ to $1\frac{1}{8}''$ | ,, |
| | Mexico | $1''$ to $1\frac{1}{8}''$ | ,, |
| | Brazil | $\frac{3}{4}''$ to $1\frac{1}{8}''$ | ,, |
| | British Africa (East & South | upto $1\frac{1}{8}''$ | Staple. |
| | ,, ,, Nigeria | ,, $1\frac{1}{8}''$ | ,, |
| | Africa (Non British) | ,, $1\frac{1}{8}''$ | Staple. |
| | Australia | $1\frac{1}{8}''$ | ,, |
| | Iraq | $1\frac{1}{8}''$ | ,, |
| | India (Long Staple) | $\frac{7}{8}''$ to $1\frac{}{16}''$ | ,, |
| | China, Korea etc. | upto $1''$ | Staple. |
| | Russia | upto $1''$ | ,, |
| Short—Grade III —— | East Indies | $\frac{3}{8}''$ to $\frac{3}{4}''$ | Staple. |
| | China | | |
| | India (Short Staple | | |
| | Japan and Korea | | |
| | Persia | | |
| | Europe and Asia Minor | | |

### CLASSIFICATION OF INDIAN COTTON BY STAPLE-LENGTH

Group I ——————**Short Staple Below $\frac{7}{8}''$.**

Khandesh Banilla.

Central India....Malvi and Nimari.

Barsi and Nagar.

Oomras (Berar)

Central Provinces.

**Group 1—'ont:**

Dholleras—Mattia, Cutch, and Wagad.
Bengals.
Commillas
Burmahs
Coconadas
Salems

Group II——————**Staple of $\frac{7}{8}''$ and over.**
Hyderabad Gaorani.
Central Provinces—Veerum 262.
Broach and Surats.
Kumptas and Dharwar American.
Westerns and Northerns.
Karungani and Tinnevellies.
Cambodia.
Punjab and Sind American—289F and 4F.

## Selection of Cotton for Yarn to be Spun.

The following table will help a spinner to select the quality of cotton required for the counts of yarn intended to be spun.

| Type of yarn | Length of Staple | Blow Room Loss% | Kind of cotton. |
|---|---|---|---|
| Coarse | $\frac{1}{2}''$ to $\frac{7}{8}''$ | 9 to 10 | Cotton waste, East Indian, Short American, C. P. No. 2, United Provinces, Sind (desi), Rajputana, Bihar and Orisa, Comillas, Oomras, Hyderabad Westerns, western Bengal, Khandesh Oomras, Hyderabad Oomras Matheo, and Burmas. |
| Medium | $\frac{7}{8}''$ to $1\frac{1}{8}''$ | 7 to 10 | Sind American, Kumptas, Nanded, Miraj, Western and Northerns, Coconadas, Umri, Bhonsa, Punjab American 289F, Surat 1027 A.L.F., Jayawant. Cambodia Co2, American, Brazilian, Peruvian, Pilion, Egyptian Uppers. |
| Fine | $1\frac{1}{8}''$ to $1\frac{3}{8}''$ | 5 to 8 | West Indian, Uganda, Egyptian Uppers, Brazilian, American Sakel, Pilion, Giza 2G, Mitafifi, Peruvian, Ashmouni, and Abassi. |
| Extra Fine | $1\frac{1}{4}''$ to $2\frac{1}{4}''$ | 3 to 5 | Sea Island, Edisto, Fiji. Tahiti, Florida, Peruvia S.I. |

## Weights of Cotton Bales of Different Countries.

The Indian cotton bale is one of the neatest bales made. It is rectangular in shape and of varying dimensions which approximately are 48 inches in length, 24 inches in width and 18 inches in thickness. The average weight per bale may be given as 400 pounds. East Indian generally about 400 pounds per bale, and Tinnevelly and Madras about 500 lbs. per bale.

The bales are pressed very hard, weighing about 48 pounds per cubic foot and each is bound with a length of strong hoop iron $\frac{3}{4}$ inch wide which is wrapped specially round the bale. The weight of the hoop iron on each bale is from five to eight pounds. The covering is made of hessian cloth or jute.

**'American'**—North American bale—average 480 to 500 lbs. per bale, But actually the weight of a bale may vary from 290 to 878 pounds.

**'South American Bale'**—Softer bales than North American Light weight bales average 250 lbs., and heavy weight bales 450 lbs. each.

**'Egyptian'**—about 700 to 750 pounds per bale.

**'East African'**—about 400 to 430 lbs. per bale.

**'Dares Salam'**—about 500 lbs. per bale.

**'Brazilian and Peruvian'**—Light bales from 160 to 175 lbs. while the heavy ones from 300 to 500 lbs. per bale.

**'Chinese'**—The weight of the bale varies from 150 to 400 lbs., also baggage of 100 to 200 lbs. each.

It will be seen from details given above that the weights of the bales may vary from about 100 lbs. to over 750 lbs., while the over all dimensions may vary from 4 cu. ft. to 48 cu. ft.

The density of bales of cotton, prepared in various parts of the world, may vary from about 8 lbs. per cu. ft. to over 55 lbs. per cu. ft.

Rule for finding the 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 :—

weight of bale =400 lbs.
Measurement of bale =4ft ×2ft. ×1 ft. 6 ins.

$$\frac{400}{4 \times 2 \times 1.5} = \frac{400}{12 \text{ cu. ft.}} = 33.3 \text{ lbs. per cu. ft.}$$

THE CHARACTERISTICS OF COTTON FIBRES.

When comparing one lot of cotton with another for quality and value, the following are the properties from which we should make our comparison.

(1) Natural twist, (2) Length of fibre, (3) Strength of fibre (4) Fineness, (5) Uniformity, (6) Colour, (7) Elasticity, (8) cleanliness (9) Freedom from short—cut fibres, neppy, or dead fibres (10) Curls or Stringiness.

The cotton becomes full of sand during wind storms; see that, it is as free from sand as possible.

## Grading of Cotton.

In classing a cotton a grader takes into account growth, grade colour, and staple. The growth is usually described by the locality from which the cotton comes, but this covers also differences in variety. "Grade" is the estimate of value judged by appearance, including lustre, the cleanliness, and amount of impurities in the cotton, namely, dirt, leaf, motes, neps, etc. The amount of impurity is checked by the waste which is extracted in processing, but a quantitative measurement for grade as defined has not yet been evolved. Staple includes length, fineness, strength, and other spinning qualities. The longest and thinnest fibres make the finest and best yarns because they contain the most natural twists. The grader estimates staple by 'hand pulling' a tuft of fibres giving a 'staple length' which is not the length of the longest fibres, or even either the average or mode, but which is usually rather above the 'most frequent length' or 'mode'. The estimate may be qualified by other terms, such as 'mixed', 'uneven', 'weak', 'weft' 'harsh', 'sticky', 'neppy, 'coarse', 'rough', 'soft', 'fine', 'lustrous'. etc.

In the United States the classers or selectors stand with their backs to the light, whereas in England they have the light facing them. First impressions are usually best in selecting cotton, and the cotton should have st ood overnight before it is handled. It does not do full justice to the cotton to select it when it has just come out of the bale.

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 judgement 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 hand—pulling method is the basis on which length of fibre is judged, and upon this judgement 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.

## Cotton used in India.

Indians use principally their own cotton, but for fine counts they buy Egyptian cotton, Soudan cotton and a large quantity of Uganda Cotton. Mombasa, the port of Uganda, being only at ten day's distance from Bombay by direct Steamer. Indian mills are the best clients of Uganda and consume the bulk of its crop. Only in years when the Uganda crop is insufficient, they turn to Ashmouni and in such years exports from Alexandria to India increase considerably. For the finest counts they buy Sakel and other Egyptian Varieties of long staple, also some Soudan Cotton.

## Raw Cotton Trade Terms.

**Abbasi Cotton**....The Abbasi variety of Egyptian cotton is very well known, as it is the only so-called white Egyptian cotton now grown. The length of fibre is from $1\frac{1}{8}$ to $1\frac{3}{8}$ inches, slightly harsh in feel, not very clean, unusually strong, and is used to spin yarns upto 60s or 70s counts.

**Afghanistan**—Several varieties of cotton are grown in Afghanis- tan, and the best Kabul is said to be as ood as cambodia.

**Akwa (or Akon) Cotton.**—is also the growth of a natural tree, a vegetable silk, which very much resembles 'Kapok', but is more white in colour. Akwa is floss from a shrub called calotropis gigantea, which grows wild all over Deccan Karnatak, Sind and Madras Presidency. Akwa is used for stuffing mattresses, cushions and similar articles, and is exported to Hamburg, Antwerp, etc.

**Argentine.**—Very little cotton is exported from this country, but with proper attention the crops could be considerably increased The varieties Rioja and Parana are the best types and have a staple of about $1\frac{1}{4}$ inches with a fibre diameter of $\frac{1}{13000}$ of an inch and are fairly clean almost white in Colour. Sanbies has about the same staple and fibre diameter but has a reddish tinge while Catamarca salts, and Sauta Fe Varieties are shorter with a staple from $\frac{7}{8}$ inch to $1\frac{1}{4}$ inches, and a decided reddish tint.

**Ashmouni Cotton.**—The cotton known as Ashmouni (also commonly termed upper) is about the poorest of all Egyptian Cottons. The length of fibre is from $1\frac{1}{8}$ to $1\frac{1}{4}$ inches or 30.4 mm. rather weak and not as regular compared with other Egyptian cottons. It spins upto about 60s counts, as, for example, 42s to 62s weft yarn for Sateen cloth, and 38s to 54s for manufacturing into sewing cotton.

**Bani.**—Hyderabad cotton. Also known as Hinganghat Barsi or Hyderabad Gaorani, grown mainly in the Hyderabad State. Best known stations Umri, Bhensa, Nanded and Parbhani. The finest indigenous Indian cotton. Staple 1″ to $1\frac{1}{8}$″. The best Bani is suitable for spinning 30's warp, 40's weft. It is a leafy cotton with high retraction.

**Bengals.**—A general name given to a number of varieties of cotton grown over the whole of the Northern India, from Bengal to the Punjab, including Rajputana. Coarse but of good colour when not stained by pink boll-worm damage. Usually the shortest stapled cotton in India. A number of varieties under this class is suitab e for spinning up to 8's—10's ordinary reeling of weft yarn.

**Berar.**—Has a staple of $\frac{1}{2}$″ to $\frac{3}{4}$″. Grown in Berar. Suitable for spinning up to 12's—14's reeling.

**Bihar and Orissa.**—Mainly grown in Saran, Santhal Parganas and Ranchi districts of Bihar and Orissa.

**Brazilian.**—This type of cotton is usually classified according to the seaport from which it is exported, such as, Maceio, Parahyba, Ceara, Maranhan, Sao Paulo, Bahia, Ataeaju, etc., while Peruam is grown in the province of that name, Pernam, Maccio, and Marahan are among the best varieties but generally there is little difference between any of them with the exception some being harsh, whilst others are soft. The length of staple varies from one inch to one and three-eights of an inch with an average of one and one-quarter inches with a fibre diameter of about $\frac{1}{1300}$ of an inch.

**Gradings.**—Good fair, Fair, Midling fair.

**Broach.**—A general name for cotton grown over lower Gujrat as far north as Baroda. The part of gujrat south of the river Narbada now grows mainly the superior surat type, and the Broach tract proper now lies north of the river.

**Broach Goghari.**—A variety of Broach grown in part of Amod and the whole of Jambusar Talukas. Staple $\frac{1}{2}''$ to $\frac{3}{4}''$.

**Brown Egyptian Cotton.**—The chief variety of the class of cotton known as Brown Egyptian upto a few years ago was the type known as Mitafifi, so—called from the name of the village in which it was first grown. Mitafifi cotton has a deep golden colour and a lustrous strong fibre that attains a length of from $1\frac{3}{8}$ to $1\frac{1}{2}$ inches. It is noted for being a good spinning cotton because of its regularity in length, Softness, and the natural oil it contains. The cotton is used for spinning warp and weft yarns upto 80s or 90s counts.

A more recent variety of Brown Egyptian cotton is Assil, which is really a pure Afifi cotton. It is similar in characteristics to Mitafifi and generally rather better in quality.

**Buri.**—An old acclimatised American cotton grown in North-East Hyderabad and to a small extent in Chota Nagpur and the Central Provinces. Of little commercial importance as it is rarely grown pure. Staple $\frac{7}{8}''$ to $1''$.

**Burmahs.**—These cottons are largely exported direct from Rangoon to China and are little known in India.

**Cambodia.**—A type of American upland obtained direct from Cambodia in 1905. The best Cambodia is grown in Coimbatore district (Tirpur) and West Madura. When well grown and properly handled probably the best of the Indian cottons. The best irrigated Cambodia is of $1\frac{1}{8}''$ staple, the unirrigated crop is extremely variable in staple, frequently only $\frac{7}{8}''$.

**Cawnpore-American.**—An old acclimatised upland American, grown with irrigation in the neighbourhood of Cawnpore. Staple 1″.

**Central India.**—Grown in Central India States. It belongs to the Oomra class. Suitable for spinning up to 16's—20's weft yarn..

**Central Provinces.**—A variety of Oomras. Grown in the following districts of the Central Provinces :—

> Chanda, Chhindwara, Nagpur, Seoni and Bhandara, Yeotmal, Wardha; in a small adjoining portion of Berar and the neighbouring part of the Hyderabad State. Average staple $\frac{5}{8}''$ to $\frac{3}{4}''$.

**China Cotton.**—is a short stapled cotton, rather harsh, but very white. It is used in China and Russia. The length of staple is $\frac{1}{2}$ to 1 inch.

**Coconadas.**—Grown in Guntur and parts of Nellore, Kistna and Godaveri districts of Madras and South-East Hyderabad. Staple $\frac{5}{8}''$ to $\frac{7}{8}''$. Suitable for spinning up to 20's warp.

**Comillas.**—A very rough cotton grown in Eastern Bengal and Assam. Staple $\frac{3}{8}''$ to $\frac{1}{2}''$.

**Dharwar-American.**—Same as saw-ginned Dharwar. Most of this cotton is now roller-ruined.

**Dhawar No. 1.**—A select type of Kumpta. Staple better than ordinary Kumptas which is rapidly replacing in general cultivation. Should not be confused with Dharwar-American.

**Dholleras.**—A general name for certain types of cotton grown in Northern Gujrat. Kathiawar, etc. A very mixed class of cotton at present includes five varieties. Suitable for spinning up to 20's—22's warp.

**Gadag No. 1**—A pure upland type established on a considerable scale in the Dharwar district. Staple 1″, spins up to 24s warp.

**Giza.**—Both giza 26 and the improved Sakha 4 are longer and finer than Sakel ever was, and Giza 26 unquestionably stronger as well. Giza 26 is probably the best where maximum strength is required, and Sakha 4 owing to its light colour and better lustre, where finish and appearance are more important.

**Gallini.**—is the best of Egyptian cottons and is grown from Sea Island seed. The staple of Egyptian Cottons ranges from $1\frac{1}{8}$ to $1\frac{1}{2}$ inches.

**Goghari.**—is a coarse cotton, but has a high yield with a staple of $\frac{1}{2}''$ to $\frac{5}{8}''$, and a ginning percentage, of 40. It grows in Kaira and Panch Mahals and North of Broach tract.

**Johannovich Cotton.**—The type of Egyptian cotton known as Johannovich or Yannovitch has a light golden colour. It is fine in diameter, silky, has a length of fibre ranging from $1\frac{3}{8}$ to $1\frac{5}{8}$ inches, is clean, elastic, easy to spin, and is used to produce yarns up to as fine as 120 counts. There is not much Johannovich cotton grown at present.

A cotton of more recent growth than Johannovich, but yet possessing similar characteristics, is known as Nubari. It is not, however, quite as regular nor as light in colour as a rule.

**Kanvi Cotton.**—A kind of mixture of Broach and Goghari cotton grown in Northern Gujrat and Kathiawar, the product of which is known as 'Kanvi.'

**Karunganni.**—The best indigenous cotton of Madras and the best type of Tinnevallys. Grown in villages near Tuticorin. Tinnevally, Madura, Ramnad, Salem, Coimbature and Trichinopoly. White in colour. Staple $\frac{9}{10}''$ to $1''$.

**Khandesh.**—The lowest grade of Oomra. Grown in East and West Khandesh and Nasik. The same type is found in adjoining parts of Hyderabad, in Ahmednagar, Sholahpur and North Bijapur Average staple $\frac{1}{2}''$ to $\frac{5}{8}''$.

**Kumptas.**—Grown in large areas in the southern par tof the Bombay Presidency and the Northern districts of Mysore: also grown in the adjoining part of the Hyderabad State. Staple $\frac{7}{8}''$. Has a yellow tint and comes in the market in a very leafy condition. Suitable up to 28's warp.

**Malwa.**—A variety of Oomra, grown in Malwa plateau in Central India. When pure staple $\frac{3}{4}''$ to $\frac{7}{8}''$.

**Maarad Cotton.**—Maarad Cotton is a very interesting variety derived from Pima cotton cultivated in Arizona, U.S.A. It is the result of several years' arduous and very detailed pedigree selection work by the Technical service of the Royal Agricultural Society.

**Maarad** has a creamy white fibre with a lustre equal or even superior to that of Sakel, and is very fine and long. Its strength when grown under suitable conditions nearly equals that of Sakel. Average lint length 42–44 mm. or about $1\frac{5}{8}''$.

**Marahans.**—is of a dull golden tint, rather dirty, and contains a fair percentage of leaf, sand, and seed, very often mixed sparingly with Texas cottons for twist yarns up to 40s counts. Generally these cottons are of a fairly uniform character but contain a fair percentage of seed owing to poor ginning.

**Mathia.**—Kathiawar district is of a drier part ofI ndia, hence cotton grown there is more dependent upon weeather conditions. Nathia is a very coarse and low class inferior cotton of early arrivals and it is of a variety of Khandesh cotton grown in Kathiawar and Ahmedabad.

**Mobile and Upland Cotton.**—is soft and clean, but rather short staple.

**Mead Cotton.**—is a variety of what is known as Upland cotton, so-called because it was first grown on the uplands of the Atlantic States. Generally included under the head of Upland Cotton are a number of other more or less similar varieties, known as Gulf, Benders, Bottom Land, Mobile, Peerless, etc.

**Nahda Cotton.**—was produced by selection (by the Botanical section of the Ministry of Agriculture.) from Assili Cotton, which is a type of the old well-known Mitafifi coton. Average lint length 31.4 mm. or about $1\frac{3}{16}$ in.

**Nandyal 14.**—A pure type of Northerns. Spins up to 36's warp.

**Navsari.**—The best type of Surtee Broach grown in the extreme south of the Surat district and of the Baroda State, the principal centres are Navsari and Billimora. Staple $\frac{7}{8}''$ to $1''$. Suitable for spinning up to 30's warp and 40's weft.

**Northerns.**—A very leafy cotton. Grown in Kurnool and part of Cuddapah districts (chief centre Nandyal). Has two sub-varieties—red and white. Staple $\frac{7}{8}''$. Suitable for spinning up to 20's warp.

**North-West Frontier Province.**—A variety of cotton grown in Peshawar Valley, superior to Punjab cotton. Staple $\frac{1}{2}''$ to $\frac{3}{4}''$.

**Oomras.**—A general name given to cottons produced over very large areas of the Central Provinces, Central India, Berar, Khandesh, Nasik and the Nizam's dominion's do and include many varieties. Name derived from Amraoti, the headquarters of the Berar division.

**Orleans or Gulf Cotton.**—is the best of American cottons. It is grown on the banks of the Mississippi river and is known as Benders, Peelers, and Allanseed.

**Peelers.**—is a good cotton, regular in staple and strength, and is very soft and pliable. It mixes well with soft Egyptian. The length of the gulf cotton staple is from 1 to $1\frac{1}{2}$ inches.

**Pernams.**—May be about $1\frac{3}{8}$ inch staple, golden tinted in colour, fairly clean, and can be spun into 60s to 80s counts, particularly twist. Ceara, Parahyba, and Maccio are light golden in colour and are sometimes used for mixing with Egyptian cottons, when used by themselves up to 60s twist or weft may be spun. They are very good for warp yarns for sizing, and when mixed with American varieties give added strength.

**Peruvian.**—There are three main variaties of this cotton namely; Peruvian Sea Islands, 'Peruvian rough" and "Peruvian Smooth."

The 'Peruvian rough' is the most important commercially, on account of its great suitability for mixing with wool. Its staple varies from $1\frac{1}{8}$ to $1\frac{1}{2}$ inches with an average of about $1\frac{1}{4}$ inches, and it has a fibre diameter of from $\frac{6}{10000}$ to $\frac{8}{10000}$ of an inch. It is usually used for warp yarns of from 50 to 80s counts with an average of about 70s counts.

It is usually creamy in colour although some are rather highly tinged and one variety raised on coppery soil is decidedly red in colour. This type of cotton is of the Perunial variety and is often known as tree cotton, the plant growing to a height of from 10 to 15 feet. Cotton is produced for about seven years, though most abundant and producing the best cotton during the second, third, and fourth years, particularly during rainy seasons. The fibre is fairly long, strong, rough, and with a crinkly staple which makes it an excellent fibre for mixing with wool for many purposes. Its price is often regulated by the price of wool and the relative supply of this type of cotton——"Gradings"—Fine, Good, Good Fair, Fair, and Middling fair.

**Smooth Peruvian.**—This has been raised from American seed and resembles Orleans or gulf cotton. It is rather shorter than the rough variety and has a staple of about $1\frac{1}{8}$ to $1\frac{1}{4}$ inches with a fibre diameter of about $\frac{1}{1300}$ of an inch. It is often used for mixing with the better grades of American cotton and for soft hosiery yarns for counts of about 50s twist and 60s weft. It often contains a fair percentage of unripe fibres and neps.

**Peruvian Sea Island.**—This is grown on the coast of the mainland from American Sea Island Seed and is about equal to Floride Sea Islands. The Staple length averages about $1\frac{1}{2}$ inches with a fibre diameter of from $\frac{4}{10000}$ to $\frac{7}{10000}$ of an inch. It is white in colour, not so clean as ordinary Sea Island, and can be used for counts of from 100s to 150s, usually for doubling purposes. Recently a cross between the rough and smooth varieties has been developed named Tanguis, which is now being largely cultivated and giving good results from a Spinning Standpoint. Peruvian mixes well with wool (the harsh or rough Peruvian), but the softer Peruvian, on account of its colour, enables it to mix well with Orleans or gulf cotton.

**Pillion Cotton.**—has neither the length, strength, nor lustre of Sakel. Average lint length 35.4 mm. or about $1\frac{7}{16}$ in.

**Punjab American**—An acclimatised upland American cotton grown in the Central Colonies of the Punjab. Resembles ordinary upland American in colour and style. Principal constituent Punjab—American 4F. Suitable in good season for Spinning up to 24s warp. Staple about $\frac{9}{10}$″.

**Rajputana.**.—A variety of Bengals grown in Rajputana.

**Roseum.**—A variety of Oomras grown in Berar and adjoining tracts. Staple $\frac{1}{2}$″ to $\frac{5}{8}$″.

**Rozi.**—Rozi grows in Khaira Zilla, and it is used in mixing with Broach coton, but Rozi cotton is of a very inferior quality.

**Sakellaridis.**—By far the greatest proportion of the total Egyptian cotton crop is the comparitive new variety known as Sakellaridis. It is rather better in quality than Johannovich, uniformly good, has an average length staple of 1.6 inches, average lint length=36.6 mm. Cream to light golden colour, and in some characteristics it is not unlike Sea—Island cotton. It spins up to 120s counts, and in some cases it is used for producing much lower counts, where yarn of unusually high strength is required, such as 26s to 36s combed and double combed both ring spun and mule spun.

**Selected Sakellaridis.**—This cotton has been derived from ordinary Sakel cotton by selecting seeds completely covered with fuzz. After several years' selection a purity of 99 per cent. from a seed point of view has been attained.

This cotton is considered to be the purest Sakel. It is rather more resilient, longer and more regular than ordinary Sakel. Average lint length 39.5 mm. or about $1\frac{1}{2}$ in.

**Salems.**—The old trade term for the cottons grown in Coimbatore, Trichinopoly and South Arcot including mainly Uppam Nadam and Bourbon. The important cotton of these districts is now Combodia Suitable for spinning up to 20s counts.

**Santos.**—is another variety grown from Orleans seed and has a staple of about $1\frac{1}{4}$ inches, fibre diameter $\frac{1}{1300}$ of an inch, and useful for up to 40s twist and 50s weft.

**Sea Islands.**—This cotton is the most valuable cotton grown on account of its length of staple, fineness, Strength, Smoothness, and cleanliness, also for the careful ginning it receives. The fibre is fine, soft, silky, long, and regular. The Length of staple is $1\frac{1}{4}''$ to $2\frac{1}{4}''$.

Sea Island cotton is mostly used for yarns for preparing aeroplane fabrics and parachute cloths. In England at the present day Sea Island coton is used and Spun upto 400s single yarn, shirtings woven from 300s Sea Island yarn looks just like silk.

**Shan State Cottons.**—Burma cottons grown in Shan States Staple up to 1″ the average being $\frac{3}{4}''$

**Sind.**—American......grown. with irrigation, mainly on the Jamras Canal. Is practically identical with Punjab—American.

**Sowri (or silk cotton).**—is floss from the tree known as "Bombay Malabariacum—which is very common in Konkan, Deccan and Southern Mahratta Country. Kapok is also floss obtained from the seed capsules Eriodendron anfractuosum, a white flowered tree found in Ratnagiri, Goa, Poona, Khandesh etc., but this is not cotton

(Gossipinm). The fibre is straight, light, silky and smooth, and its chief use is for filling cusions, mattresses and similar articles of upholstery, and also for mixture in immitation silk; also used for filling in life—buoy.

**Surat.**—A variety of Broach grown in Surat and Southern part of Broach district staple $\frac{7}{8}''$ to $1''$. Suitable for spinning up to 20s warp.

**Tinnevallys.**—A mixture of varying productions of Karunganni and Uppam. Strong of a slightly creamy colour. Grown in Madura, Ramnad and Tinnevally, Staple $\frac{3}{4}''$ to $\frac{7}{8}''$. Suitable for spinning up to 20s warp.

**United Provinces.**—A Variety of Bengals grown in the United Provinces.

**Upland Cotton.**—Constitutes more than 99 per cent of the total American crop and about 60 per cent of the world's total supply of cotton. About 95 per cent. of all the cotton dealt in on the American markets and about 75 per cent. of all the cotton dealt in on the British markets is Upland Cotton. Except when otherwise specified all cotton market reports and quotations in the United States refer to Upland Cotton.

**Uppain.**—A variety of Salems grown in Coimbatore, Trichinopoly and parts of South Arcot. Staple $\frac{3}{4}''$.

**Wagad.**—(Synonym Wagadia or Sakalio). The best variety of Dholleras grown in North Gujrat, Kathiawar and Cutch. Is a closed boll type and the Kapas is separated from the bolls after picking. Staple $\frac{3}{4}''$ to $\frac{7}{8}''$. Good up to 22's warp.

**Westerns.**—The general name for the cotton grown in Anantapurand Bellary districts of Madras, part of Bijapur district ofBombay and South-west Hyderabad. Staple $\frac{3}{4}''$. Suitable for spinning up to 20's warp. Usually a very leafy cotton due to defective picking.

**White Flowered Aligarh.**—A variety of Bengals, grown in Aligarh and surrounding tracts. Staple $\frac{3}{8}''$ to $\frac{1}{2}''$.

**Zagora Cotton.**—is a cotton of the Ashmouni type.It is grown chiefly in Upper and Middle Egypt. Average length 33mm. or about $1\frac{1}{16}$ in.

## COTTON MARKET TERMS.

**Allowaneers**—Allowances 'On' and 'Off' are stated in Bombay in Rupees per Candy (in Liverpool in 'points,' i.e., hundredths of a penny per lb.). Cotton tendered against a Hedge Contract is subject to mutual allowances. The buyer is entitled to receive cotton not more than half class below the basic grade in Bengal and Oomras Contracts and not below a grade in case of Broach and Southern Contracts and must accept cotton within these ranges at the Off allowance fixed by the arbitrators. The seller can claim 'On' allowances up to two full grades above the basic grade and must accept the arbitration award. The difference in value between grades is determined from the Spot Rates fixed by the Daily Rates Committee.

**Arbitrations.**—Under East India Cotton Association rules all disputes as to quality between buyer and seller must be referred to arbitration. One arbitrator is appointed by each party and the arbitrators must nominate an Umpire if they disagree. An appeal lies to the Appeal Committee from all arbitrators. Appeals are 'blind', i.e., the Committee are not aware of the names of the parties involved or the marks on the bales.

**Arrivals.**—Cotton still to arrive. May be on its way, in Indian or American warehouses or godowns, or even still growing. Purchased according to description or sealed samples.

**Baflas.**—Half-pressed bales.

**Basis.**—Relation between future contracts and even running spot cotton.

**Bloom.**—The very light, creamy, lustrous, and generally clean appearance of certain cottons, especially in the early part of the season. Other terms with the same meaning are 'blush' and 'blooming.' Such cotton, exceptionally free from leaf, etc., is also referred to as 'stylish' or 'showy.'

**Boll-Weevil.**—The most destructive insect pest known in the American cotton belt. This pest was first found in Texas in 1892, and has since spread all over the cotton belt, supposed to have originated in Mexico.

**Blue Cotton.**—Uncommonly white cotton.

**Bonne Soie.**—Good Staple.

**Bump Cotton.**—Hard, flat slabs cotton in bales owing to the presence of excessive moisture, and possibly sand also, when the bale is being compressed.

**Burrs.**—Husks of bolls.

**Buttery Cotton.**—Cotton with a deep creamy, or even a very light brown colour.

**C. I.F. Cotton.**—Cotton bought according to a certain standard, or type standard for forward delivery at a given rate weekly or monthly. The invoice months are stated when the contract is made the seller paying costs, insurance, freight to Liverpool.

**City Crop.**—Accumulations of mixed bits of everyday sorting of cotton of various grades in broker's offices.

**Class.**—May be defined as—Leafy, Stainy, Dirty, Seedy, Musty, etc.

**Colour.**—may be defined as—Bright, White, Chalky White Dull, Grey, Creamy, Glossy, Reddish, etc.

**Cotton Varities.**—are classed as follows :—

- **"American"**—good ordinary, low middling, middling, and good middling.
- **"South American"**—middling fair, fair, and good fair.
- **"Egyption"**—fair and good fair.
- **"East Indian"**—fair, good fair, and good.

**Country Damage.**—Damage done to the cotton on the outside of bales during transit after leaving the baling press.

**Curly Cotton**.—Also known as stringiness. Caused by the cotton being ginned when excessively damp.

**Cut Staple.**—Cotton obviously cut during ginning, owing to excessive speed of saws, blunt saws, feeding gin to excess, grid bars rubbing on saws, etc

**Delivry Contract.**—Any forward contract other than a Hedge contract.

**Docket Cotton.**—Tendered cotton.

**Desi.**—means local or idigenous.

**Dokra.**—Loose bale or packing gunnies.

**Dampness.**—The natural amount of moisture in cotton is 7.8 per cent. Any materially higher percentage of moisture is excessive.

**Description Cotton.**—Cotton purchased on the understanding that it will come up to a certain grade, or be equal to certain mark previously purchased.

**Due Date.**—The latest date for delivery. In the case of Hedge contracts the 25th of the month is the date of maturity.

**Exotic Cotton.**—Foreign cotton.

**Ex-Quay Cotton.**—Cotton in the ship at the quay side.

**False Pack.**—A bale of cotton consisting of two or more qualities, the good cotton being generally on the outside.

**Fair Tender**—In order to constitute a 'fair tender' under East India Cotton Association rules the following conditions must be fulfilled :—

1. All bales must bear press marks in conformity with the provision of the Cotton Ginning Pressing Factories Act or with the law in force for the making of bales in any Indian State.
2. The cotton must be of the description sold.
3. If tendered against a Hedge Contract :—
   (*a*) Each unit of 100 bales must be of one and the same description of cotton.
   (*b*) The cotton must have been pressed at one of the stations approved for the description tendered.
   (*c*) The standard against which the cotton is entitled to be surveyed shall be correctly stated.
   (*d*) The delivery order must comply with the rules of the Association.
4. If tendered against a delivery contract, if a district is mentioned in the contract, the cotton must have been pressed of one of the stations approved for the district tendered.

**Futures.**—Cotton purchased as a cover against loss, generally 'paper' cotton. There is also much speculation in futures.

**Gaorani.**—means local or idigenous.

**Goghari.**—An inferior variety of cotton, having a weak Staple.

**Gossypium.**—The scientific name for cotton.

**Genetics.**—Science which deals with hereditary factors both in. plants and animals.

**Good Colour**—A colour, depending on buyer's requirements which is neither too creamy nor too white.

**Grade.**—The one to three-word description of quality and value, such as 'middling', 'good middling,' etc. The comparative length of staple, degree of cleanliness, appearance, and freedom from leaf. Bloom adds to the grade, but tinges, stains, etc., detract from the grade.

**Green Cotton.**—Cotton picked before it is properly matured. The moisture content generally very high. Mostly in evidence at the commencement of the season.

**Hedge Contract**—A Hedge Contract is a contract for future delivery of cotton within a specified period of a certain broad description (in units of 100 bales of cotton) tenderable against a Hedge Contract as specified in Schemes 'A' and 'B' appended to the bye-laws of the East India Cotton Association. It differs from a delivery contract in that it can be 'passed on' to another buyer and that differences are always settled periodically (in Bombay fortnightly through the Clearing House of the East India Cotton Association Ltd.). The object of purchase or sales of futures is to protect a consumer or merchant who has entered into future commitments against wide market fluctuations. Thus a spinner who has made a forward sale of yarn, or a merchant who has accepted an order for the sale of cotton on a future date, can partially protect himself against a rise in the market by purchasing the appropriate Hedge Contract. Rarely does he accept actual cotton tendered against a contract, but after securing the particular cotton required by spot purchase usually sells back his contract. Similarly a merchant holding unsold stocks can insure himself against heavy fall in the market by selling Hedge Contracts. He also comparatively rarely tenders cotton against his sales but buys back his Hedges as he makes sales of actual cotton. Hence daily transactions in Hedge Contracts prevent wide market fluctuations by discounting in advance changes in crop and market prospects.

*Note.*—Differences in respect of Delivery Contracts are also settled periodically except in respect of those Delivery Contracts made for cotton equal to stamped bales or sealed or type samples and in which delivery is stipulated to be taken within a period of six weeks from the original date of contract.

The Hedge Contracts in Bombay are :—

*No.* 1.—Fully Good M. G. Bengal Contract—fair average staple of the season, including cotton from the United Provinces, the Punjab, Sind and Rajputana. The following standard samples are prepared for this contract, *viz.* ;—

Of M. G. U. P., Superfine, Fine, fully, Fully Good (Basis), Good to Fully Good ( half a class off Fully Good), Good.

Of M. G. Sind-Punjab, Superfine, Fine, Fully Good, Good to Fully Good (half a class off Fully Good), Good.

Of M. G. Rajputana, as above.

Cotton below Good to Fully Good (half a class of Fully Good) is rejected. Months of delivery :—December/January, March, May, and July.

*No. II.*—Fully Good M. G. Broach Contract—fair average staple of the season, including Broach, Saw-ginned Dharwar, Punjab-American, Surat, Navsari, Rajpipla, Dholleras, Kalagin, Cutch and Kadi Viramgaum. The staple of Punjab-American Dholleras and Kadi Viramgaum tendered to be not less than $\frac{3}{4}''$ long and that of Navsari, Surat, Rajpipla, Cutch and Kalagin not less than $\frac{7}{8}''$. The following standards are prepared for this Contract :—

Of M. G. Broach, Superfine, Fine, Fully Good (Basis), Good, Fully Good, Fair to Good.

Of Saw-ginned Dharwar, Superfine, Fine, Fully Good, Good to Fully Good, Fair to Good.

Of M. G. Punjab-American as in the case of Saw-ginned Dharwar.

Of M. G. Surat as in the case of Saw-ginned Dharwar.

Of M. G. Rajpipla as in the case of Saw-ginned Dharwar.

Of M. G. Navsari as in the case of Saw-ginned Dharwar.

Of M. G. Dholleras as in the case of Saw-ginned Dharwar.

Of M. G. Cutch as in the case of Saw-ginned Dharwar.

Of M.G. Kalagin as in the case of Saw-ginned Dharwar.

Of M. G. Kadi-Viramgaum as in the case of Saw-ginned Dharwar. Cotton tendered below 'Good' standard is rejected Months of delivery :—

April/May, July/August.

*No. III.*—Fine M. G. Oomra Contract, fair average staple of the season including cotton from the Central Provinces and Berar. The following standards are prepared for this contract :—

Of M. G. Berar, Extra Superfine, Superfine, Fine (Basis) Fully Good to Fine (half a class off Fine).

Of M. G. C. P. No. 1 and M. G. C. P. No. II, Extra Superfine, Fine, Fully Good to Fine (half a class off fine).

Cotton below Fully Good to Fine (half a class off Fine) standard is rejected.

Delivery :—December/January, March, May and July.

*No. IV.*—Fully Good M. G. Oomra Contract, fair average staple of the season, including cotton from Berar, the Central Provinces, Central India, Khandwa-Burhanpur, Khandesh and Kathiawar (Muttra.)

The following standard samples are prepared for this Contract:- Of M. G. Berar, Fully Good (Basis), Good to Fully Good (half a class off Fully Good) Good.

Of M. G. C. P. No. 1 and M. G. C. P. No. II.—Fully Good, Good to Fully Good (half a class off Fully Good), Good.

Of M. G. Khandwa-Buranpur, M. G. Central India, M. G. Khandesh and M. G. Muttra—Superfine, Fine, Fully Good, Good to Fully Good (half a class off Fully Good), and Good.

Cotton below "Good to Fully Good half a class off Fully Good)" standard is rejected.

Delivery :—July and September.

*No. V.*—Good M. G. Southerns Contract including Northerns (excluding 'Red'). Compta, Miraj Cambodias and Karungannis of not less than $\frac{7}{8}''$ staple and Westerns, Bijapur, Bagalkote and *Tinnevallys* of not less than $\frac{3}{4}''$ staple. Compta cotton not less than $\frac{3}{4}''$ length may be tendered if the seller declares on his Delivery Order "No premium claimed over basis." Karungannis not less than $\frac{3}{4}''$ length may be tendered if the seller declares "No premium claimed over *Tinnevally*." The basis is M. G. Western, Good. The following standard samples are prepared for each of the above descriptions :—

Fine, Fully Good, Good, Fully Good Fair, Good Fair to Fully Good Fair (half a class off Fully Good Fair.)

Cotton below "Fully Good Fair" Standard is rejected.

Delivery :—MAY/JUNE and AUGUST/SEPTEMBER.

*Hybridization.*—A plant produced from the mixture of two Species.

*Leafy.*—There are generally three kinds of leaves found in cotton namely Black, Red and Brown. The cotton with red leaves is generally considered good cotton as it has not been spoilt by rain.

*Longs.*—Spinners who have bought more cotton than their actual orders for the manufacture of yarn.

*Marks.*—The combination of letters or numbers or both. On the tare or label to enable one lot of cotton to be readily distinguished from one another.

*Meaty Cotton.*—Cotton capable of producing a high percentage of yarn with very little waste. Takes twist well in Spinning.

*Kapas.*—Unginned cotton or seed cotton (i.e., cotton as it is picked from the bolls of cotton plant and includes both seed and lint ).

*Indigenous Cotton.*—Cotton produced naturally in a country.

*Jetha-terms.*—This is the usual custom of Bombay for Ready cotton, and unless specially mentioned otherwise (except Bengal and Sind), it is generally understood that the business is to be done on this terms. And the price includes usual Muccadam—allowance per bale (and brokerage charges if agreed upon) to be paid by the sellers to the buyers, and delivery to be taken at the Seller's Jetha or Godown.

**Mill-Terms.**—By this term, the usual Muccadamage allowance per bale (same as Jetha-terms) to be paid by the sellers, and also ½ per cent. more as brokerage to the buyer. If the cotton is sold to Mills, beside the above charges, charity—allowance 1¼ annas per candy is to be paid to the Mill—buyers by the sellers. This latter item of charity-allowance is paid by the mills to the Society for the Prevention of Cruelty to Animals, and a receipt to that effect is given by the buyers.

**Mossy Cotton.**—Cotton which contains an excessive amount of short and immature fibre.

**No Mark.**—Bales of cotton without mark, or the mark label missing or mark obliterated.

**Neps.**—Pin-head clusters, or small 'flecks' of rolled-up, intermingled fibres.

**On-call Cotton.**—Cotton selected on an agreed' basis,' the final price depending upon the time the spinners require "calls" the cotton.

This system which is of a non--speculative nature, enables a mill to operate without actual Futures contracts and serves the purpose of a spot purchase and a future cover.

**Pickings.**—Damaged or dirty cotton picked off country-damaged portions of the bales.

**Railway-terms.**—In this term, the Muccadum-allowance is not included, and the delivery to be made by the Railway/Receipt on which 90 per cent. advance is generally paid to the sellers, and the buyers to take the delivery of goods from the Railway Station. Unless specially stipulated, the buyers have to bear all charges such as the Bombay Town Duty, Cartage, Landing charges, etc. In this term, the delivery of R/R constitutes the lawful tender against the contract.

**Reclamations.**—Claims made for shortage in weights, class or deviation in the cotton from the samples submitted.

**Scalping Affair.**—Making a small, quick profit by slight fluctuations in the market.

**Sealed Samples.**—Samples taken from actual bales in America and sent over per passenger boat.

**Shade.**.—Light segments between the capsule proper and the lint.

**Specks.**—Damaged bales which have been made to work neat and free outside the defects.

**Spot Cotton.**—Cotton which is on the spot ready for inspection, purchase, and delivery. The samples or re-draws from the actual bales are available for inspection and the price fixed on spot. Payment is in 10 days and 4 per cent. allowed to cover tare.

**Squeeze.**—Holding back of the stock or buying special description of cotton, taking advantage of limited stock on the market.

**Staple Cotton.**—A term employed to designate cotton suitable for spinning into twist or warp yarn. Such cotton with the natural twist well developed and strong is also referred to as having plenty of bone in, hence the terms 'Bony' cotton, 'Bant' cotton, etc.

The Bombay standard for staple is any cotton measuring $\frac{3}{4}''$ or over in staple.

**Staple is known as follows:**—

| | |
|---|---|
| Short and Rough staple .. .. | $\frac{3}{8}$ to $\frac{1}{2}$ inch |
| Short staple .. .. .. .. | $\frac{3}{8}$ to $\frac{5}{8}$ ,, |
| Fair ,, .. .. .. .. | $\frac{3}{8}$ to $\frac{3}{4}$ ,, |
| Fair to good Staple .. .. .. | $\frac{5}{8}$ to $\frac{7}{8}$ ,, |
| Good staple .. .. .. .. | $\frac{5}{8}$ to $\frac{7}{8}$ ,, |
| Good silky staple .. .. .. | $\frac{7}{8}$ to $1\frac{1}{8}$ ,, |

**Besides the above the staple is known as:**—

Poor staple, Weak staple, Long staple, Fair staple of the season. Ordinary staple.

Staple and Colour are factors of important consideration in determining the value of cotton.

**Ton (Freight).**—40 Cubic feet (on an average 100 bales = about 27 tons).

**Weight of Bale.**—Unit of cotton for shipment. The standard Indian bale is 400 lbs., gross (392 lbs. nett); in Madras 500 lb. bales are common.

The limits of weight allowed in Bombay are :—

| | *Max.* | *Min.* |
|---|---|---|
| Cambodia, *Tinnevally* and Karunganni | 580 | 340 |
| All other cottons .. .. .. .. | 450 | 340 |

If delivered against forward contracts the weight of 100 bales must be within the following limits :—

| | Max | Min. |
|---|---|---|
| Cambodia, *Tinnevally and* Karunganni .. .. .. .. | 64 Candies | 49 Candies |
| Saw-ginned Dharwar and Machine-Ginned Kumpta .. .. .. | 51 Candies | 46 Candies |
| All others .. .. .. .. | 51 .. | 49 .. |

Differences outside this range are at buyer's option. The dimensions vary considerably but the average Indian bale of 400 lbs. gross is about 48″ ×20″ ×16″.

**Candy.**—In Bombay and South India =784 lbs. in the former and generally 500 lbs. in the latter. weight of two bales =784 lbs.

**Zoda.**—The cotton of last picking (inferior stuff).

## INSPECTION ETC., OF COTTON BALES.

### COTTON BALE BOOK.

*Date*..............194 .

*Bales*.............................*Marks*..................

*Length of Staple*......................*Grade*..................

| Metal tag Number or Stenciled Mark. | Broker's tag or Stenciled Marks. | No. of Hoops | Broker's Weight. | Weight as received. | Remarks. |
|---|---|---|---|---|---|
| | | | | | |

Each bale of cotton that arrives in a mill is weighed for the purpose of checking them with the purchase weight and noted down in a special book which on reference shows the mark, number, and quality or description of the cotton. After weighing the bales, a number should be attached to the bale, and the weight of the bale as received must be opposite the same number in the books, for which purpose it is preferable to use a system of progressive numbering. The bales should carefully be inspected for the apparent defects on the outside of the bale, etc.

The defects such as very heavy tare, bands missing, very wet condition, insufficient covering etc., should be noted down in a book and reported to the manager with the least possible delay.

It is the duty of the person in charge of classifying the bales to have recorded any faults he may find. Quite a lot of money is lost through not attending to these details

A few bales of inferior cotton are easily slipped—sometimes quite accidentally—into a better lot. It is unfair that the spinning master or the manager should overlook an inferior grade or staple that he should receive against a stipulated type of cotton which has been paid for. The mill-agent or proprietor depends on his employers—whether manager or subordinate—to understand and recognize their responsibilities.

A record should be kept of the cotton godown or storeroom to show the quantity of bales of each mark which should be arranged together in stock, all new arrivals of cotton being added thereto and the cotton taken to be mixed deducted. Every month the stock book figures should be checked with the actual work.

## A Trial Sample.

Before the cotton is carried to the department a trial sample is generally taken say of 100 pounds, out of a bale that is sent for sample before the bales are actually purchased to ascertain whether or not the cotton is good for the purpose, for which it is intended to be purchased and the loss in percentage, in other words whether the cotton is good for twist or weft and whether it contains impurities in excess to what there should be. It is preferable to examine the cotton on a black table with plenty of light in the room.

## Impurities in Cotton.

The impurities to be found in cotton are as follows —

(1) Seeds, (2) Seed husks, (3) Brown leaf and stalk, (4) Sand and mineral matter, (5) Excessive moisture, (6) Nep, (7) Broken fibres, (8) Unripe fibres, (9) Dead fibres, (10) Motes (11) Stained fibres.

During heavy rains cotton becomes stained with the earth. As far as possible stained cotton should not be used for weft. But it may be used for Twist yarn if it is going to be sized.

The average allowance for loss of weight on any one mark of cotton shall not exceed three pounds per bale, with cotton in sound and dry condition.

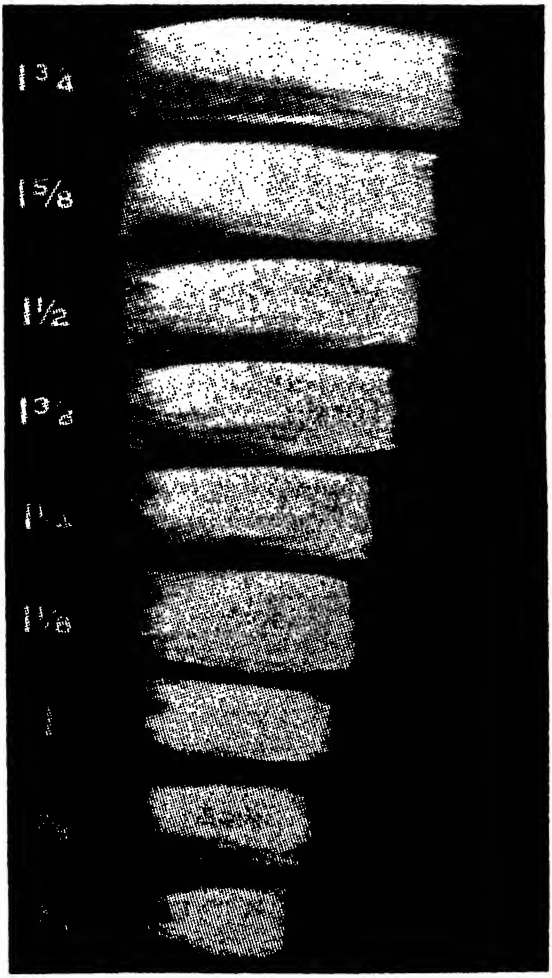
The worst impurity is nep, the next irregular fibres, then leaf, seed, and lastly sand etc.

In the examination of samples of cotton the presence of these impurities should be carefully considered, and when that is done, it is time to decide about length and strength.

Every one in the trade is familiar with the rough and ready test of pulling out and breaking between the fingers, and in the hands of an expert—a very accurate decision is arrived at.

## Stapling of Cotton.

Cotton is valued according to its characteristics that best adopt it to the use for which it is intended.




**Staples drawn from various types of cotton**
*(actual size)*

The whole procedure of stapling has been simplified by the invention of two machines which enable the percentage composition of staple length to be determined more or less mechanically. These are the "Balls Sorter" and the "Baer Sorter." Although quite different in their mechanism, they both depend for their action on bringing to a common line one end of each fibre in a group; in the Balls Sorter this is effected by a pair of rollers which first nip the end of a fringe, and then, by their traverse along a strip of plush, deposit the fibres thereon according to their length, because the revolution of the rollers causes the fibres gradually to pass between them, and as the shorter fibres come to their other end first, they are naturally deposited first. It only remains to gather the fibres between length intervals and to weigh these various parts of the deposit, to get the weight distribution of the different lengths. With this sorter it is very necessary to have the fibres thoroughly disentangled when presented to the machine otherwise, fibres not actually in the nip of the rollers at the beginning may be dragged through by others which were in the nip, and erroneous results will ensue. With the Baer Sorter more depends upon the individual. A sliver is laid across a number of combs and the worker nips the ends of a number of protruding fibres in a Special nipper, and then proceeds to place the group of fibres across the combs again in a different place, the nipper resting against the back comb. He repeats this operation a number of times and so obtains a bunch of fibres all of which have one end along a common line—that of the back comb. Obviously those which are longest will stretch furthest across the combs, and he now therefore selects them by nipping the distant ends, taking the longest first, and building up a diagram of even density, the length of the fibre being the ordinate, the abscissa depending upon the length distribution. From this diagram the mean and the model lengths can easily be obtained, and, much less readily or accurately, the fibre—length distribution.

## COTTON BUYING AND IMPORTING.

On arrival in the Liverpool warehouse the cotton bales are weighed, the canvas cut again and samples taken. To do this it is necessary to take off one or two bands. As samples are drawn the bales are ticketed with bale numbers. The tickets are perforated and half the ticket is torn off and put inside the sample which the spinner sees when the cotton is shown to him on the Liverpool Counter. Before the sample is seen, however, it has been through the hands of the dresser. The dresser trims the edges of each sample and puts 16 drawings of cotton to a complete sample sheet.

The samples now go to the salesman for selection. In the selection process the cotton is sorted into even running lots, according to grade and staple. Close to the selector's hands are the official Washington Standards for each grade of cotton, arranged in shallow boxes about 2 ft. Square and each containing 12 pieces of cotton, each piece varying slightly but each within the grade they represent. The best bale in the Low Middling box, for instance, would be almost equal in grade to the worst in the Strict Low Middling.

After selection, the bales in the warehouse are resorted into lots tallying with the corresponding numbers in the pieces of cotton chosen by selector to represent each quality he decides to make. The lots are then each given a separate mark. The cotton is now offered on the spot market. Brokers with inquiries from spinners then go around each merchants' sale-room, make their inquiries known, look at any lots the merchant considers suitable, order certain lots to be sent into their buying room, and await the arrival of the spinners. During the war, when the salesmen were scarce, a system was introduced whereby brokers put their inquiries on a blackboard at the entrance to the Liverpool Cotton Exchange, and this system is carried on to-day in addition to the one mentioned above.

## Methods of Buying Cotton.

The two principal ways of buying cotton are on Spot terms or, alternately, on C. I. F. terms. In the former case the cotton is sold equal to a sample shown, which is kept as a buying paper by the broker. If the bales come up lower than the buying paper samples, the merchant has to tender other cotton that is equal. If two tenders have been made and the buyer is not satisfied he may invoice the cotton back at the price the right cotton would be worth on that day.

The C. I. F. Contract is mainly used by merchants buying from shippers, though it is becoming more and more popular among Spinners buying for groups of mills able to use different qualities. In C. I. F. Cotton Contracts bales that are below the buying type have to be accepted with an allowance, though no allowance is made to the seller for cotton better than type. There are slight differences in tare, too, between cotton bought C. I. F. and on spot terms, but the final invoice amount does not vary greatly. C. I. F. cotton is usually offered 15 points to 25 points cheaper than spot and usually one expects to get something on the top side of what one buys for quality.

The real objection to a spinner buying American Cotton C.I.F. is that he might only get 50% of the cotton he wants, the balance might be 30% of it above and 20% lower, and, unless he has several mixings, the higher and lower qualities would be useless to him.

After a spinner has bought his cotton off the counter men are sent down to the warehouse to sample the cotton. A sample is drawn from each bales, the bale is tagged or labelled, and the perforated end of the tag is put into the sample. The samples are taken to the buying room and carefully compared, bale by bale, with the buying paper. Any bales that are down in grade or staple are exchanged and a list of "runners" and "back numbers" is sent down to the warehouse.

## False-Packed Bales.

If when the bales arrive at the mill any are found to be false-packed—that is, contain any inferior cotton rags, dirt, lump of wood, bars of iron, etc.,—the false—pack may be returned and the value of the cotton claimed.

## Hedging.

Put in its simplest form means the "selling" of futures against a stock of actual cotton, yarn or cloth, or the "buying" of futures against sales of these until such time as the actual grade of cotton, yarn or cloth can be procured to satisfactory order.

## Futures.

Futures are an insurance against any fall in values, though not a complete insurance against fluctuations on basis. Even in the case of hedges held against actual cotton the insurance is not 100% perfect because there is no infalliable way of hedging basis.

**Hedging is an art.** Many of the prosperous firms of importers have, year after year, made all their profits out of the placing and manipulation of their hedges. Their cotton has, in many cases, been sold at a lower price and lower basis than that at which it was bought; yet they make money through the skilful placing of their hedges.

Hedges are not by any means always sales. Thousands of bales of cotton futures are bought, for instance, by spinners who have sold yarns but have not secured their cotton; and by cloth shippers who feel that cloth will be dearer in a few month's time, but who hesitate to book a large quantity of cloth because they do not know the particular "sort of quality of cloth to stock." But, by securing their futures they can easily convert orders into cloth of the desired quality when the demand materializes.

There are still people in the trade who think that to buy a hundred bales of futures is to take the first step to perdition. Yet the shrewdest men in the trade follow and operate in the future markets as freely as cotton brokers, and with great success.

Spinners, are very prejudiced against anything that savours of speculation. They would like to keep all speculators out of the cotton market altogether, yet it would be impossible to handle the world's cotton crops without what are known as "outside Speculators." All business is speculation to a very great extent. Speculater mean a great many more transactions in cotton than if the market were confined to members of the trade. This means a closer price when spinners are "fixing" and consequently cheaper cotton.

## "Cotton Sampling & Testing."

### FACTORS TO BE OBSERVED WHILE SAMPLING COTTON.

(1) Take at least 100 lbs. of cotton, shake it well if it contains sand on a piece of hessian cloth spread out on the floor. weigh the sand that is dropped from the shaken cotton and you thus get the percentage of loss through this source.

(2) Cotton stained with earth due to heavy rain, should be used for warp that is to be sized and not weft.

(3) Examine the cotton for dampness, leaf, dirt, staple, strength, colour, etc. etc.

(4) The tare weight should not exceed the stipulates or standard weight.

(5) The net weight of cotton of the bale under test should be varified before starting the test.

(6) Details of defects as the result of examination should be recorded in the test report under the General Remarks.

## TEST REPORT I.

### "Sampling and Testing Report"

Cotton issued to mixing on ..............................
Description of Cotton and Lot No.......................
Length of Staple ..........................................
Condition ....................................................
Quantity issued ..........................................

| Description. | Hank or count | | Production in 10 Hours. | | | Yards | Weight | | Eff. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nom. | Actual | 100% | Actual | Ozs. per Spindles | | dwt. | grs. | | |
| Lap .. .. .. | | | | | | | | | | |
| Carding .. .. .. | | | | | | | | | | |
| Drawing .. .. .. | | | | | | | | | | |
| Slubbing .. .. .. | | | | | | | | | | |
| Inter .. .. .. | | | | | | | | | | |
| Roving .. .. .. | | | | | | | | | | |
| Ring Frame .. .. | | | | | | | | | | |

________ Average counts Test.________
________ Draft .. .. Turns per inch.________
________ Ring Travellers .. Diameters of Ring.________
________ Pinion .. .. .. Tin Roller Wheel ________
________ Twist wheel

Roller gauging
Ring
Roving
Inter
Slubbing
Drawing

Shaper wheel
Ring
Roving
Inter
Slubbing.

| | Ring. | Roving. | Inter. | Slubbing. |
|---|---|---|---|---|
| No. of Spindles .. .. | | | | |
| Speed of Spindles .. .. | | | | |
| Dia. of Wharfe .. .. | | | | |
| Front Roller speed .. .. | | | | |

| | Ring. | Roving. | Inter. | Slubbing. | Drawing. | Carding. | Blow-room. |
|---|---|---|---|---|---|---|---|
| Speed of Frame | | | | | | | |
| Speed of Main Shaft .. | | | | | | | |
| Driving Drums | | | | | | | |
| Pulleys .. | | | | | | | |

*General Remarks* :—

## "Waste Loss in Cotton Opening and Cleaning Machinery."

The accuracy of finding the clean cotton cost depends on the correctness of tests made in the mills. A large amount of the waste made in the spinning mill is confined to the opening and blowing room machinery. Tests of 100 lbs. are of no practical value. The errors are not merely due to the sample not being representative, but mainly due to the fact that the cotton is not being submitted to the normal treatment.

Cleaning in hopper machines depends very largely upon the density of cotton in the hopper. In a small sample it is impossible to have the hoppers functioning in their usual way, and the thin sheet of cotton that emerges on the lattice of the lattice feeder proves, on examination, to have received less opening than would have been the case had it been fed in bulk. The action of the air suction, drawing the cotton from the Crighton opener, through the dust trunks, has the effect of lifting the small weight if cotton is away from the grid bars. There is no lag, and consequently the cleaning effect is minimized.

A similar case applies to the Crighton opener; here the action is due to centrifugal force and the heavier weights of cotton show a more decided action on the bars of the machine. With such source of inaccuracy, one feels, in submitting figures of a small test, that they leave much to be desired.

Monday morning is the best time to carry out a test for waste. The machines are clean, empty, and, if one has been able to plan ahead, the position of the lap supply for the cardroom will not cause any anxiety. If a mixing of the mark or marks to be tested can be put down, make the mixing as large as possible, certainly representative of the bulk. One thousand pounds may seem a big quantity to weigh off but if scales are handy, the job is not a difficult one at all. Should it not be possible to do this, choose two or three bales; carefully weigh them, and have them put down as a mixing. The bands and tares (when they come out) should be weighed off and deducted from the gross amount.

Where a new mark, or more particularly a new growth, is being used, the strippers on the hopper machines will require attention, either lowering or raising. This adjustment will be found to be indicative of the general trend of the cotton, following out even in the regulation of the finisher scutcher.

Lap waste made on the exhaust opener should be kept separate and weighed off against the total cotton weight for that process. In the case of single lapper machines there will be no intermediate stage, and the finisher scutcher will be the equivalent.

Laps should have been made of the correct weight on the exhaust, and one or two finishers prepared. Weigh off a number of lap rods, in batches of ten, to the estimate of the requirements, and have them placed convenient to the machines, but used in lots. Prepare a chart having two columns, one marked "*light*" and the other column marked "*heavy*". Book down the weights of the laps accordingly, putting those that are dead weight as 0 in the heavy column.

If this is done progressively, i.e., booking each weight down beneath the previous one in the correct column, one has then a record of the movement of the lap weights, which, when completed, will be interesting to retain for comparison witn future tests and an indication of the behaviour of the machines. Of course if two machines are to be used, the weighings will be recorded separately. When the test is over, weigh the lap rods remaining and deduct the weight from the gross lap rod weight. Total up the gross lap weight and deduct the weight of the lap rods.

All waste from the finisher is treated as cleaned cotton; as also any laps outside the scale allowed. Do not put them back to be fed again. Have all waste and sweepings carefully collected and weighed for each machine.

## TEST FOR WASTE

| Per cent. | | lbs. | ozs. | lbs. | ozs. |
|---|---|---|---|---|---|
| | Two bales taken (Gross weight) .. | | | 1,004 | 0 |
| | Bands .. .. .. .. .. | 11 | 0 | | |
| | Tares .. .. .. .. .. | 44 | 0 | | |
| | | 60 | 0 | 60 | 0 |
| 100 | Net weight .. .. .. .. | | | 944 | 0 |
| | COTTON ROOM: | | | | |
| | Droppings Breakers .. .. .. | 4 | 8 | | |
| | „ Lat. Feeder .. .. .. | 11 | 2 | | |
| 1.81 | Sweepings .. .. .. .. | 0 | 12 | | |
| | | | | 16 | 6 |
| 98.2 | | 16 | 6 | | |
| | | | | 927 | 10 |

## Exhaust Opener Combination:

| | | | | | |
|---|---|---|---|---|---|
| | Crighton .. .. .. .. | 7 | 4 | | |
| | Dust Trunks .. .. .. .. | 2 | 15 | | |
| 1.41 | Exhaust Droppings .. .. .. | 3 | 11 | | |
| | | | | 13 | 14 |
| 96.79 | | 13 | 14 | | |
| | | | | 913 | 12 |

## Finisher:

| | | | | | |
|---|---|---|---|---|---|
| | No. 1 Droppings .. .. .. | 1 | 11 | | |
| .34 | „ 2 „ .. .. .. .. | 1 | 7 | | |
| | | | | 3 | 2 |
| 96.45 | | 3 | 2 | | |
| | | | | 910 | 10 |
| | 19 Laps and Lap Waste .. .. | 908 | 3 | | |
| | Loss not accounted for .. .. | 2 | 7 | | |
| .26 | | | | 910 | 10 |
| 3.82 | Total loss. .. .. .. .. | | | 910 | 10 |

### "Descriptions of Wastes"

### "Blow Room Waste".

Dropping No. 1 =
„ No. 2 =
Flues and dust Chamber etc. =
Total

Per cent. =

### "Carding Waste".

Flat Strips =
Cylinder and Doffer Strippings =
Fly =
Sliver =
Other Waste (clean & dirty Sweeping etc =
Total

Per cent. =

**"Frame Waste."**

Sliver (clean & dirty Sweepings) =
Ends =
Frame clearer =
Other Waste (clean & dirty Sweepings) =
Total
Per cent. =

**"Ring Frame Waste."**

Soft Waste (Bonda—clean & dirty) =
Bottom & Top clearer =
Hard Waste =
Ends waste (clean & dirty Sweepings) =
Ends Broken =
Total
Per cent. =

**"Reeling."**

Hard waste =
Broken cops =
Reeling dirty =
Total
Per cent. =
Grand Total =
Total Per cent. =

## Recording of Waste.

Where different kinds of cotton are spun, the waste made should, as far as possible, be recorded separately. It must be remembered that in mills where soft waste is re-used in the mixing, this waste is not a true loss, but it is useful to keep a record of the different classes in order to compare percentages, for it must be borne in mind that "manufacture cost" for these quantities is being paid for "twice over" up to and including the machine whence such waste originated. It is therefore imperative that it be kept down to a minimum. Percentages may be calculated daily, weekly or monthly, but in order to obtain a better average, it is preferable to calculate them for each day and for each kind of waste or loss (whether visible or invisible) and should be recorded carefully. Should there be an abnormal increase in any one class of waste, investigation should follow immediately.

The standard percentage for each kind of loss may differ in one mill from another, and the routine standards for local application can only be established after several months of observation.

## TEST REPORT II.

*Name of Firm*...................................

| | | |
|---|---|---|
| Tests | Counts to be Spun ........................ | |
| Counts Pull | Quality of Cotton......................... | |
| | Hank .................................... | |
| | Draft .................................... | |
| | Turns per in.............................. | |
| | Actual Spindle Speed | per min. |
| | Front Roller ,, | ,, |
| | Ring | dia. |
| | Traveller ............................... | |
| | Frame .................................. | |
| | Roller Stand ............................ | |
| | Tin Roller Wheel ... | Twist Wheel ........ |
| | Crown ,, ....... | F. R. ,, .......... |
| Av. | Back Roller ,, ..... | Draft ,, ........ |
| | Ratchet ,, ..... | Motion ............ |
| Spindle No....... | Heart ............. | Quadrant .......... |
| Dia. of Wharve .... | Worm & Wheel ..... | Start ............... |

| **Roller Setting** | | 1st | 2nd | 3rd | 4th |
|---|---|---|---|---|---|
| ....1st to 2nd | Bottom Rollers | | | | |
| ....2nd to 3rd | Top Rollers, uncov | | | | |
| ....3rd to 4th | 2nd Top Roller | | | | |

## TEST REPORT III.

*Quality of Cotton* .. .. .. .. ABX

*How worked* .. .. .. .. 6 ends combed ABX

*Date*...........194 .

| | Weight. | No. of yards. | No. of ends up. | Draft. | Speed. | Turns per inch. |
|---|---|---|---|---|---|---|
| Opener .. | | | | | | |
| Scutcher .. | | | | | | |
| Card .. | | | | | | |
| Draw Frames .. | | | | | | |
| Derby .. | | | | | | |
| Ribbon .. | | | | | | |
| Comber .. | | | | | | |
| Draw Frames .. | | | | | | |
| ,, ,, .. | | | | | | |
| ,, ,, .. | | | | | | |
| Slubber .. | | | | | | |
| Intermediate .. | | | | | | |
| Roving Frame .. | | | | | | |
| Ring Frame .. | | | | | | |

*Card Waste* %

*Comber* ,,

,, Feed Wheel

,, Star ,,

---

*Remarks* ;—

All above particulars are supposed to be those at present running, if any alteration from above is suggested in any detail, a fresh sheet must be made out and returned to the office for approval

# TEST REPORT No. IV.

## Sampling and Testing of Cotton.

| | lbs. | ozs. |
|---|---|---|
| Actual quantity of cotton .. .. .. .. | 828 | 0 |
| Waste made in Blow Room (16.60%) .. .. | 137 | 8 |
| | 690 | 8 |
| Good Waste of lap pieces left after Carding .. .. | 19 | 8 |
| Quantity passed through carding .. .. .. | 671 | 0 |
| Waste made at carding (7%) .. .. .. .. | 47 | 0 |
| Net quality carded .. .. .. .. .. | 624 | 0 |
| Waste made in Frame Dept. (2-1/5%) .. .. | 13 | 12 |
| Net quantity on Roving Bobbins. .. .. .. | 610 | 4 |
| Waste made in Ring Dept. (4.30%) .. .. .. | 26 | 4 |
| | 584 | 0 |
| Actual quantity of yarn obtained .. .. .. | 546 | 12 |
| Invisible loss through various processes (4.49%) .. | 37 | 4 |

SUMMARY.

| | lbs. | ozs. | lbs. | ozs. |
|---|---|---|---|---|
| Actual quantity of cotton taken = .. .. .. | | | 828 | 0 |
| Yarn produced and good waste of lap pieces | 546 | 12 | =566 | 4 |
| | 19 | 8 | | |
| | 566 | 4 | 261 | 12 |

Total loss per cent of Wastage = 34.59.

*Remarks* :—

| Actual Count. | Test | Twist Wheel. | Change Pinion. | Turns per inch. | Remarks. |
|---|---|---|---|---|---|
| 20.10 | 68 | 40 | 43 | 22.17 | |
| 19.70 | 63 | 42 | 44 | 21.11 | |
| 20.20 | 62 | 44 | 43 | 20.15 | |
| 19.19 | 58 | 46 | 46 | 19.28 | |
| 20.94 | 52 | 48 | 43 | 18.47 | |

## COTTON MIXING OR BLENDING

### Cotton bale (Mixing Room) Book.

| Date. 194 . | Progressive Number. | Metal tag Number or Stenciled Marks. | Cotton clerk's weight. | Mixing Room weight. | Tare of bagging. | Weight of hoops. | Remarks. |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

The cardinal point of laying a mixing by a mechanical means or by hand is that the hard baled cotton must be opened up as thoroughly and as gently as possible.

It is essential to lay a mixing as large as possible particularly so if the practice of blending of varieties of cotton is adhered to and stack mixing is favoured. Because, it is seldom one finds two mixings alike, this being due not only to the variation found in different bales of the same mark, as it is a peculiarity of the cotton plant that differences exist between fibres from the same boll and even from the same seed. Some of the fibres may have no convolution at certain parts, some may have short twist and other may have long twists, and these differences are very often marked and hence careful mixing will have to be resorted to.

As enormous quantities of cotton are gathered carelessly and lumped together at the ginnery it is very essential that the irregular mass of cotton on arrival at the mixing room, it must be thoroughly mixed up in order to distribute the faulty portions equally among the good fibres. It is even necessary to mix up cotton confined to one class or mark.

In order to produce cotton yarn, the cotton is passed through a number of processes. These processes may be divided into three classes, namely, (1) Mixing, (2) Cleaning, (3) Parallelizing and Attenuating and (4) Reeling, Bundling and Baling.

## Loosening-up of Cotton.

A mixing should be composed of at least 100 bales at a time so that the firmly pressed cotton may be given the chance of loosening-up and adapt itself to the conditions of temperature and humidity in the room where it is to be dealt with. It should be allowed to lie for at least two or three days, as it is a precaution of great importance for the production of clean, even laps, but it is one which is often neglected. The moisture content of raw cotton is often higher than the standard regain. It is much more difficult to clean damp cotton than when it is dry, and hence it is always best to keep the atmospheric humidity in the Blow Room lower than in the Roving and Spinning departments.

If the cotton is to be properly stacked in the mixing chambers there must of course be ample space to allow the loose cotton to lie for a few days in that condition before it is subjected to further processing.

The objects sought by mixing cotton from a number of bales are generally (1) to allow the cotton to assume its normal condition, (2) to establish an average quality of grade in the lot, (3) to obtain a certain quality of yarn as low a cost as possible, (4) it is possible by skilful selection to mix a cheaper grade of raw cotton with cotton of a better, grade, and thus reduce the cost of yarn without reducing the quality appreciably or vice versa, (5) To obtain uniformity of tint or some desired tint, (6) To increase or lower strength by incorporating superior or inferior grade of cotton, (7) To obtain a smoother or rougher yarn. But it is very essential to be borne in mind that the fewer the varieties blended the better the result, as regards :—

(*a*) wastage, (*b*) production, (*c*) more labour in keeping the machinery clean, (*d*) general discontent throughout the mill, (*e*) the mill gets a bad name in the market, etc.

When blending cottons together, the following points must be borne in mind :—

(1) Length of staple; (ought to be about equal).
(2) Fineness of fibres; (uniform in freedom from neps).
(3) Strength of fibres; (should be good).
(4) Softness of fibres; (Sufficiently alike in feel and colour).
(5) Colour of fibres; (Sufficiently alike in feel and colour).
(6) Cleanliness; (Quantity of impurities should carefully be watched.)

It may be emphatically added that the mills that are spinning twist yarns for their own weaving-shed and if they desire good production and quality from it, they must therefore put their hands off all wastes of any descriptions and grade for twist yarn, all soft wastes may be added to the weft mixing which should be whiter in grade than warp yarn. Because the warp yarn can be tinted, the weft cannot; and if good white cloth is desirable then the above suggestion may be adopted. In laying a stack or feeding mixing by hand, the first bale should be spread evenly over the entire space, the second bale of another mark should be spread to cover the first, the third bale of yet another mark should be spread over the second and so on. By this means the mixing is built up of successive layers, so arranged that no two bales of the same mark come in contact with each other, and thus the stack is built in horizontal layers. The heap should be cut from top to botton, that is, vertically by means of a short pronged iron rake to avoid too much of one kind going in at once and thus unevenness is avoided and strength is maintained. There are several methods in vogue for mixing cotton. One of a recent improvement made in this particular department by the introduction of pneumatic conveyors.

Experience, knowledge or skill, attention and care coupled with cheapness are the foremost factors in laying a mixing. When an incompetent hand has been dabbling in cotton, buying the qualities not qualified for the quality of yarn to be spun, it has often proved disastrous to the firm, and poor wages, hard work for the spinners and rovers, loss of production, increase in waste have been the results. Cotton buying and mixing are things not to be lightly passed.

## How to Select Cotton for Twist.

As a rule twist yarns are of higher counts than weft yarns. The selection of cotton for spinning into twist, or warp yarn, should be determined by the following characteristics.

The staple ought to be both longer and stronger than for similar counts of weft yarn, the natural twist of the fibres should be well developed so that the cotton is a little harsh to feel, and when "drawing" a tuft of fibres by hand more power is required than for a soft or weft, the strength of the cotton is very important as twist yarn must be stronger than weft yarn; the colour of the cotton, although much less important than that for weft yarns, must be noted and considered in conjuction with the effect of the process of sizing the warp yarn; such terms as "staple cotton" "baut" and long are given to suitable cottons for twist yarns. In case of twist a strong cotton may be mixed with a flexible or soft cotton so long as their characteristics are similar with the result that a stronger yarn will be made, otherwise, wastage will accrue if there are much difference in staple and quality.

## Precautions to be Taken in Mixings.

Hard and soft fibres should not be mixed, otherwise, a yarn showing unevenness and irregularity in strength will be produced. Soft fibres better adapt themselves to twisting than hard fibres, therefore, in diameter and stiffness the yarn must be strong, and weak fibres should not be mixed; a combination of strong and weak fibres will result in soft places in the yarn, since the fibres will not be sufficiently mixed to give uniformity. Long and short fibres should not be mixed, for an irregular yarn will be produced. In addition, much of the short fibre is thrown out in the form of flat, clearer and other wastes, while-some quantities entwine themselves erratically round the long fibres, giving a hairy, loose appearance to the yarn. Dry and moist cotton should not be mixed together nor old and new season's cotton. Care should also be taken to avoid the mixing of cottons of different shades, this is most important in weft yarns, as it causes an irregularity in tint and gives the yarn a dull appearance. In twist yarn this is not so noticeable as it is somewhat hidden by the sizing process. Again dirty and clean cotton should not be mixed if all the cleaning processes come after mixing; the same treatment of both cottons is detrimental to the making of a good yarn, for either the dirty cotton is insufficiently cleaned, making a dirty sliver or else the staple of the clean cotton is damaged by the excessive treatment required for the dirty cotton resulting in a weak yarn. Weft yarns are considered good when made from fibre of proper length and moderate strength coupled with a soft oozy nature which in weft yarn is particularly desired. It is very important for the purpose of giving a good white appearance to the cloth that the weft should be of a good class or colour. The uniformity in staple is very important as the draft rollers cannot be set to suit two different lengths of cotton.

When choosing cotton for making into weft yarns, the characteristics of the required yarn and its use must be borne in mind. Generally, the cotton must be as regular in staple as possible, the length depending on the counts and quality of the yarn, the cotton ought to feel fairly soft, but yet strong enough for good spinning and without it being necessary to insert more than the usual amount of twist in the yarn, the cotton should be as clean as possible and also a good bloom. Cotton that is tinged and dark coloured should not be used for weft. In many cases, soft waste made at various machines in the mill is used up gradually along with the new cotton for making into weft yarns. Card strippings of superior quality of cotton can be used for making weft yarns for Blankets (raised) or flannelette cloths.

## Blending of Long and Short Staples Should be avoided.

Long-staple cotton with a large percentage of short fibres mixed into it is almost useless for fine spinning, for the finer spinner is obliged to comb out all the short fibres, and he would call it a "Wasty Cotton."

Short staples are used chiefly for counts below 10's and very often the lower counts will be spun from a mixture of waste cotton. Counts up to 4's are usually spun from all wastes, sweepings, droppings, card fly, roller laps, etc. These counts are produced chiefly on waste plants, the tape and ring doffer condenser being the system employed. Much of this coarse yarn is reeled and sold in bundle form and is used in the manufacture of carpets or blankets, etc. If the mixing is to contain long and short staple cotton the short staple should not exceed 25%.

## Practical Hints.

(1) Cotton rooms should not be a cold miserable place but should have steam pipes installed and have a temperature which will give the cotton a chance to remain in the same temperature as the mill running temperature while standing in the bale.

(2) The same marks of cotton bales should always be stored together to avoid any risk of mixing wrong marks when the cotton mixer is taking them away for use.

(3) It is very important that care should be exercised to have the speed of bale breaker such that the machine is not over-producing the requirements of the mill by too great a margin as any unnecessary and extra production from the machine means that the cotton has been opened up much less because the production of the bale breaker is determined by the distance of the evener roller spikes from the lifting lattice spikes.

(4) Other matters of importance in connection with the running of the breaker are that the machines should be placed so that there is a good air ventilator immediately behind the feed part in order to give the fan a chance to do its work.

## Influence of Moisture in Mixing and Blowing Rooms.

It is very seldom that bale cotton possesses uniformity in its moisture content. Parts may be very damp and other parts very dry. This state of affairs is quite usual even in the best batches of baled cotton, and the general average percentage of moisture may be a reasonable one. A frequent experience, however, is one where, in a batch of bales set apart for a mixing, there are complete bales that may be very dry and complete bales that have excessive moisture.

## Average Conditions of Moisture.

It may be presumed that mixing of cottons in their varied condition of moisture contents will produce a fair average condition of moisture. This would be correct if the cotton is looked at as merely as mass of material, and time is allowed for the moisture in the damp portions to be partially absorbed by the dry portions. Stacking the cotton is an effective method of attaining this average result, but even then two conditions are necessary. First, the cotton must be well opened before placing it in the bin or stack; and secondly, a reasonable time must be allowed for the whole mass of cotton to become uniformly moist before using.

The drier bale of cotton is easier to open, and the impurities, the finer dust and sand can more readily be eliminated in the opening processes. If cotton is wet it is difficult to open it; the fibres get matted together and any impurities adhering to the fibres or mixed up in the entanglements of the fibres cannot easily be freed.

## Necessity for Correct Humidification.

All mixing and blowing rooms ought to have a well organised system of humidification, and carefully regulated to suit the atmospheric conditions. It will be found much easier and more reasonable, in most cases, to get cotton into a condition to suit the machine than to fool with the machine to suit the condition of the cotton.

The fact that long passages in openers, the use of long passages as dust trunks, and the excellent results of using a properly designed Crighton Opener are indications that cleanliness and openness of the fibres are produced thereby.

(5) Pay keen attention to both the mixing and blow room in a general way as there lies a part of the foundation for the production of an even yarn.

(6) (*a*) Peeler and soft Egyptian mix well to spin from 60s to 80s yarn.

(*b*) Gulf Texas, and soft Peruvian mix well for yarns of 40s and 60s.

(*c*) Rough Egyptian and rough Peruvian incorporate well, and are suitable for spinning yarns from 40s to 50s.

(*d*) Hinganghat and Broach mix well with lower classes of American cotton such as Georgia or Boweds.

## CHAPTER XV.

## ROVING WASTE OPENER.

It cleans and opens roving and clearer waste and prepares it for mixing with the cotton coming from the bale opener. This helps to make saving in raw material and cheapness in mixing.

The waste is fed to the machine on an ordinary travelling lattice. It is drawn by a pair of feed rollers to a small cylinder $9\frac{3}{4}''$ in diameter covered with saw tooth wire clothing. The surface speed of the cylinder is much greater than that of the feed rollers, and as it revolves the teeth of the clothing catch the cotton in such a manner as to cause it to be carried round in short lengths. The material is then transferred from the small cylinder to a large one $24''$ in diameter beech logs containing black forged cast steel by the aid of the knife edge guide plate. It is then opened, the twist is taken out, and it is delivered in a loose state in various ways which can be arranged either with cage to deliver the cotton loosely on to the floor, or to feed into an exhaust opener by means of a pipe to suit the requirements of the blow-room department.

## THE WILLOW MACHINE.

The willow machine is used for treating various kinds of waste made in the spinning mill, such as droppings from the lattice feeder crighton opener, combined opener and lap machine, scutcher etc. The waste after being treated by the willow, is taken in many cases to the mixing room where it is put into mixings that are being made for spinning yarn of lower counts than were being made when the waste was originally produced. Thus if the waste was produced when the mill was making 20's counts, the waste after being put through the willow would probably be used in mixings that were being prepared for 10's to 12's counts and below. In other cases laps consisting entirely of the waste are made by the combined opener and lap machine, are fed to a scutcher. Owing to the fact that the waste treated by the willow is to a large extent of a low character a part of it in some cases being taken from the floors of the various rooms. It may contain a certain quantity of small pieces of metal such as broken spikes, nails, etc. It is, therefore, very liable to fire, and for this reason it is advisable to have the willow kept apart from other machinery and put in a fire-proof room.

Power =3 I. H. P.
Speed =about 350 R.P.M.
Production=1000 to 1500 lbs. per day of 9 hours.

## Thread Extractor.

The thread extractor is used for treating card and spinning room sweepings etc. This class of waste, is composed mainly of "soft" waste mixed with a fair proportion of threads. In order to make the best use of same and thereby increase its value it is found necessary to separate or extract the threads. This work was formerly achieved by a slow process of picking by hand labour, but since the introduction of this machine, which both cleans and separates the two kinds of waste in a simple and effective manner, the process has been considerably cheapened. The soft waste that it usually contains good fibre, can readily be re-worked and spun into yarn or coarse counts, or in the case of roller laps returned to the cotton mixing, and the threads can be used for making into cleaning waste etc.

Power =2 to 3 I. H. P.
Speed =400 R. P. M.
Production=700 to 900 lbs. per day of 9 hours.

### COTTON MIXING AND ITS COST.

20's Warp Mixing.

| Date 1941 | | Description of Cotton. | Per cent | Rate per Candy. Rs. | As. | Cost per lbs. As. | Ps. | Loss per cent | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| May | 1 | Sind-American | 30 | 473 | 0 | 3 | 2.58 | 10 | |
| | | Tripur-Cambodia | 25 | 551 | 0 | 3 | 0.23 | 7 | |
| | | Bhagalkote .. | 30 | 399 | 0 | 2 | 9.30 | 12 | |
| | | Koompta .. | 15 | 399 | 0 | 1 | 4.65 | 12 | |
| | | | 100 | | | 10 | 4.76 | | |

(1) *Example ;—*

*Q.* Find the price per lb. of the following quantities of cotton when mixed.

20,000 lbs. of cotton A at 10 annas per lb.
30,000 lbs. of cotton B at 7 annas per lb.

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

$$\frac{\text{lbs, } 20000 \times 10 \text{ Annas} + 30000 \text{ lbs} \times 7 \text{ annas}}{20000 + 30000} = \text{price of mixture per lb.}$$

$$\frac{410{,}000}{50{,}000} = 8.2 \text{ Annas per lb.}$$

(2) *Example ;*—Supposing you were given four different kinds of cotton of the following rates :—

1st lot Rs. 260 per candy, 2nd lot Rs. 170 per candy,
3rd ,, Rs. 180 ,, ,, 4th ,, Rs. 190 ,, ,,

and if you were asked to prepare a mixing of 40 bales out of the above lots so that the average price per candy will be Rs. 175.

*A.* The mixing will be as follows :—

| | | | |
|---|---|---|---|
| 15 candies | of the 1st lot | 160 | 175 |
| 5 ,, | ,, ,, 2nd ,, | 170 | |
| 5 ,, | ,, ,, 3rd ,, | 180 | |
| 15 ,, | ,, ,, 4th ,, | 190 | |
| 40 | | | |

*By verification.*

| | | | | |
|---|---|---|---|---|
| The price of 15 candies | of the 1st lot | Rs. 160 is | =Rs. | 2,400 |
| ,, ,, ,, 5 | ,, ,, ,, 2nd ,, | Rs. 170 | =Rs. | 850 |
| ,, ,, ,, 5 | ,, ,, ,, 3rd ,, | Rs. 180 | =Rs. | 900 |
| ,, ,, ,, 15 | ,, ,, ,, 4th ,, | Rs. 190 | =Rs. | 2,850 |
| 40 | | | Total | 7,000 |

The average price per candy therefore is Rs. 7,000÷40 =Rs.175.

*Q.* If the loss per cent of Sind-American cotton is 12, of Khandesh cotton 16, and that of Khamgaon cotton be 15, and if a mixing is made of 10 candies of Sind-American, 20 candies of Khandesh, and 30 candies of Khamgaon, what should be the total loss per cent ?

*A.*

| Candies | Loss% |
|---|---|
| $10 \times 12$ | 120 |
| $20 \times 16$ | 320 |
| $30 \times 15$ | 450 |
| 60 | 890 |

Therefore the total loss is $= 890 \div 60 = 14.83$.

*Q.* If three types of cotton A, B, and C are to be mixed together in the proportion of 2 parts of A, 7 parts of B, and 3 parts of C, and if A costs 6 as. per lb., B costs 7 as. per lb., and C costs 8 as. per lb., what will be the price per lb. of the mixing and the cost of 30,000lbs.?

| | | Rs. | as. | p. |
|---|---|---|---|---|
| *A.* | 2 lbs. of A at 6 as. per lb. is .. .. .. | 0 | 12 | 0 |
| | 7 ,, ,, B ,, 7 ,, ,, ,, ,, .. .. .. | 3 | 1 | 0 |
| | 3 ,, ,, C ,, 8 ,, ,, ,, ,, .. .. .. | 1 | 8 | 0 |
| | 12 | 5 | 5 | 0 |

Price per lb. = Rs. $5.5 \div 12 = 7.08$ as. cost of 30,000 lbs. = $7.08 \times 30{,}000$ = Rs. 13,275.

---

## COTTON MIXING

4's *Reeling.*
100% Waste (Sweeps etc.)

4½'s *Reeling.*
20% Bengal
45% Card Fly
15% Dropping
20% Bonda 6's
100%

5's *Weft.*
50% Bengal
50% Sweeps and Drops.
100%

6's *Reeling Special.*
45% { Agra / Ambala / Hathras }
55% Waste
100%

6's *Warp.*

100% Khandesh

6½'s *Reeling.*

75% Bengal
25% Soft Waste

100%

6½'s *Reeling.*

15% Badwai
10% Botad
30% Wadhwan
20% Bengal
10% Sliver
5% Dropping
5% Roving Ends
5% Stripping

100%

7's *Warp.*

Molisoni N. T. 100%

7's *Weft.*

50% Coconada
50% Sweeps and Drops

100%

8½'s *Reeling.*

100% Hinganghat.

8½'s *Reeling.*

25% Senabad
25% Bengal
50% Good Waste

100%

8½'s *Reeling.*

10% Senabad
10% Khamgam
25% Karachi
15% Ring Bonda
35% Sliver
5% Segam

100%

8½'s *Reeling.*

50% Badwai
20% Bengal
25% Indore
5% Sliver of 20s

100%

9's *Warp.*

84% Karunganni
16% Pulichai

100%

10's *Reeling.*

40% Sind
35% Bengal
25% Waste

100%

10's *Reeling.*

55% Bengal
45% C. India & Ujjain

100%

10's *Reeling.*

62% Sind
24% Bengal
14% Khandesh

100%

10's *Reeling.*

70% Bengal
20% Khandesh
10% Waste

100%

$10\frac{1}{2}$'s *Reeling.*

60% Firozabad
40% Umrawati

100%

*Add*—

1000 lbs. Roving Ends
1000 lbs. Clearer Waste
500 lbs. Stripping
500 lbs. Dropping No. 1.

3000 lbs.

10's *Weft.*

75% Broach
25% Soft Waste

100%

12's *Warp.*

75% Western
25% Waste

100%

12's *Warp.*

50% Punjab-American
50% Mollisoni N.T.

100%

12's *Warp.*

75% Northern
25% Coconada

100%

12's *Warp.*

74% Karunganni
26% Pilichai

100%

12's *Weft.*

20% Purna
20% Umrao
10% Senabad
15% Khamgam
25% Sliver 20's
10% Broken Ends (Roving)

100%

14's *Warp.*

100% Western

14's *Warp.*

5% Cocanada
30% Wadhwan
20% Yadgiri
35% Morvy
10% Broach

100%

14's *Weft.*

20% Umrao
20% Berar Bora
25% Umrawati
20% Sliver 20's
15% Bhasyet Nager

100%

14½'s *Reeling.*

50% Broach
25% Warangal
25% Soft Waste

100%

14½'s *Reeling.*

48% Bengal
16% Nagpur C.P.
16% Wardha
20% Berar (Umrawati)

100%

15's *Warp.*

100% Western.

15's *Weft.*

75% Broach
20% Soft Waste

100%

16's *Warp.*

100% Punjab-American 4F.

16's *Warp.*

100% Western.

16½'s *Reeling.*

50% Bengal
50% Waste

100%

17's *Weft.*

50% C. P. and Oomra
25% Ujjain
25% Local American

100%

18's *Warp.*

100% Western

18's *Warp.*

100% Surat

18's *Warp.*

100% Northern

20's *Warp.*

45% Sind-American
10% Coompta
20% Bhagalkote
25% Tinnevally

100%

20's *Warp.*

55% Sind-American
15% Coompta
25% Tinnevally
5% Cocanada

100%

20's *Warp.*

- 65% Sind-American
- 15% Yadgiri
- 15% Sangli
- 5% Cocanada

100%

20's *Warp.*

- 30% Sind-American
- 25% Tirpur-Cambodia
- 20% Nanded
- 15% Coompta
- 10% Belungal

100%

20's *Warp.*

- 15% Latoor
- 20% Coompta
- 20% Seloo
- 20% Barshi
- 25% Sind-American

100%

20's *Warp.*

- 100% Western.

20's *Warp.*

- 50% Karunganni
- 0% Punjab-American

100%

20's *Weft.*

- 26% Kadi
- 6½% Dhrangadra
- 11½% Pachora
- 20% Khandwa
- 30% Jalna
- 6% Doolia

100%

20's *Reeling.*

- 30% Western
- 30% Khandesh
- 20% Central India
- 20% Cocanada

100%

20's *Warp.* & 24's *Weft.*

- 60% Umri
- 40% Hinganghat.

100%

21's *Warp.*

- 30% West African
- 60% Latoor, Nanded, Bhensa & Dharanabad
- 10% Cambodia & Parwani

100%

21's *Warp.*

- 50% Karunganni
- 50% Punjab-American

100%

21's *Warp.*

- 20% Coompta
- 20% Cocanada
- 20% Gujrat
- 20% Central India
- 20% Western

100%

22's *Twist & 26's Weft.*

16% Am. Lyalipur
8% Am. Jaranwalla
8% Karunganni
12% Khangaon Staple
10% Ujjain
8% Wardha
30% Pandarkora
8% Hinganghat

100%

22's *Warp.*

70% Karunganni
20% Am. Lyallpur
10% Hinganghat

100%

22's *Warp.*

50% Karunganni
50% Cambodia

100%

22's *Warp.*

100% Punjab-American 4F.

22's *Warp.*

60% Punjab-American 289F.
40% Molisoni N.T.

100%

22's *Warp & 26's Weft.*

20% Hinganghat
60% Punjab-American
20% Nagpur

100%

22's *Warp & 28's Weft.*

100% Bhikamgam Upland

22's *Warp & 26's Weft.*

14% Karunganni
34% Superior Western Farm
26% Punjab American
8% Cambodia
11% Adilabad
7% Pandarkora

100%

22's *Warp & 26's Weft.*

10% Chandajuri
20% Tinnevally
30% Am. Lyallpur
15% Karunganni
20% Pandarkora
5% Roving Ends, Sliver, Broken pieces of Laps.

100%

23's *Weft.*

75% Broach
25% Umra.

100%

24's *Warp.*

85% Cambodia
15% Tinnevally

100%

24's *Weft.*

40% Dhrangdra
15% Latoor
15% Seloo
30% Khargun

100%

24's *Weft.*

70% Tinnevally
30% Local American

100%

26's *Reeling.*

100% Punjab-American.

26's Weft.

100% Broach.

26's Weft.

28% American Lyallpur
12% American Oookara
12% Karunganni
48% Pandarkora

100%

26's Weft.

The mixing given under 22's Warp can be used to spin 26's Weft.

27's *Weft.*

20% West African
20% Cambodia
60% { Nanded, Bhensa, Dharanabad.

100%

32's *Weft.*

30% Cambodia.
20% American 289
30% Kampalla American
20% American Middling

100%

32's *Warp.*

100% African (Kampala) A.R.

32's *Warp.*

20% P. American 289
30% Uganda
50% Kampalla A. R.

100%

32's *Weft.*

50% Ookara American
25% Veeram
25% Tirpur Karunganni

100%

36's *Warp.*

80% Cambodia
20% Egyptian Cotton Waste.

100%

36's *Strong Twist.*

100% Memphis $1\frac{1}{8}''$ to $1\frac{3}{16}$

40's *Warp.*

40% African Kampala
25% African Busogo
15% Punjab American 289
10% Lyalpur Veerum
10% Sarawar.

100%

40's *Warp.*

60% Oram Egyptian
30% Polo Egyptian.
10% Modra 289.

100%

40's *Weft.*

20% P. American 289
50% Kampalla A.R.
30% American Middling

100%

40's *Reeling.*

100% Ankleswar.

44's *Twist.*

100% Memphis $1\frac{3}{16}$

50's Twist.

100% Memphis $1\frac{1}{4}''$

50's *Warp.*

100% Uganda

60's *Warp.*

100% Sakals Egyptian

62's Warp.

100% Memphis $1\frac{5}{16}$

60's *Weft.*

60% Oran Egyptian
40% Polo Egyptian

100%

60's Weft.

95% Uganda
5% Soft Waste.

100%

62's Weft.

50% Brazilian
50% Egyptian

100%

64's *Warp.*

100% Memphis $1\frac{5}{16}$

64's *Warp.*

28% Pernams
28% Maceis
30% Sakellaridis F.G.F.
14% Sakellaridis Good.

100%

70's *to* 80's *Twist.*

100% Memphis $1\frac{7}{16}$

70's *to* 84's *Weft.*

20% Sakellaridis F.G.F.
20% Sakellaridis G. F.
40% Maceis.
20% Pernams

100%

82's *Weft.*

20% Brazilian
80% Egyptian

100%

82's *Super Weft.*

100% Memphis $1\frac{7}{16}$

100's *Good Quality.*

50% Peruvian Good
50% New Orleans Best.

100%

## DRAFTING.

Drafting means drawing out or attenuating the cotton fibres by means of revolving rollers. For instance, if 1 yd. of draw frame sliver, passed through a slubber, is drawn out to 6 yd. of roving the draft in this case is six, and so on.

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 machinery 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 :—

$$\frac{\text{weight of Slubbing} \times \text{Inter draft} \times \text{roving draft} \times \text{Spinning draft}}{\text{doublings of } 2 \times 2 \times 2}$$

= 5 per cent higher than the Counts.

$$\frac{1.5 \times 6 \times 6.7 \times 14}{2 \times 2 \times 2} = 105$$

The result shows that the above drafts would be suitable for 100 Counts.

## Hank Lap, Hank Sliver, and Hank Roving.

The above terms designate the product which is desired to obtain on the Scutcher, Carding Engine or Draw frame and on Speed frames respectively. These products are governed by the counts of the yarn required to be spun on the ring frames or the mules.

The Hank Roving coming from a frame is simply the hank fed to that frame multiplied by the draft put into it.

Hence, working backward from the known counts to be obtained in the spinning process and dividing by the draft put in on each machine, the result will be the respective hank to be produced at the preceding stage, or *vice versa*. The hank-sliver multiplied successively by the drafts put into it during each process will give the final counts. Allowance must of course be made for doubling upon any machine, suitable drafts for all counts and all cottons in each operation being known, it is easy to determine any hank required. By this process, the result will eventually be arrived at the hank-lap to be made at the first measurable stage in the mill.

The scutcher hank-lap indicate the decimal part of 840 yards contained in 1 lb. of lap.

## Working Draft.

| | | |
|---|---|---|
| 3 to 4 | between | Drawing and Slubbing machine. |
| 4 to 5 | ,, | Slubbing and Intermediate frame. |
| 5 to 6 | ,, | Intermediate and Roving frame. |
| 6 to 7 | ,, | Roving and Ring frame for medium count |
| 6 to 9 | ,, | ,, ,, ,, ,, ,, ,, higher ,, |

To get the best result it is wise to work on a base of six of a draft between Roving and Ring frame unless long drafting system is adopted where it is practicable to get up to 12 of a draft.

The shorter the staple of cotton the less the draft required and *vice versa.*

(1) Lap weight may be standardised from 10 to 16 ozs. to the yard, which of course depends upon supply and demand. If the Blow-room can supply more than the requirements of the cards, it is then advisable to go finer in the lap, as it helps in cleaning the cotton better in the card, otherwise *vice versa,* that is, go coarser.

(2) Find the Hank Rovings for the counts of yarn intended to be spun.

(3) Draft is based on the ratio of Roving spindles to Ring spindles.

The lesser the draft the more roving spindles are required and *vice versa.* When changing from coarse counts to fine counts then less draft will be required, because it takes longer time to spin a roving bobbin and *vice versa.* Should the roving bobbins be found accumulating then it is advisable to go lower in the draft, that is, finer Hank Roving with a correspinding increase in the number of teeth in the pinion on ring frames.

(4) Should a base of six of a draft be established then proceed as follows, for instance, if 16's counts of yarn is intended to be spun.

Then 6 plus .8 (for milling up=6.8)

16's divided by 6.8=2.5 Hank Roving

5 to 6 is the working draft between Intermediate and Roving frames.

∴2.5 Hank Roving÷3 draft=.50 Hank Roving for 2 Intermediate ends.

∴1 End will be 1 Hank Roving

3 to 4 is the working draft to be taken between Drawing and Slubbing.

∴.50 Hank Roving ÷3 draft=.16 Hank Drawing of 1 End.

(5) Allowing 6 of a draft (6 Ends up) in the Drawing frame. Therefore the card hank will be

( 6 Ends by .16 Hank Drawing)÷6 of a draft=.16 card sliver.

The card draft is anywhere between 85 and 100, according to the condition of the cards and class of cotton.

Supposing you take 85 as card draft and .16 as the card sliver, then proceed thus:

To find the side shaft wheel.

.16÷85=18 side shaft wheel which is a change wheel.

(6) To get Scutcher Hank Lap—if the lap is 14 ozs. to a yard and the length of the lap is 40 yds.

Then 1 lb.=1.14 yds.

1.14÷840=.00136 Hank of a Lap.

An alternative method to find Hank Lap is as follows :—

Weight of lap per yard in ozs. by 437.5 grs. and divide into 8.33 the product so obtained=Hank Lap.

*i.e.* 8.33÷(14×437.5)=833÷6125=.00136 Hank Lap.

*Examples :—*

Hank Drawing. If 6 yds. weigh 65 grains per yard, proceed thus: **6×65=390 grs.**

**50 (const)÷390=.13 Hank** Drawing or Carding.

HANK SLUBBING. If 15 yds. weigh 16.6 grains per yard, proceed thus:

$15 \times 16.6 = 250$ grains.

125 (const.) $\div 250 = .50$ Hank Slubbing

HANK INTER. If 30 yards weigh 8.3 grains per yard proceed thus:

$30 \times 8.3 = 250$ grains.

250 (const.) $\div 250 = 1$ Hank Inter.

HANK ROVING. If 60 yds. weigh 2.4 grs. per yard proceed thus:

$60 \times 2.4 = 144$ grains.

500 (const.) $\div 144 = 3.47$ Hank Roving.

COUNTS OF YARN. If 1 Lea weigh 50 grains, proceed thus:

1000 (const.) $\div 50 = 20$'s Counts.

## Suitable Hank Rovings.

Suppose that the weight of sliver per 6 yards at the draw frame is 200—grain then proceed as follows:—

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

This .25 hank drawing is put up at the Slubber, which has a draft of 5.1, the slubber will therefore deliver a .25 hank drawing $\times$ Slubber draft $5.1 = 1.275$ hank, or

$$\frac{30 \times 7000}{1.275 \times 840} = 196 \text{ grains per 30 yards.}$$

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

$$\frac{1.275}{2} \times 6.6 = 4.21 \text{ hank.}$$

$$\text{or } \frac{60 \times 7000}{4.21 \times 840} = 118 \text{ grains per 60 yards.}$$

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:

$$2.104 \times 6.1 = 12.83 \text{ hank,}$$

$$\text{or } \frac{120 \times 7000}{12.83 \times 840} = 77 \text{ grains per 120 yards.}$$

This 12.83 hank is put up at the mule, two ends up =6.42 hank, and spun say, into 90s Counts with a total mule draft of 14.

*N.B.*—If the hank slubbing is multiplied by all the drafts and divided by the doublings, the counts spun will be obtained.

$$\frac{1.275 \times 6.6 \times 6.1 \times 14}{2 \times 2 \times 2} = 89.83 \text{ counts Spun.}$$

CONSTANT NUMBERS.

| Yards. | Dividends. | REMARKS. |
|---|---|---|
| 1 | 8.333 | Divide the constant number by the Hank according to the number of yards taken and the quotient will be the weight in grains per wrap. |
| 2 | 16.666 | |
| 3 | 25.000 | |
| 4 | 33.333 | |
| 5 | 41.666 | |
| 6 | 50.000 | *Example* ;— |
| 7 | 58.333 | Constant number for 40 yards |
| 8 | 66.666 | =333.333 |
| 9 | 75.000 | Hank of Lap = .00136 |
| 10 | 83.333 | :. the weight =333.333÷.00136 |
| 15 | 125.000 | =245000 grains |
| 20 | 166.000 | =245000÷7000 |
| 30 | 250.000 | =35 lbs. |
| 40 | 333.333 | |
| 60 | 500.000 | |
| 80 | 666.666 | *N.B.* (7000 grains =1 lb.) |
| 1 Lea or 120 | 1000.000 | |
| 4 Lea or 480 | 4000.000 | |
| 1 Hank or 840 | 7000.000 | |

## LAP WEIGHTS AND HANK LAP.

The weight of Scutcher Lap will vary according to the class of coton, requirements of cards and other factors.

| Spinning Counts. | Ounces per yard. | Hank of Lap. | Weight of 40 yds. lbs. | ozs. | REMARKS. |
|---|---|---|---|---|---|
| 6's—14's | 16 | .00119 | 40 | 0 | The width of Laps is generally ½″ wider than the wire on the cards. The Laps fed to the Scutcher should be about 1″ wider than the finished lap. |
| ,, | 15½ | .00123 | 38 | 12 | |
| ,, | 15 | .00127 | 37 | 8 | |
| ,, | 14½ | .00131 | 36 | 4 | |
| 16's—22's | 14 | .00136 | 35 | 0 | |
| ,, | 13½ | .00140 | 33 | 12 | |
| 24's—32's | 13 | .00146 | 32 | 8 | |
| ,, | 12½ | .00154 | 31 | 4 | |
| 34's—40's | 12 | .00158 | 30 | 0 | |
| 42's—60's | 11½ | .00165 | 28 | 12 | |
| 62's—75's | 11 | .00173 | 27 | 8 | |
| 76's—100's | 10 | .00190 | 25 | 0 | |
| ,, | 9½ | .00202 | 23 | 12 | |
| ,, | 9 | .00218 | 22 | 8 | |
| ,, | 8¼ | .00224 | 21 | 4 | |
| ,, | 8 | .00238 | 20 | 0 | |

The lighter the weight of the lap the better the yarn, inasmuch as it gives the card a chance to clean the webb better. But bear in mind when standardising the weight of the lap, the number of cards per preparation at one's disposal must be considered.

## COTTON SPINNING MACHINERY.

The process order of the machinery in a modern Cotton Spinning Mill is as follows :—

1. The Bale-breaker and Mixings.
2. The Hopper Feeder.
3. Opening and Scutching Machinery.
4. The Carding Engine.
5. The Sliver Lap Machine.
6. The Ribbon Lap Machine.
7. The Comber.
8. The Draw Frame (three heads).
9. Bobbin and Fly Frames (Slubber, Intermediate, and Roving Frame).

10. The Ring spinning frame or the Mule. For specially fine counts an extra Fly-frame is introduced namely the Fine Jack frame, which follows the Roving frame.

In the case of carded yarn 5, 6 and 7 are omitted.

## The Hopper Bale Breaker.

The first mechanical treatment to which the cotton is submitted in the mill is that of passing it through the bale breaker so that the cotton may be rendered back to the same soft state that it was after ginning, also to remove the many impurities that it contains.

For economic reasons, chief of which are the large amount of space needed, and the considerable amount of money which must of necessity be tied up, in carrying, a larger stock of coton, stack—mixing has been largely abandoned, except in the case of good long—stapled cotton. Hence the duty of a mixing agent has devolved upon the modern bale breaker, and it must be said that it lends itself extremely well to carrying out this function. It is on the long feed lattice that an attempt is first made of mixing the various cottons for a particular preparation. The operatives distributes as evenly as possible, cotton from each of the particular bale. These on entering the hopper bin are subjected to a considerable amount of agitation which aids mixng.

It is at the bale breaker the cotton is blended. The procedure is as follows :—

(1) Lay out the bales to be mixed as near to the feed lattice as possible.

(2) Take off the bands by means of cutters.

(3) Remove the tare.

(4) Tear off chunks or pieces of cotton from each bale in turn roughly according to the proportion to be used placing them on the feed lattice.

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

(6) 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.

(7) Dont work the machine at its maximum production.

(8) 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.

(9) 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.

The principal parts of the machines are the bottom lattice, spiked lifting lattice, spiked evener cylinder and leather bladed beater. By its rotation, the botton lattice forces the cotton against the spiked lifting lattice, which in turn carries it forward to the evener cylinder, the largest pieces being thrown back into the hopper by the spikes and rotation of this cylinder. The suitably opened cotton is carried forward to be stripped from the spiked lattice by the beater, the striking part of which is leather fastened to wood lags. Underneath the beater is a wire grid through which sand and other impurities are driven out.

By the time the cotton has passed through the machine and has been deposited in the mixing bin, it will be fairly well blended if the above system is adopted. The machine is made from 36 inches to 48 inches wide, the former is more popular, these machines capable of partially opening about 2200 lbs. of Indian cotton per hour.

Lifting aprons may be made from very strong endless canvas sheets mounted on leather belts which come into contact with the driving bowls, the spikes being attached to strong strips which are in turn secured firmly to the sheet and the belts.

Sometimes the evener roller is self-stripping, although this is more generally found in the hopper feeder. The machine should be inspected periodically, and, if necessary, it should be overhauled at least twice a year, all bearings, shafts, etc., should be well picked, cleaned, and oiled each time the machines are going to run.

All bands and straps should be kept in good condition as the drive is naturally a fairly heavy one.

*Settings.*—From the spikes on the evener cylinder to the points of the pins in the lifting lattice is equal to $\frac{1}{2}$ an inch.

*Adjustments.*—The bearings of the evener roller are adjustable so that the spikes can be set to the required distance from the spikes of the lifting apron, usually from ½ to 1 inch. All lattices have the bearings of the lattice bowls movable so that the required tension can be put on the lattices, in order to allow for stretching of the leather, etc.

For the best results never overfill the hopper, three-quarters full is ample.

If soft waste is used in mixing, it should be used sparingly and worked in with the cotton as evenly as possible.

If bobbin waste is being used in the mixing, it should not be used more than 1 per cent as too much bobbin waste tends to cause stringy laps, which is an evil for the carding process to overcome.

## Pneumatic Conveyers.

As the cotton is enclosed in trunks, the whole distance from breaker to bins is freed from dust; and the cotton during its passage through the trunk, owing to the action of the fan, passes in an open state. A rivet or hard metal trap is fixed in the trunking so that the risk of fire is considerably reduced.

## Blow Room Machinery.

Every care should be taken to see that the best method of dust extraction is employed with the hopper, not only by having a fan powerful enough to draw and deliver the dust, but to see that the right diameter of piping is used to get the best results from the fan, and also that the piping has a free outlet to the settling chamber. From experience it is found that a round delivery pipe of 10″ diameter is very suitable for a fan delivering about 1600 c.ft. of air per minute.

## Exhaust Fan (Dobson & Barlow).

| | |
|---|---|
| Speed of Main Shaft .. .. .. .. | 220 R.P.M. |
| Drum on „ „ .. .. .. .. | 36″ |
| Pulley on Counter .. .. .. .. | 14″ |
| Speed of „ .. .. .. .. .. | 565 R.P.M. |
| Drum on „ .. .. .. .. .. | 40″ |
| Pulley on Fan .. .. .. .. .. | 8″ |
| Speed of Fan .. .. .. .. .. | 2825 R.P.M. |
| Diameter of Pipe .. .. .. .. | 12″ |
| „ Fan .. .. .. .. .. | 22″ |
| „ Balance Pulley .. .. .. .. | 18″ |

## Pneumatic Boxes (Dobson & Barlow).

| | |
|---|---|
| Speed of Counter | 330 R.P.M. |
| Drum on ,, | 16″ |
| Pulley on 2nd Counter | 24″ |
| Speed of ,, ,, | 220 R.P.M. |
| Drum on ,, ,, | 12″ |
| Pulley on Boxes | 16″ |
| Speed of ,, | 165 R.P.M. |
| No. of ,, | 2″ |
| Dia. of Pipe | 9″ |
| No. of Bins | 3″ |

## Bale Breaker (Dobson & Barlow).

| | |
|---|---|
| Speed of Main Shaft | 220 R.P.M. |
| Drum on ,, ,, | 36″ |
| Pulley on Counter | 24″ |
| Speed of 1st ,, | 330 R.P.M. |
| Pulley on 2nd ,, | 24″ |
| Speed of 2nd ,, | 275 R.P.M. |
| Drum on 2nd ,, | 24″ |
| Pulley on Frame or Evener Roller | 16″ |
| Speed of ,, ,, ,, ,, | 412 R.P.M. |
| Pulley on same Shaft as ,, ,, | 12″ |
| ,, ,, Driving Spiked Lattice | 9″ |
| ,, ,, other End Evener Roller | 8″ |
| ,, ,, Stripper | 15″ |
| Speed of Stripper Roller | 219 R.P.M. to 350 |
| ,, 2nd Evener | 549 R.P.M. |
| ,, Spiked Lattice | 100 R.P.M. |

Production in 9 hours .. Indian cotton 10,000 to 18,000 lbs. app:

## Thread Extractor (Dobson & Barlow).

| | |
|---|---|
| Speed of Main Shaft | 220 R.P.M. |
| Drum on ,, ,, | 36″ |
| Pulley on Counter | 24″ |
| Speed of ,, | 330 R.P.M. |
| Drum on ,, | 24″ |
| Pulley on 2nd Counter | 8″ |
| Drum on ,, ,, | 18″ |

| | |
|---|---|
| Pulley on Spiked Roller . .. .. .. | 5″ |
| ,, ,, Screw Shaft .. .. .. .. | 3″ |
| 2nd Drum on 2nd Counter .. .. .. | 6″ |
| Pulley on Feed End .. .. .. .. | 16″ |
| Cage Pulley (Driven by Shaft) .. .. | 18″ |
| Speed of Spiked Roller .. .. .. .. | 3564 R.P.M. |
| ,, ,, Screw Shaft .. .. .. .. | 5940 R.P.M. |
| Production in 9 hours .. .. .. .. | 900 lbs. app. |

## Roving Waste Opener (Dobson & Barlow).

| | |
|---|---|
| Speed of Main Shaft .. .. .. .. | 220 R.P.M. |
| Drum on ,, ,, .. .. .. .. | 36″ |
| Pulley on Counter .. .. .. .. | 24″ |
| Speed of Counter .. .. .. .. .. | 330 R.P.M. |
| Drum on ,, .. .. .. .. .. | 28″ |
| Pulley on Frame .. .. .. .. .. | 10″ |
| Speed of Cylinder .. .. .. .. | 924 R.P.M. |
| Pulley on ,, .. .. .. .. .. | 13″ |
| ,, Driving Licqurin .. .. .. | 8″ |
| ,, other End of Cylinder .. .. .. | 6″ |
| ,, Fan .. .. .. .. .. | 12″ |
| Speed of Licqurin .. .. .. .. | 1501 R.P.M. |
| ,, Fan .. .. .. .. .. | 462 R.P.M. |
| Production in 9 hours .. .. .. .. | 3600 lbs. app. |

## Willow Machine (Dobson & Barlow).

| | |
|---|---|
| Speed of Main Shaft .. .. .. .. | 220 R.P.M. |
| Drum on ,, ,, .. .. .. .. | 24″ |
| Pulley on Counter .. .. .. .. | 15″ |
| Speed of ,, .. .. .. .. .. | 352 R.P.M. |
| Drum on ,, .. .. .. .. .. | 15″ |
| Pulley on Frame .. .. .. .. .. | 14″ |
| Speed of ,, .. .. .. .. .. | 377 R.P.M. |
| Pulley on Cylinder .. .. .. .. | 16″ |
| ,, Fan .. .. .. .. .. | 6″ |
| Speed of ,, .. .. .. .. .. | 1005 R.P.M. |
| Production in 9 hours .. .. .. | 1500/2500 lbs. app. |

## Blow Room Machinery.

The compressed bales of coton received at a mill contain the bolls of cotton plant, which have already been freed (by "ginning") of most of the seeds etc. Considerable dirt, however, is still present and the cotton fibres are bunched, matted and interwound. It is the function of the cotton mill to complete the cleaning process, to straighten the fibres, to lay them parallel, to draw them out in light extended rope or roving which is then spun into yarn.

Therefore the function of openers is chiefly to mix, beat and open the cotton sufficiently to extract or release from it the great bulk of the impurities it contains to be treated successfully by the opening and scutching processes without injuring or stringing them.

The effectiveness of the opening and cleaning processes has much to do with the strength, uniformity and cleanliness of the finished yarn.

Concentration and energy should be devoted to devising and obtaining means to open and clean the dirtiest and cheapest of cotton in such a way that a yarn may be made equal in quality to that of other countries made from the high-priced clean cotton, and to do this wthout increasing the cost in labour.

Further, if difference in cost between the best and the cheapest mixing and blow room machinery is considered carefully, it will be found that it is not excessive in view of the few machines required and the very great importance of this, the first process in cotton spinning. Again, additional machines in an opener combination which do not increase the amount of labour required but which give improved results, are always worth adding. There is no part of a spinning plant which pays better to keep up to date and in good working condition than the mixing and blowing machinery.

But bear in mind that the object of the cotton spinning mill is to produce from a bale of raw cotton as a large percentage as possible of cotton yarn, which should be smooth, clean, even and strong. The problem is not only a mechanical one, but one involving a constant study of economy and also aiming at an excellence of production as far as is consistent with the proper economical operation of the spinning mill.

Yarn is spoken of as being 'Coarse,' 'Medium' or 'Fine', according to the thickness of the thread, and this in turn is determined by the number of hanks to the pound. A hank of cotton yarn contains 840 yards, and the counts or number of the yarn is indicated by the number of these hanks required to weigh 1 pound; thus, 20's yarn would contain 20 hanks or $840 \times 20$, that is, 16,800 yards in a pound.

## The Hopper Feeder.

The hopper feeder's function is the same as that of the bale breaker, and the settings owing to the more open state of the cotton are closer, which will vary according to the cotton being used. The heavier the cotton the closer the setting; a good setting is about $\frac{3}{8}''$.

The hopper feeder is usually made 36″ wide.

In all lattice work it is important to remember that for good work it is essential that the leather to which the wood lattice is attached and which runs over the lattice bowls, should have the piecing facing in the right direction, that is, it should run so that the piecing will strike the bowl first but should come away from the bowl last.

*Feeding.*—The machine can be fed by hand, hopper bale breaker, lattice, trunk, or by cages.

*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. 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 with the trunk space. Do not permit any slackness of belts, ropes, or of lattices, especially the spiked lattice. Test occassionally 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.

*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 a day except high—speed bearings, which should be lubricated twice per day.

## Openers.

There are different kinds of openers, namely, Crighton opener, Porcupine opener and Exhaust opener.

## The Crighton or Vertical Opener.

The essential feature of this machine is a vertical conical beater consisting of seven sheet-steel discs, round the circumference of which are riveted a number of knife blades. The discs vary in diameter and are threaded on to a vertical shaft, the smallest one being at the bottom. From this they gradually increase in diameter to the top (15″ to 30″ diameter). The whole of the discs are firmly fastened in position by keys and by the nuts screwed on the shaft. The knife blades do not all stand out from the disc in the same plane, they are bent out of the straight at different angles. The beater shaft has two bearings, one at the top of ordinary construction and the other at the bottom known as the foot-step.

The best method to feed is to first pass the cotton through a porcupine opener which may be connected direct to the vertical opener.

This type of opener is generally to be found used for the treatment of Indian cottons Because it possesses more cleaning and opening power than any other beater. The double crighton opener consists of two conical beaters and in working with the medium stapled cotton it performs its work satisfactoryily. An important advantage possessed by the crighton opener is that there is no liability of injury to the staple as the cotton is fed loosely to the beater. Also the cotton does not remain very long under the action of the beater, for as soon as it is loosened it is immediately carried away by the fan.

## The Porcupine Opener.

The porcupine opener consists of a travelling lattice, feed roller and a horizontal beater cylinder covered with projecring teeth. It is a good machine for opening the cotton. It is generally used for long stapled cottons. It is also in general use (small size) as a feeder to a crighton opener.

## The Exhaust Openers.

There are many types of exhaust openers in use, both single and double (that is with either one beater or with two beaters).

The exhaust opener is one of the several methods of taking the cotton direct from the mixing room to the opening machine, in this way dispensing with carrying, and the accompanying expense of employing hands for that operation.

It is generally placed between the crighton opener and the breaker scutcher, all making one combination.

The double exhaust opener is the most popular type. The cotton is drawn from the lattice feeder or cylinder part of the Crighton opener, as the case may be, down the trunk and is presented to the cylinder by the drawing power of the fans, which are keyed to the cylinder shaft and are placed one on each side of the cylinder. This cylinder beats it and passes it over the dirt bars, the fans then drawing it out at the sides and passing it down the passage to the first pair of cages, which are either of perforated tin or else, as is probably best, of wire gauze and as their interiors are exhausted by the fans, they act as fine sieves and small particles of dust, etc., are taken out of the cotton and discharged by the fans through the aperture in the dust chamber underneath. The cotton then passes through the cage delivery rollers and second beater feed rollers and is given to the second beater. This beater, which might be either two-blade, three-blade or cylinder (18″ dia.) passes the cotton over the dirt bars and the dust box and deposits it in a level sheet on the second pair of dust cages which again are acted upon by the fan. It now passes through the calender rollers and is made into a lap.

Opener beaters make from 1000 to 1200 R.P.M. according to the class of cotton being treated; the higher speeds being for dirtier cotton.

## Scutchers.

Although the cotton has now passed through the opener, and has had extracted from it probably about 8 per cent of impiurities (of course depending upon the quality of cotton), it is not in any sense of the term what would be called clean. The opening process is therefore continued under the name of scutching which literally means beating or whipping. It is a matter of fact a repetition of the action of the beater in the double form of opener, the object of course, being to drive out as much as possible of the impurities the opener has failed to expel. It is the first machine, where attenuation of the cotton takes place, that is the drawing out of the cotton from a shorter to a longer length, the cotton, being formed into what is called a lap. Three or four laps are taken from the opener and placed upon the travelling lattice. The friction produced by their weight on this moving lattice cause them to unroll and go forward.

Any irregularity in any one lap is reduced to one-third or one-fourth by this doubling, and in practice we find that the thin places in one lap tend to counterbalance the thick places in some of the other laps, and the result is that the lap sheet fed to the carding engine is even as much as it is practicable. Irregularity is also eliminated by means of the cone drums. If the laps from the same machine can be made all to weigh the same within the narrow limit of, say, 2 to 4 ounces in a 35 lb. lap , this would be considered good regulating. Laps that are either too light or too heavy over the stipulated weight should either be sent back to the scutcher to run over again or a light lap and a heavy lap are worked on adjacent cards to save time and overscutching.

Generally a finishing scutcher takes about 5 min. 24 sec. to make a lap of 35 lbs. The usual draft in these machines is generally equal to the number of laps doubled.

The speed of the beater is regulated according to the number of blades in it and the quality of coton under treatment. The three-bladed beater is used for low class cottons while the two-bladed beater is used for superior qualities.

Low class cottons are generally fed more thickly and irregularly than better kinds; consequently, in passing under the action of the beater it is more easily cleared from the comparatively sharp edge of the pedal nose, and its short length of fibre stands less chance of being damaged in doing so. It is almost impossible for the fibres to get crushed between the beater and the pedal nose, unless through carelessness in setting. But in case of clean and long staple cotton it is advisable to omit the inter-scutcher as it damages the staple. More beating is only necessary when the cotton is dirty and short stapled.

## Intermediate Scutcher.

Four laps turned out from the hopper breaker scutcher are placed on the travelling lattice of the intermediate scutcher. The cotton passes through a continuous sheet and once more rolls itself on to a lap roller into an inter-scutcher lap.

## Finishing Scutcher.

Four laps turned out from the inter-scutcher are now placed on the travelling lattice of the finisher scutcher. The finisher scutcher produces more uniform and clean laps ready for feeding at the cards.

## Cages and Fans.

The cages are used in conjunction with the fan. The cages are generally arranged so that the top one is the largest of the two with the object of permitting the current of air to drive the cotton upon it. The bottom cage is left comparatively free so that dust and very fine fluff can fall upon it and be taken on to the dust chimney. The top cage also serves the purpose of carrying away the fine impurities that are sufficiently loosened to enter the cage through the wire or perforations.

The fan exhausts the air, dust, fly, etc., from the inside of the cages and passes them through to the dust flue. The outlet to the fans or the passages along which the air is forced after leaving the machine, must be of a form calculated to allow perfect freedom for the moving air.

Sharp covers, abrupt turnings, narrow passages, etc., must be avoided. if not, complications will ensue, such as back pressure, chopping of the air and partial neutralisation of the fan's action.

When it becomes necessary to connect two machines to the same flue, it is essential for the machine nearest the dust chamber to displace more air than the other. If this is not done, back currents will arise. The amount of air that should be drawn through a machine varies according to conditions.

Some scutchers are constructed with dampers in the flue so that the required adjustment may be made.

The speed of the fan varies from 1000 to 1300 revolutions per minute.

## Lap Licking.

This is caused by two layers of cotton sticking to one another when unrolling at the next process, and makes unnecessary waste and uneven work. It should be remedied as soon as it is noticed, if allowed to go on, it will be very troublesome.

## Dust Flues.

Beneath the blow-room there are cellars and each machine has its own flue attached to the fan, in order to permit easy escape for the dust and air.

The most suitable kind of dust flue is that which is dry, contains plenty of room and will not prevent the free passage of the air current. Whenever the dust flue bends it should be rounded off, so as to allow the air current to pass along easily. Dust flues are usually made large enough in section to admit the body of a man when it becomes necessary to clean them.

When two or more machines are connected to the same flue, the machine nearest the exit should displace more air, otherwise back draught will occur.

CRIGHTON OPENER COMBINED WITH HOPPER & SCUTCHER
( DOBSON & BARLOW)

| | |
|---|---|
| Speed of Main Shaft .. .. .. .. | 220 R.P.M. |
| Drum on ,, ,, .. .. .. .. | 36″ |
| Pulley on 1st Counter .. .. .. .. | 18″ |
| Speed of ,, ,, .. .. .. .. | 440 R.P.M. |
| Drum on 2nd ,, .. .. .. .. | $6\frac{1}{2}$″ |
| Pulley on Evener Roller .. .. .. | 12″ |
| Speed of ,, ,, .. .. .. .. | 238 R.P.M. |
| Drum on 2nd Counter .. .. .. .. | 28″ |
| Speed of ,, ,, .. .. .. .. | 440 R.P.M. |
| Pulley on Porcupine .. .. .. .. | 14″ |
| Speed of ,, .. .. .. .. .. | 880 R.P.M. |
| Drum of 1st Counter .. .. .. .. | 28″ |
| Pulley on Beater .. .. .. .. .. | 12″ |
| Pulley on other end of Beater .. .. .. | 8″ |
| Pulley on Fan .. .. .. .. .. | 6″ or 7″ |
| Speed of Beater .. .. .. | 730 to 1026 R.P.M. |
| ,, Fan .. .. .. .. | 100 to 1368 R.P.M. |
| Rope Pulley on 1st Counter .. .. .. | 32″ |
| Rope Pulley on Driving Vertical Beater .. | 14″ |
| Speed of Vertical Beater .. .. .. | 1005 R.P.M. |
| Clearance between grid bars .. .. .. | $\frac{3}{8}$″ to $\frac{9}{16}$″ |
| Gauge between Beater and Striping rail .. | $\frac{3}{8}$″ |
| ,, ,, ,, ,, Feed Roller .. | $\frac{5}{16}$″ |

| | |
|---|---|
| Diameter of Feed Roller.. .. .. .. | 2″ |
| Width of Lap .. .. .. .. .. | 37″ |
| Length of Lap .. .. .. .. .. | 40 yds. |
| Weight of Lap per yard .. .. .. | for 22s–14 oz. |
| ,, ,, ,, ,, ,, .. .. .. | 36s–60s–12 oz. |
| Production in 9 hours .. .. .. .. | 7200 to 7650lbs |

## Finisher Scutcher (Dobson & Barlow).

| | |
|---|---|
| Speed of Main Shaft .. .. .. .. | 220 R.P.M. |
| Drum on ,, ,, .. .. .. .. | 36″ |
| Pulley on Counter .. .. .. .. | 18″ |
| Speed of ,, .. .. .. .. .. | 440 R.P.M. |
| Drum on Counter Shaft .. .. .. .. | 28″ |
| Pulley on Frame .. .. .. .. .. | 12″ |
| Pulley on Beater .. .. .. .. .. | 8″ |
| ,, ,, Fan .. .. .. .. .. | 6″ |
| Speed of Beater .. .. .. .. .. | 1026 R.P.M. |
| ,, ,, Fan (Pulleys 6″ & 7″) .. | 1172 to 1368 R.P.M. |
| Pulley driving the Pulley on Lap End. . .. | 5″ |
| Pulley on Lap End .. .. .. .. | 24″ |
| Speed of ,, ,, ,, .. .. .. .. | 213 R.P.M. |
| Diameter of Calender Roller .. .. .. | $5\frac{1}{2}$″ |
| ,, ,, Fluted ,, .. .. .. | $8\frac{3}{4}$″ |
| ,, ,, Large ,, .. .. .. | $7\frac{1}{4}$″ |
| Knocking off Wheel. .. .. .. .. | 72T |
| Revolution of Lap Roller .. .. .. | 6.25 |
| Beater (3 Blades) .. .. .. .. | 18″ |
| Length of Lap .. .. .. .. .. | 40 yds. |
| Width of ,, .. .. .. .. .. | 37″ |
| Draft .. .. .. .. .. .. | 1.113 |
| Total Draft .. .. .. .. .. | 3.62 to 4.5 |
| Clearance between Beater & Bars .. .. | $\frac{3}{8}$″ |
| Gauge between Beater & Stripping Rail .. | $\frac{3}{32}$″ |
| ,, ,, ,, & Feed Roller .. .. | $\frac{5}{16}$″ |
| Diameter of Feed Roller.. .. .. .. | $2\frac{1}{4}$ |
| Change Pinion for Inter & Finisher Scutcher | 21 |

| | | |
|---|---|---|
| Production in 9 hours. .. | 10's | 3200 |
| | 22's—24's | 2772 |
| | 36's | 2310 |
| | 50's | 1800 |

**Beater Speed.**

| | | Double Bladed Beater. | Treble-Bladed Beater. |
|---|---|---|---|
| Sea Islands Cotton | .. | 900 | 750 |
| Egyptian Cotton .. | .. | 1,050 | 900 |
| American Cotton .. | .. | 1,150 | 950 |
| Indian Cotton .. | .. | 1,250 | 1000 |

The higher the beater speed the greater the grid-bar waste and loss at leaf bars.

**Fan Speed.**

Fans in blowing room machinery make from 1,000 to 1,500 R.P.M

Cylinder beaters of 18″ diameter make something like the same speeds as three-blade beaters.

**Power.**

From $3\frac{1}{2}$ to $4\frac{1}{2}$ I.H.P. for single beater Scutcher.

**B. H. P. of Individual Motors.**

The required number and rated horse power to drive Blow and Mixing rooms motors individually are as follows :—

| | |
|---|---|
| Bale Opener motors .. .. .. | .. 3.5 B.H.P. |
| Hopper feeder motors .. .. .. | .. 3.0 ,, ,, ,, |
| Opener motors .. .. .. .. | .. 7.0 ,, ,, ,, |
| Scutcher motors .. .. .. .. | .. 7.0 ,, ,, ,, |
| Intermediate Scutcher motors. .. | .. 3.5 ,, ,, ,, |
| Finishing Scutcher motors .. .. | .. 3.5 ,, ,, ,, |
| Waste opener motor .. .. .. | ..15.0 ,, ,, ,, |
| Willow room group drive motor .. | ..15.0 ,, ,, ,, |

**Floor Space.**

Varies according to maker.

**Adjustments.**

The spacing of the grid bars varies according to the maker and date of machine, etc.

One machinist arranges the upper bars to be nearer together than the lower bars.

The angle of each bar could be individually adjusted, or one or more bars removed if thought desirable.

The dust-box damper should be lowered, the first thing in the morning and again in the afternoon. In some cases it is lowered five or six times daily, depending on the amount of impurities removed at this point. The dust box damper must be kept properly shut during working hours.

## Production.

For Indian or ordinary American cotton, 180 to 320 pounds of laps per hour.

Uniform production from Blow Room machinery is very essential. Enforced shut down or break down of any machine curtails production, and may, if prolonged for a length of time, interrupt the continuous flow of cotton throughout the mill.

## Settings in the Blow Room.

### Setting of Beater.

The distance between the beater blades and the pedal noses or the bottom feed roller depends on thickness of cotton fed, speed of beater, condition of beater, feed roller diameter or shape of pedal nose and type of cotton.

| *Indian cotton* | *American cotton* | *Egyptian cotton* |
|---|---|---|
| $\frac{5''}{16}$ to $\frac{3}{8}''$ | $\frac{3}{8}''$ to $\frac{1}{2}''$ | $\frac{3}{8}''$ to $\frac{7''}{16}$ |

The longer the staple the smaller the diameter of the feed roller, and the thicker the cotton being delivered, the farther should the feed rollers be set from the beater. The shorter the staple the bigger the diameter of the feed rollers and the closer the settings to the beater.

### Stripping Rail.

It should be set just to clear the beater blades only.

| | *Indian* | *American* | *Egyptian or African.* |
|---|---|---|---|
| Feed Roller to Beater | $\frac{3}{8}''$ | $\frac{3}{8}''$ | $\frac{3}{8}''$ |
| Beater to Grid Bar .. | $\frac{5''}{16}$ | $\frac{5''}{16}$ | $\frac{5''}{16}$ |
| Grid Bar to Beater .. | $\frac{3}{8}''$ to $\frac{5''}{16}$ | $\frac{3}{8}''$ to $\frac{5''}{16}$ | $\frac{3}{8}''$ to $\frac{7''}{16}$ |

Good settings for Egyptian cotton are 1 in. space. Periodically the dirt bars of all blowing room machinery should be well-cleaned and black-leaded in order to prevent sticking. Watch your droppings and laps and if necessary close or open out. The longer the staple the less is the beating required.

The number of bars that are suitable for various counts are as follows :—

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

There appears to be no special reason for these specific numbers or for their variation for different cottons.

## Labour Saving Machinery.

In many of the modern textile plants (especially in the South of America) much attention is directed to the use of material--conveying equipment for eliminating manual labour, speeding up production, and reducing productive costs.

One example of the application is that operating in one of the mills in U. S. A. whereby the roving for the spinning—room is brought in boxes by means of a spiral chute from the card–room, placed on special trucks, and taken to frames. Empty roving bobbins are returned to the card–room by means of an inclined finger conveyor.

Another labour saving device which is making rapid headway is the one–process opener and scutcher. Its first and foremost advantage, the saving of manual labour, has been definetly proved. There is no handling of the cotton from the time it is fed to the bale–breaker until the lap is removed from the calender rollers ready for placing on the card–back.

The machine is fitted with synchronised control, which, it is claimed, has resulted in better cleaning, better appearance, and greater evenness of the lap than can be obtained on the two or three process system.

The spinner whether he or she should devote his or her entire time to piecing ends and thus more sides or frames can be looked after. The frames should be cleaned and doffed by special gangs of cleaners and doffers.

## CALCULATIONS AND EXAMPLES.

**To Find the Speed of Beater.**—

$$\frac{\text{(Revs. of line shaft) (Drum on line shaft) (Drum on counter shaft)}}{\text{( Pulley on counter) (Pulley on beater)}}$$

$$=\frac{220\times36\times28}{18\times12}=1026 \text{ R.P.M. of Beater.}$$

**To Find the Speed of Fan.**—

$$\frac{\text{(Revs. of beater) (Drum on Beater to drive fan)}}{\text{Diameter of Fan Pulley}}$$

$$=\frac{1026\times8}{6}=1368 \text{ R.P.M. of Fan.}$$

**To Find the Hank of Lap.**—

Weight of Lap =35 lbs.
Length of Lap =40 Yds.

$$\frac{\text{Constant number for 40 yards}}{\text{Weight in grains for 40 yards}}=\frac{333.20}{245000}=.00136 \text{ Hank of Lap.}$$

**Draft.**—

(*a*) $$\frac{\text{Dia. of Calender Roller}\times3.1416\times\text{Speed of Calender Roller.}}{\text{Dia. of feed Roller}\times3.1416\times\text{Speed of Feed Roller}}$$

$$=\frac{5.5\times3.1416\times11}{2.25\times3.1416\times7}=3.84.$$

(*b*) $$\frac{\text{Weight of Feed}\times\text{Length of Lap}}{\text{Length of Feed}\times\text{Weight of Lap}}=\frac{7.5\times9}{7\times2.625}=3.67$$

(*c*) $$\frac{\text{R.P.M. of lap roller}\times\text{dia.}}{\text{R.P.M. of feed roller}\times\text{dia.}}=\text{ draft of Scutcher.}$$

$$\frac{11\times55}{7\times2.25}=3.84$$

**To Find Length of Lap—**

$$\frac{\text{Weight of Full Lap} \times \text{given yards}}{\text{Weight in pounds of given yards}} = \frac{35 \times 6}{5.25} = 40 \text{ yards.}$$

**To Change the Weight of Lap Without Altering its Length—**

$$\frac{\text{Weight of Lap} \times \text{Bevel change pinion on horizontal shaft}}{\text{Weight of Lap required.}}$$

$$= \frac{35 \times 18}{33} = 19 \text{ Change Pinions.}$$

**How to Alter the Weight of Lap—**

(1) To make the lap heavier—

(*a*) Increase the weight of the lap per yard being led to the scutcher.

(*b*) Speed up the feed end through the cones.

(2) To make the weight of lap lighter—

(*a*) Decrease the weight per yard of lap being fed to the scutcher.

(*b*) Slow down the feed end through the cones.

(*c*) Decrease the Speed of Side Shaft.

**How to Alter the Length of Lap—**

The length of the lap is increased about 22 inches by every tooth added to the number of teeth in the measuring motion stud wheel and *vice versa.*

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.

**Measuring Motions—**

The length of lap can be found in following ways :—

*Hunter Cog Motion.*—Circumference of calender roller multiplied by teeth in the driving change wheel and divide by 36.

*Worm Wheel Motion.*—Find the product of the worm wheel, the driven knocking off wheel and circumference of fluted lap roller, divide by the product of 36 and driving change wheel.

*Ratchet Motion.* —Multiply the teeth in the ratchet wheel by the circumference of the bottom calender roller and divide by 36.

### To Find the Percentage of Waste Made.—

$$\frac{\text{Loss in weight} \times 100}{\text{Weight of cotton fed to machine}} = \text{Waste per cent.}$$

### To Find Strokes Given to the Cotton By the 3 Bladed Beater.

$$\frac{\text{Revs. of beater} \times \text{No of blades}}{\text{Length in inches delivered by feed roller per min.}}$$

$$= \frac{1000 \times 3}{84} = 35.1 \text{ Strokes per min. per inch of cotton fed.}$$

The speed of the beater should be regulated in such a way that the cotton may not be subjected to the action of the beater for more than about 50 strokes per inch of cotton fed.

### Change Places for Draft and Production.—

The draft may be changed by altering the shaft wheel (Bevel) or bottom cone shaft wheel.

The weight of lap fed or lap end pulleys may be changed when producing lighter finisher lap by the reducing speed of feed or weight of lap fed, care must be taken not to treat the cotton excessively.

For increased production a larger beater end pulley is used. The output of scutchers should keep the cards supplied allowing the former cleaning time.

Higher speed is false economy.

### Faults and where to Find Them.

1. For long staple cotton the beater should strike off two feed rollers. For short staple the beater should strike off the pedal as the latter allows of a closer setting.

2. All beaters should be perfectly balanced and have special oil bearings.

3. The grid bars should have ample provision for adjustments.

4. The ends of cages should be air-tight to allow of a good uniform draft.

5. The regulators should be kept clean and in good working order.

6. *Uneven laps* may be due to uneven feeding of the cotton or the feed regulator motion on the intermediate or finisher scutcher may be out of order, possibly through not being cleaned and oiled properly or having faulty driving strap for the cones. This strap should be perfectly pliable and have good piecings, but it should not have soft edges or it may cause uneven laps at irregular intervals. Also the cone strap should not be too broad or it will cover too much space on the cones and thus the sensitiveness will be decreased. The strap should not be too narrow or too slack. The position of the cone strap on the cones of the regulator motion should be watched.

Other faults, may be, not enough weight on feed rollers, feed lattice slipping, dirty shafts of cages interfering with air current, a tooth broken in the pedal roller wheel, cone belt not set in centre of cones when correct weight of cotton is passing through, feed roller binding in bearings, badly worn cone drum footstep washers, badly constructed dust flues, fan fixed wrong way about, fan speed too low.

*Conical laps* may be due to improper adjustment of discs on the exhaust beater shaft, panel slides of the exhaust opener feeding trunk unsuitably adjusted, dust box too small regulator motion pedals at one side of the machine choked with dirt, door leaf bars not fitting well up at both sides. Back draught, dirt preventing free action of the feed regulator bowls, blunt beater blades.

Laps should be tested occassionally for uniformity yard by yard, and for uniformity in thickness: in the former case, by unrolling them on the floor and measuring them off by a gauge in uniform short lengths and weighing them, and in the case of the latter, by unrolling before a window so that variation in density or thickness can be observed. The first and last yard of a lap should be rejected in making this test. The thorough and systematic testing of finished laps is important, as a lap may be correct in total weight and yet have very serious faults. If a test of a lap along its length reveals a tendency for it to become heavier as the bottom of the lap is approached, it is possible that stretching is occuring as the lap is being rolled up.

7. Run the beaters according to the class of cotton being used. Beater speed should be more for coarse counts and less for fine counts.

If necessary reduce the speed of the beater in hot season, as test of yarn rests on class of cotton used and speed of beater which if excessive, will treat even good cotton cruelly.

The beater blades should not have knife edges which is bound to injure the cotton staple until the keenness wears off. If the striking edges of the blades are too dull, owing sometimes to the wearing away of the edges, the cotton is not given the straight stroke that is necessary but is plucked from the feed roller nip or is given a slovenly stroke.

This results in faulty opening of the cotton ineffective cleaning and production of an uneven lap.

(*a*) Do your beater blades need sharpening ?
(*b*) When were your beater blades sharpened ?

8. Be careful to set the feed rollers according to the length of staple used.

9. The cleaning properties of the scutcher can be increased by placing a special toothed rail between the feed rollers and the grid bars.

10. The licking or splitting of scutcher laps when being unrolled at the back of the carding engine may be caused in various ways namely :—

(*a*) By mixing long and short staple ;
(*b*) By mixing hard and soft cotton ;
(*c*) By dropping of oil on cotton ;
(*d*) Too much weight on the lap rack levers or by feeding the hopper bale breaker in large layers from the bales instead of in small layers ;
(*e*) By putting in too much soft waste or unusual quantity of short fluffy fibres ;
(*f*) By using damp cotton or a too damp atmosphere ;
(*g*) By drawing an equal amount of cotton on top and bottom cage ;
(*h*) By running the cage fan too quickly ;
(*i*) By improper use of the brake motion ;
(*j*) Insufficient weight on calender rollers.
(*k*) Dirty cages or calender rollers.
(*l*) Beater blade worn, excessive production.

In some cases a polished drag board is applied to press up on the surface of the lap drums. In other cases two or three ends of slubbing ends may be run along with the lap between calender rollers to bind each layer together at the formation of the lap. Another way to prevent this is to sprinkle french chalk on the lap rollers of the scutcher.

11. Dirty laps are due to grid bars set too close together, excessive fan speed, beater speed too slow, beater set too far from feed roller or pedals, back draught door under grate bars not fitting perfectly.

12. *Rich Droppings.*—This is a term meaning that too much good fibre is being ejected between the grid bars along with the impurities.

The causes are :—

Mixing in an excessive amount of soft waste at an earlier process at frequent intervals.

Grid bars spaced too widely, air current too weak, excessive beater speed.

13. The amount of waste made at the opener varies with the types of cotton used, the arrangement of machinery, etc. In cases of Indian cotton the waste is from 4 to 6%. In cases of American cotton the waste is from 1 to 3%. The waste consists of short fibres, leaf, sand, grit, and broken seed. The sand and grit are generally found in the four bottom corners of the framing round the beater and the grid.

14. Laps with defective edges are generally caused by the accumulation of waste at some parts of the machine. Cotton accumulating between the cages and the stripping plate will cause ragged edges. If the leaf bars are not regularly cleaned and well black-leaded, the waste accumulates near the sides of the machine or the bars which does not permit the air current to follow the course it otherwise would. Bad lap edges are also caused by dirt on the grate bars at each side of the bottom cage on the opener and scutcher combined the laps at times forming into conical shape due to drawing more cotton to one side of the cage than to the other by reason of irregular feeding or an uneven air current. When such laps are made, much trouble and waste of cotton result afterwards. To prevent it, various adjustments are made such as moving the adjustable disc plates on the cylinder shaft nearer to or farther from the fans at the sides of the machine.

## MAINTENANCE OF BLOWING ROOM MACHINERY

### Lattices.

The insides of all lattices should be examined and cleared of foreign matter and fly, every week, convenient hand holes are provided for this purpose. The beaters of hoppers should be cleaned once a week. The cleaning time should be more frequent if waste is being put through the machines.

### Exhaust and Dust Fans.

These should be cleaned once a week at the point where dust is drawn into the fans and round the blades.

### Cages.

The cages of Patent Condensers, Pneumatic Delivery Boxes, Shirley Cages, and Lap Machines should be cleaned weekly, the Condenser and the Pneumatic Delivery box are fitted with convenient doors for this purpose. The inside of the Shirley cage is easily accessible.

### Crighton opener Cyiinder Parts.

Remove the Crighton footstep and clean thoroughly every two months if the footstep has a thrust washer without ball bearings. If the footstep has ball bearings, it should be removed and cleaned every 4 to 6 months where a 9 hour day is being worked, more frequently in proportion with a longer working day.

### Lap Machines.

The Calender Bearings, Racks, and adjacent parts should be removed and cleaned monthly. The flannel strips in the cup steps should be renewed when necessary. The Feed Rollers should be removed and cleaned about once in 2 months.

### Droppings.

The droppings under cylinders, under the beaters of Hoppers and in the Crighton should be removed two or three times every 'nine' running hours as required. The droppings under Dust Trunk Bars should be removed twice every nine running hours.

### Bale Breaker Cylinder.

This should be examined weekly.

## Electro Automatic Distributor.

The terminal screws of the Electro Automatic Distributor should be examined and adjusted if necessary once every four month of 9–hour working day.

## Feed Regulator Motions.

In case the piano motion is used it should be kept very sensitive, hooks and eyes free from rust and dirt, and pendants and bowls to be kept free from flat places. The entire motion should be dismantled at intervals, say every week, each part well cleaned and overhauled, if necessary, replace badly worn parts, and give the bowls and bearing parts a rubbing with dry blacked and then a good brushing. The pedal roller should be kept free from laps, due to scratched or rough places or the cotton not condensed enough, else the finisher scutcher lap will be too light. When a rope is used to drive the rear conedrums, the rope must be kept at the correct tension, otherwise the feed will be too slow.

## Oiling and Cleaning.

In order to ensure the satisfactory working of the machinery, it is absolutely necessary to insist throughout the mill on the careful cleaning and systematic oiling and greasing of the machines. By so doing a more efficient working and longer life of the machines are obtained.

Sufficient emphasis cannot be laid on the extreme importance keeping the lubricators, containing grease or oil lubricants well closed. In order to prevent the entrance of grit, dust, and fly, as if these impurities get into the bearings with the grease or oil, premature wear of the bearings is inevitable.

## Pneumatic Delivery Boxes.

It is essential to clean out the cages and lubricate all working parts weekly, including the replenishing of all grease cups. The cage must be blackleaded monthly.

The grease cups on the fan bearing must be examined weekly and replenished when necessary. A hand hole with cover plate is provided near the fan outlet for the purpose of examining the fan propellor, and also for clearing away any foreign matter which may be adhering to the propellor, or the inside of the fan casing.

## Openers and Scutchers.

All bearings must be oiled once a day, and those of quick running shafts twice a day.

The bottom of the dust box behind the beaters, should be let down once every two hours, in order to throw out refuse which has fallen through the grid bars. Great care must be taken that the machine is stopped when this operation is performed.

The waste from the opener when using Indian cotton should be removed four times a day. When using American cotton it should be removed three times a day. The grid bars should be taken out once a month. They must be thoroughly cleaned and blackleaded.

It is also necessary to clean the machines all through once a week and the calender rollers to be taken out periodically. Whilst doing this, the bearings will of course be thoroughly cleaned and freshly oiled. The dust flues must also be cleaned.

Where the cone feed regulator is of the link pattern, the parts need only be brushed with a hand-brush.

In oiling care should be taken not to allow the oil to get on the inside of the casings where the cotton passes.

## Starting New Laps.

Care is necessary to prevent the fingers being trapped.

## Principal Parts Requiring Lubrication.

### Mixing Room.

Pneumatic Delivery Boxes.

| | |
|---|---|
| Cages .. .. .. .. | .. Stauffer Grease Cups. |
| Stripping Rollers .. .. .. | .. ,, ,, ,, |
| Swing Boxes .. .. .. | .. ,, ,, ,, |
| Carrier Wheels .. .. .. | .. ,, ,, ,, |
| Out end Stripping Roller Bearing | .. ,, ,, ,, |
| Damper Shaft Bearings .. .. .. | .. Hand oiled. |
| Loose Pulley Bush .. .. .. | .. ,, ,, |

### Hopper Bale Breaker.

| | |
|---|---|
| Stretching Bracket for Feed Lattice .. .. | Hand oiled. |
| Front Block and Carrier Block Shafts .. | ,, ,, |
| Bottom Back, Middle & Front Block Shaft Bearings | ,, ,, |
| Spiked Lattice Top & Bottom Block Shaft Bearings | ,, ,, |
| Stripping Roller Bearings .. .. .. | ,, ,, |
| Evener ,, ,, .. .. .. .. | ,, ,, |
| ,, ,, & Stripping Roller Bearings .. | ,, ,, |
| ,, ,, & Carrier Pulley Stud .. .. | ,, ,, |
| Spiked Lattice Driving Carrier Pulley Stud .. | ,, ,, |
| Fan Shaft Bearings .. .. .. .. | ,, ,, |
| Block Shaft for Delivery Lattices (when used) .. | ,, ,, |

### Hopper Feeder.

| | |
|---|---|
| Spiked Feed Roller for Trunk Feed motion .. | Hand oiled. |
| Front, Middle and Back Block Shafts on Automatic Feed Lattice .. .. .. .. .. | ,, ,, |
| Bottom Feed Lattice .. .. .. .. | ,, ,, |

### Porcupine.

| | |
|---|---|
| Feed Lattice .. .. .. .. .. | Hand oiled. |
| Front, Middle & Back Block Shaft Bearings .. | ,, ,, |
| Pedal Roller Bushes .. .. .. .. | ,, ,, |
| Press Roller Bearings (when used) .. .. | ,, ,, |
| Cylinder Pedestals .. .. .. .. | Ring oiled. |
| Cylinder Pedestals (with Ball Bearings) .. | Grease packed |
| Rope Pulley Carrier Studs .. .. .. | Stauffer Grease Cups. |
| Top & Bottom Cone Drum Bearings .. .. | Hand oiled. |
| Top & Bottom Cones with Ball Bearings .. | Grease packed. |
| Out End Top Cone Drum Shaft Bearing .. | ,, ,, |

### Scutcher and Openers.

| | |
|---|---|
| Block Shafts or Feed Lattices .. .. | All hand oiled. |
| Pedal & Feed Rollers .. .. .. .. | ,, ,, |
| Beater & Cylinder Shafts with Swivel Bearings | Ring oiled. |
| ,, ,, ,, Ball ,, .. | Grease packed |
| Fan Shafts .. .. .. .. .. | ,, ,, |
| Lap End Calender Roller & Hand Lap End Shafts | Hand oiled. |
| Cone Drums .. .. .. .. .. | ,, ,, |
| Cone Drums with Ball Bearings .. .. | Grease packed. |
| Front, Middle & Back Block Shafts .. .. | Hand oiled. |
| Spiked Lattice .. .. .. .. .. | ,, ,, |
| Top, Bottom & Middle Carrier Block Shafts .. | ,, ,, |

| | |
|---|---|
| Strippings Roller Bearings .. .. .. | Hand oiled. |
| Evener Roller Bearings .. .. .. .. | ,, ,, |
| Top Spiked Lattice Side Shaft .. .. | ,, ,, |
| Delivery Press Roller Bearings (when used) .. | ,, ,, |
| Delivery Lattice Block Shaft Bearings (when used) | ,, ,, |
| 24's—48's Spiked Lattice Driving Carrier Stud | ,, ,, |

## PARTICULARS OF MACHINERY.

| DESCRIPTION. | Maker. | Date. | No. of Frames. | REMARKS. |
|---|---|---|---|---|
| Crighton Opener with Hopper & Scutcher combined .. | D. & B. | 1924 | 5 | |
| Intermediate Scutcher .. | ,, | ,, | 5 | |
| Finisher .. .. .. | ,, | ,, | 5 | |
| Bale Breaker .. .. .. | ,, | ,, | 1 | |
| Pneumatic Boxes .. .. | ,, | ,, | 3 | |
| Roving Waste Opener .. | ,, | ,, | 1 | |
| Thread Extractor .. .. | ,, | ,, | 1 | |
| Willow Machine .. .. | ,, | ,, | 1 | |

## HANDS EMPLOYED.

| DESIGNATION. | No. | Rate. Rs. a. | Per | REMARKS. |
|---|---|---|---|---|
| Jobber .. .. | 1 | 60 0 | M | |
| Bale Breaker .. .. | 1 | 18 0 | ,, | |
| Mixing Men .. .. | 3 | 18 0 | ,, | Each. |
| Opener Feeder .. .. | 3 | 16 8 | ,, | ,, |
| ,, ,, Front .. | 3 | 18 0 | ,, | ,, |
| Scutcher Men .. .. | 8 | 18 0 | ,, | ,, |
| Spare Men .. .. | 6 | 16 8 | ,, | Each, for fetching cotton bales from godown also replacing the absentees. |
| Willow Men .. .. | 1 | 20 0 | ,, | ,, , |
| ,, ,, .. .. | 1 | 18 0 | ,, | ,, ,, |
| Roving Waste Opener | 1 | 18 0 | ,, | ,, ,, |
| Thread Extractor .. | 1 | 16 0 | ,, | ,, ,, |

## DIMENSIONS OF MIXING ROOM.

| Size of Room. | | | Door | | Windows. | | Skylights. | | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|
| L. | B. | H. | No. | Size. | No. | Size. | No. | Size. | |
| 77′—6″ | 62′ | 12′—6″ | 1 | 7′-3″ × 7′ × 6″ | 6 | 5′-3″ × 7′—0″ | *Nil.* | | |

## STORE CONSUMED

Blow room, Carding and Fly trames

| DESCRIPTION. | Quantity. No. | Quantity. lbs. | Per | |
|---|---|---|---|---|
| Spindle oil .. .. .. | .. | 246 | M. | |
| Castor oil .. .. .. | .. | 42 | ,, | |
| Carding oil .. .. | .. | 640 | ,, | |
| Kerosene oil .. .. | .. | 13 | ,, | |
| Grease Lubricator .. | .. | 45 | ,, | |
| Leather Belting .. .. | 100 ft. | .. | ,, | All sizes. |
| ,, Lace .. .. | .. | 14 | ,, | |
| Cotton Banding $\frac{3}{8}$″ .. | .. | 44 | ,, | |
| ,, ,, $\frac{5}{8}$″ .. | .. | 7 | ,, | |
| Lattice Sticks .. .. | 16 | .. | ,, | |
| Emery Cloth .. .. | 11 | .. | ,, | |
| Blacklead .. .. | .. | 11 | ,, | |
| Emery Fillet 1″ .. .. | 1 Roll. | .. | ,, | |
| Emery Fillet $1\frac{1}{2}$″ .. .. | $\frac{1}{2}$ Roll. | .. | ,, | |
| Soda Ash .. .. | .. | 4 | ,, | |
| Hessian Cloth .. .. | 70 yds. | .. | ,, | |
| Brooms .. .. .. | 174 | .. | ,, | |

## DIMENSIONS OF BLOW ROOM.

| Size of Room. | | | Door. | | Windows. | | Skylishts. | | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|
| L. | B. | H. | No. | Size. | No. | Size. | No. | Size. | |
| 112′—6″ | 92′ | 12′—6″ | 1 | 5′ × 7′ | 12 | 8′ × 6′ | *Nil.* | | |
| | | | 1 | 5′ × 6′ | 1 | 6′ × 6′ | | | |
| .. | | | 1 | 4′ × 7′ | | | | | |
| | | | 1 | 8′ × 6′ | | | | | |

# CHAPTER XVI.

## CARDING.

Carding is probably the most important process in cotton manufacturing. After the raw material has passed through the opening and scutching machinery which only deal with the cotton fibres in mass, and hence it is that the fibres are found matted together or lying in different directions. In spite of the efficiency of the present-day machinery quite a fair amount of sand, seed, husks, shell, motes, leaf, etc., still remain in the cotton after scutching, and of course, no attempt has been made to rid the cotton of gin-cut short, dead or unripe fibres, nep, etc.

Now to present the fibres in a condition to be spun into thread, they must first as nearly as possible be placed parallel to each other. To do this and owing to their tendency to curl, repeated brushing or combing is necessary, not only to place the fibres straight but to remove such as are short in length, as well as the neps and any other remaining impurities.

Impurities as far as possible must not be allowed to escape a good carder as they are not only troublesome in the succeding processes but they reduce the value of yarn.

### Carded Yarns.

Drawn cotton yarns may be subdivided, according to the method of treatment which the cotton undergoes, into two classes known as carded yarns and combed yarns. Drawn cotton yarns are further subdivided, according to the method of spinning, into mule yarns, and ring yarns. The processes required for making all classes of cotton yarns, up to and including carding, are substantially the same, and when the cotton is afterwards passed through drawing frames, the fly frames, and finally the spinning process, it is known as carded yarn.

As a rule the cotton is passed only once through the carding process, but the amount of waste removed at this process depends on the quality of yarn to be ultimately produced from a given type of cotton.

A super-carded yarn indicates that more than the ordinary quantity of waste has been eliminated from the cotton during the carding process, say about 2 per cent. The super-carded yarn should therefore be correspondingly stronger and more even.

**Functions of a Card are:**—

(*a*) To remove the impurities and clean the cotton further than was done by the blowing-room machinery. The carding engine will extract from 3 per cent. to 10 per cent. of waste, according to the class of cotton used and the quality of yarn desired.

(*b*) To remove from the cotton short fibres, neps, etc., so that even yarn may be produced as far as possible.

(*c*) To loosen the fibres, separate them, etc., in order that the work of the draw frame which is to make them parallel may be done with perfection.

(*d*) To make a round strand of loose, soft cotton, known as a sliver, from the lap sheet presented to it by the scutcher, from 10 ozs to 14 ozs. per yard; 30 to 70 grains per yard.

The cards must be kept in the best possible condition when the cards are in first class condition the price per lb. of raw material can be considerably reduced without any serious deterioration in the quality of yarn produced. If efficiency is to be obtained each department and each machine must be called upon to perform its functions in the proper manner. The carding engine requires more attention than any other machine in the mill, as these machinery, once they are set to suit the cotton being used for a considerable time, or until a change in the class of cotton is made, necessitates some readjustment.

*Opening.*—Performed (1) by a saw—covered roller combing the cotton from the nip of a roller and dish plate, (2) 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.

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

*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 tells tales of the 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.

The lap on the carding engine is elongated about 100 times and delivered, is technically called as "100 draft."

The types of cards used for Indian cotton are the roller card and the revolving flat card. The other makes of cards are combinations of rollers and flats. The roller card is best adopted for low and medium counts. The revolving flat card is best suited for medium and fine numbers and it is the most popular.

The method of managing a card-room very materially affects the quality of the product of a cotton mill as in order to ensure satisfactory results. It is very essential that the carding process shall have careful attention. Care must essentially be given to several important operations that must be perfomed at intervals Those parts of the cards that are clothed, namely the flats, the cylinder and the doffer, are constantly collecting waste from the cotton that is being operated on.

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

This waste consisting of short fibres and foreign matters that fill up the interstices of the card wire and prevent the card from doing its best work, must be removed at intervals from the clothing, the process being known as stripping which is done by a stripping brush. The waste thus removed is known as stripping. A card working on Indian cotton should be stripped 4 times or more a day and on American cotton 3 times a day. When the output is heavy and the cotton is not as good as it should be, the cylinder may be stripped once per day oftener than the doffer. A card produces a sliver slightly lighter in weight for a short time after it has been stripped until the spaces between the teeth of the clothing fill up again with fibres. It is not advisable to strip at one time all the cards, or to take them in sections of either two or four supplying different machines. Another method is to strip the cards having odd numbers and then to strip the evenly numbered cards about an hour afterwards.

As the points of the card wire become dull on account of the constant friction, and consequently do not card the cotton so satisfactorily as when sharp, they must be sharpened by means of emery rollers. This process is known as grinding.

During grinding the cylinder may be driven at the usual speed but in the opposite direction to that in which it is driven for carding purposes. It is necessary to reverse its direction in order that the back of the teeth may be presented to the grinding roller. If the front of the teeth were presented to the grinding roller, the teeth would be levelled at the front which is exactly the reverse of what is desired. In addition this grinding roller acting on the front of the teeth would tend to raise it from its foundation and cause it to stand higher than it should. In order to reverse the direction of the cylinder it is necessary to cross the driving belt, if it was previously open, and *vice versa*. The condition of the wire influences the time required for grinding. It is advisable to grind frequently and lightly for a long time, rather than at more remote intervals and heavily for a short time. The usual time required for grinding the cylinder and the doffer of a card not newly clothed is from 5 to 10 hours, at intervals of 3 or 4 weeks, although a good carder would prefer to grind for only 2 or 3 hours at a time and grind twice as frequently.

In a carefully constructed card the flats will be true along the entire face of the wire, the distance between the flats and the cylinder being uniform throughout. It is a common practice to grind the flats repeatedly while on the card. This practice will not produce the best results in carding. Another fault that sometimes occurs when grinding the flats on the card is that, when the grinding is not properly adjusted, the flats are caused to tilt when they come in contact with the grinding roller, the result being that the roller grinds more heavily on the heel of the flat wire than on the toe, and the heel may in time become ground quite low. The heel of the flat is the setting point, and, therefore, when it is brought within the proper distance of the cylinder, the toe will have been brought too near to the cylinder by an amount equal to the difference in height of the wire. The combination of the flats is thereby impaired, and the web produced will be neppy, cloudy and generally dirty, and a greater amount of waste will be made. The taker-in seldom needs grinding except after an accidental injury, which may either be slight or serious. The taker-in should be recovered every 6 years.

It is a good practice to give the card a thorough overhauling every year, and to devote fully two days to burnishing of the wire.

## COUNTS OF WIRE.

| | Indian | | American | Egyptian | | Remarks. |
|---|---|---|---|---|---|---|
| | Low | Good | | Ord. | Super | |
| Cylinder | 80's | 90's | 100's | 110's | 120's | Card clothing will require to be renewed every 10 to 15 years, of course a lot depends on the man handling it. |
| Doffer .. | 90's | 100's | 110's | 120's | 130's | |
| Flats .. | 90's | 100's | 110's | 120's | 130's | |

## SPEED OF TAKER-IN.

| | |
|---|---|
| Indian Cotton .. .. .. .. .. | 420 to 450 R.P.M. |
| American ,, .. .. .. .. .. | 420 to 450 R.P.M. |
| Egyptian ,, .. .. .. .. .. | 360 to 400 R.P.M. |
| Sea Island ,, .. .. .. .. .. | 340 to 360 R.P.M. |

### CARD CYLINDER SPEEDS

*Diameter overall* = 50 *Inches.*

| | |
|---|---|
| Indian Cotton .. .. .. .. .. | 180 R.P.M. |
| American ,, .. .. .. .. .. | 170 R.P.M. |
| Egyptian ,, .. .. .. .. .. | 165 R.P.M. |
| Sea Island ,, .. .. .. .. .. | 150 R.P.M. |

### *Card Doffer Speed.*

*Diameter overall* $26\frac{3}{4}$ *Inches*

| | |
|---|---|
| Indian cotton .. .. .. .. .. | 8 to 14 R.P.M. |
| American ,, .. .. .. .. .. | 8 to 14 R.P.M. |
| Egyptian ,, .. .. .. .. .. | 8 to 10 R.P.M. |
| Sea Island ,, .. .. .. .. .. | 7 to 9 R.P.M. |

With regard to speed of cylinder and doffer if the best result is to be obtained should be varied in accordance to the staple of cotton.

***For an example***;—if the staple of cotton is say $\frac{7}{8}$ then the speed of cylinder and doffer should be 177 and 13.50 and if the staple is 1″ then 170 and 11.50 and if $1\frac{1''}{16}$ is the staple then the speed of cylinder and doffer should be 168 and 10.50 respectively

## Speed of Flats.

Usually $2\frac{1}{2}$ inches per minute on a 50-in. cylinder 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.

PRODUCTION PER DAY OF 10 HOURS.

| | | |
|---|---|---|
| Indian cotton | .. 159 to 230 lbs. | According to quality of cotton, weight of sliver etc. |
| American ,, | .. 106 to 180 ,, | |
| Egyptian ,, | .. 44 to 110 ,, | |
| Sea Island ,, | .. 25 to 55 ,, | |

## Power.

.8 to 1 I.H.P. according to the width of card.

## Electric Drive.

Carding department has a very steady uniform load throughout the day where one can very conveniently instal 2 motors of 100 B.H.P. each centrally situated on a platform over four pillars. The motors should be pipe ventilated. Shafting should be of 160 feet on each side commencing from 3″ diameter and ending in $2\frac{1}{2}$ inches diameter for 84 cards.

### Guide of Card Setting.

| Description. | Gauge. | |
|---|---|---|
| Feed Plate to taker-in .. .. | 12's tigh | 10's slack. |
| Top mote knife to taker-in .. | 10's slackt | |
| Bottom ,, ,, ,, .. .. | 10's | |
| Licker-in under casing at front .. | $\frac{1}{8}$″ adjust according to fly. | 34's |
| Taker-in to cylinder .. .. | 10's tight | 7's slack. |
| Back knife plate to cylinder top .. | 12's | |
| ,, ,, ,, ,, bottom .. | 24's | |
| Flats to cylinder .. .. .. | 10's—slack | 12″ tight |
| Under-casing to cylinder back .. | 34's | |
| ,, ,, ,, ,, front .. | 34's | |
| ,, ,, ,, ,, bottom .. | 34's | |
| Doffer to cylinder .. .. | 7's | |
| Front knife plate to cylinder top | 15 | |
| ,, ,, ,, ,, bottom .. | 22 | |
| Doffing comb to doffer .. .. | 10's | |
| Stripping comb to flats .. .. | 10's | |
| Back Plate .. .. .. | 34's | |

## 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 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 stud 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 between 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 engine. Flats will work badly if every flat is not ground true, all flat wire should be of equal length.

## Front Plate.

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 judgement, and in any case it is never a satisfactory one. A wide divergence of settings is adopted, and scarcely two mills set alike. 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 carder's qualifications in managing a card.

## Setting of the Flat Card.

In the setting of the flat card, the flats should be set with very great care at first so that there will be no trouble afterwards, otherwise the carding operation will not be effective. It is customary to set the flats by ear by touch or by gauge. The best way to do it is by gauge.

While setting the various parts of the machine, set the feed roller as near the taker-in as posible and the taker-in roller, clearer and doffer as close to the cylinder as possible, but on no account must any of the parts touch each other.

## Grinding.

Hardened and tempered steel wire requires grinding at longer intervals, whereas the mild wire requires a shorter interval.

If a good point is to be preserved and the rough action of a severe grinding is to be avoided then it is much better to grind frequently and lightly, say every fortnight.

While grinding the flats, cylinder and doffers, it must be remembered that it should always be on the back of the teeth and never on the front.

One cylinder and doffer grinder be enough for 30 cards. Each flat card has 109 flats, $1\frac{3}{8}''$ broad. To determine hand of machine, stand at the feed end and note on which side the driving pulleys are to be placed. Each mixed or union card has 74 flats, $1\frac{3}{8}''$ broad, 2 rollers 5″ in diameter and 2 strippers 3″ in diameter. The quality of cotton treated in union card is waste, Indian, American and dirty Egyptian.

Table showing intervals for Grinding, Stripping and Re-setting.

| Parts | Grinding | Stripping | Setting |
|---|---|---|---|
| Cylinder .. | Every week | Every 3 hours | Every fortnight |
| Doffer | ,, fort-night | ,, ,, ,, .. | ,, ,, |
| Flats .. | ,, ,, .. | continuous .. | ,, ,, |

Horsfall Grinding Roller with Traversing Disc.

The grinding by the Horsfall roller is very accurate. It is used for cylinder and doffer and it is generally run at a speed of about 750 R.P.M. driving pulley $3\frac{1}{2}''$ in diameter.

Ordinary or Dead Grinding Roller (*covered with plain or grooved emery*)

The dead grinding roller is used for grinding the top flats of revolving flat carding engines. Driving pulley 4″ in diameter. When working this roller it runs perfectly true and without vibration.

Wire Stripping Brush (*for cylinder and doffers*).

The wire brush is superior to bristle brush and it is very effective. It saves time in stripping and it is less liable to damage the wire on card.

Wire Burnishing Brush (*for revolving flats, roller and clearer cards*).
It is very beneficial to use this brush when the wire has just been ground or is a little rusty. This brush must not, however, be used too often or it will have a tendency to spoil the wire.

There is no fixed speed of the flats. It varies from 3 to 6 inches per minute according to requirements, but a speed of 4 inches per minute is advisable.

The object of under-grid attached to the carding engine is to prevent the omission of good fibre on the one hand and on the other to prevent impurities on the floor, from again being picked up by the cylinder.

Removing the under-casing or setting it too far away leads to waste of good fibre. The teeth of the card clothing are set in either plain, ribbed or twill arrangement. The teeth of the licker-in are inclined in the direction of its revolution. The teeth of the cylinder are also inclined in the direction of its revolution. The teeth of the flats and the doffer point against those of the cylinder and their own direction of motion.

To test setting and grinding of cards, the film that leaves the doffer should be examined. It must be free from motes and dirt, even, and with clean sides. Very often the web is cloudy which is generally the result of improper or insufficient stripping, grinding and setting. If these are not properly attended to, raw and uncarded portions of cotton are to be seen in the web. If the various carding organs get full of fly, or are too far away from each other or the points of wire are not in good condition, it is certain to result more or less in a cloudy web. If the web hangs between calendar roller and doffer, it may be remedied by speeding the calender roller or shortening the stroke of doffer comb. If flocks are forming at the side of web, it may be due to bad linings, or the draft wants making up or the ends are getting rough. If the web follows the doffer instead of leading it clearly, either speed up the doffer comb or set the comb a little lower down. If the strips are leaving the flats in continuous web instead of being merely joined by a few fibres, either the flats are roughly levelled or the front plate is set too near the cylinder.

The smaller the barrow wheel pulley, the more will be the production, and the weight of the sliver will be the same. The smaller the plate wheel, the more the production and the sliver the heavier. The smaller the doffer bevel wheel, the less the production and the sliver the lighter.

All other conditions being equal, a small barrow wheel means more efficient carding, hence the machines should be fully employed, only absolutely necessary stoppages being allowed.

Carding Engine ( Roller and Clearer Card )—(*Dobson and Barlow*).

| | |
|---|---|
| Line Shaft Speed .. .. .. .. .. | 160 R.P.M. |
| Pulley on L. Shaft .. .. .. .. | 18″ |
| „ „ Cylinder .. .. .. .. | 18″ |
| Speed of „ .. .. .. .. | 160 R.P.M. |
| Pulley on Cylinder Shaft .. .. .. | 18″ |
| „ „ Licqurin .. .. .. .. | 7″ |
| Speed of „ .. .. .. .. | 411 |
| Off Pulley on „ .. .. .. .. .. | 5″ |
| Swing Lever Pulley .. .. .. .. | 12″ |
| Compound Carriers .. .. .. .. | 24—37, 37—64 |
| Doffer Wheel .. .. .. .. .. | 195 |
| Speed of Doffer (slow motion) .. .. .. | 8 R.P.M. |
| „ „ „ „ (fast „ ) .. .. .. | 14 „ |
| Dia. of Doffer .. .. .. .. .. | 26″ |
| „ Rollers .. .. .. .. .. | 5″ |
| „ Clearers .. .. .. .. .. | 3″ |
| Cylinder Fillet .. .. .. .. .. | 2″ |
| Gauge of wire of cylinder fillet.. .. .. | 100's |
| Doffer Fillet .. .. .. .. .. | $1\frac{1}{2}$″ |
| Gauge of wire of Doffer Fillet .. .. .. | 110's |
| Roller Fillet .. .. .. .. .. | $1\frac{1}{2}$″ |
| Gauge of wire of Roller Fillet .. .. .. | 80's |
| Clearer Fillet .. .. .. .. .. | 1″ |
| Gauge of wire of Clearer Fillet .. .. | 100's |
| Flats .. .. .. .. .. .. | 74 |
| „ speed per minute .. .. .. .. | 2″ |
| Gauge of wire of flats .. .. .. .. | 110's |
| Plate Wheel .. .. .. .. .. | 154 |
| Side Shaft Wheel .. L | 24 |
| „ „ „ .. .. .. II | 26 |
| Barrow Wheel .. .. .. .. .. | 27 |
| Doffer Bevel Wheel .. .. .. .. | 32 |
| Cylinder .. .. .. .. Dia. | 50″ |
| Cylinder width .. .. .. .. .. | $37\frac{3}{4}$″ |
| Doffer .. .. .. .. Dia. | 26″ |
| „ width .. .. .. .. .. | $37\frac{3}{4}$″ |
| „ on wire .. .. .. .. .. | $26\frac{3}{4}$″ |

Details of machinery are given here for a guide and reference.

| | |
|---|---|
| Total Draft .. .. .. .. .. | 100 to 125 |
| Total draft constant (allowing 6% for waste) | 2,385 |
| Doffing Comb beats per minute .. .. | 1,600 |
| Stripping Brush beats ,, ,, .. .. | 9 |
| ,, Comb ,, ,, ,, .. .. .. | 70 |

**Carding Engine (Flat Cards).**

| | |
|---|---|
| Rev. Line Shaft .. .. .. .. .. | 165 R.P.M. |
| Pulley on Line Shaft .. .. .. .. | 18″ |
| Cylinder Pulley .. .. .. .. .. | 18″ |
| ,, Revolution .. .. .. .. | 165 R.P.M. |
| ,, Pulley driving Licqurin.. .. .. | 18″ |
| Licqurin Pulley .. .. .. .. .. | 7½″ |
| Speed of Licqurin .. .. .. .. | 396 |
| Off end double Pulley for Licqurin .. .. | 5 |
| Swing Lever Pulley .. .. .. .. | 12 |
| ,, ,, Wheel (compound carrier) .. .. | 37/64, 24/77 |
| Barrow Wheel .. .. .. .. .. | 25 |
| Doffer ,, .. .. .. .. .. .. | 202 |
| Doffer Bevel Wheel .. .. .. .. | 26 |
| ,, side Shaft Wheel .. .. .. .. | 32 |
| Change Pinions .. .. .. .. .. | 27 for 22's/26's |
| Rev. of Doffer (slow motion) .. .. .. | 6 |
| ,, ,, (fast ,, ) .. .. .. | 11.75 |
| Dia. of Feed Roller .. .. .. .. | 2¼ |
| ,, Doffer .. .. .. .. .. | 26″ |
| Plate Wheel Feed Roller .. .. .. | 152 |
| Calender Roller Dia. .. .. .. .. | 4″ |
| Lap ,, ,, .. .. .. .. .. | 6″ |
| Dia. of Doffer on wire .. .. .. .. | 26¾″ |
| Dia of Cylinder .. .. .. .. .. | 50″ |
| Width of Cylinder .. .. .. .. | 37¾″ |
| Dia. of Cylinder on wire .. .. .. | 50¾″ |
| Cylinder wire gauge .. .. .. .. | 100 |
| Doffer Fillets .. .. .. .. .. | 1½″ |
| ,, ,, gauge .. .. .. .. .. | 110 |
| Flats .... .. .. .. .. .. | 74 |
| ,, wire gauge .. .. .. .. .. | 110 |
| Speed of Flat per min. .. .. .. .. | 2″ |
| Feed Roller revolution (27 change pinions) .. | 1.70 |
| Lap Roller revolution .. .. .. .. | .60 |
| Doffing Comb beats per min. .. .. .. | 1,600 |
| Stripping Brush Rev. per min. .. .. | 9 |

| | |
|---|---|
| Stripping comb Rev. per min. | 70 |
| Total Draft | 100/125 |
| Draft const. between Feed Roller and Doffer allowing 6% for waste | 2,527 |
| Pinion on Feed Roller | 21 |
| Wheel on Lap Roller | 59 |

## Howard and Bullough (Carding Engine Flat Card).

| | |
|---|---|
| Rev. Line Shaft | 160 R.P.M. |
| Pulley on Line Shaft | 18″ |
| Cylinder Pulley | 18″ |
| ,, Revolution | 160 R.P.M. |
| ,, Pulley driving Licqurin | 19″ |
| Licqurin Pulley | 7½″ |
| Speed of Licqurin | 405 |
| Off end Double Pulley for Licqurin | 3½ and 6 |
| Swing Lever Pulley | 9″ |
| ,, ,, Wheel .. change | 26 |
| Barrow wheel off End | 104 |
| ,, ,, | 26 |
| Doffer wheel | 180 |
| Side shaft wheel .. (Uganda cotton) | 17 |
| ,, ,, ,, .. (India ,, ) | 16 |
| Plate wheel | 120 |
| Doffer bevel wheel | 22 |
| Doffer side shaft wheel | 16, 17 or 19 |
| Rev. of Doffer (slow motion) | 5 |
| ,, ,, ,, ( fast ,, ) | 9 |
| Dia. of feed roller | 2″ |
| Doffer .. Dia. | 26″ |
| Doffer on wire | 26¼″ |
| Cylinder ,, | 50″ |
| Width of Cylinder | 37¾″ |
| ,, ,, Doffer | 37¾″ |
| Cylinder wire | 2″ |
| ,, wire gauge | 100's |
| Doffer wire | 1½″ |
| ,, wire gauge | 110's |
| Flats | 110 set |
| ,, wire gauge | 110's |
| Speed of flat per min. | 2″ |

| | |
|---|---|
| Feed roller revolution .. .. .. .. | 1.1 to 2.5 |
| ,, ,, ,, ,, .. .. .. .. .. | .5 to 1.25 |
| Doffing comb beats per min. .. .. .. | 1,550 |
| Stripping brush Rev. per min. .. .. .. | 12 |
| ,, Comb ,, ,, ,, .. .. .. | 50 |
| Total Draft .. .. .. .. .. .. | 100/125 |
| Draft constant between Feed Roller and Doffer allowing 6% for waste .. .. | 1,701 |

## Suitable Hank Sliver for Counts to be Spun.

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

## Suitable Hank and Draft for Counts to be Spun.

| Spg. Counts | Hank | Draft | Weight of 6 yds. D. | G. |
|---|---|---|---|---|
| 6's—8's | .107 | 90 | 19 | 11.28 |
| | .112 | 90 | 18 | 14.96 |
| 10's—14's | .112 | 90 | 18 | 14.96 |
| | .120 | 90 | 17 | 8.66 |
| 16's—22's | .120 | 90 | 17 | 8.66 |
| | .130 | 90 | 16 | 0.60 |
| 24's—32's | .130 | 95 | 16 | 0.60 |
| | .140 | 95 | 14 | 21.0 |
| 34's—40's | .140 | 100 | 14 | 21.0 |
| | .160 | 100 | 13 | 0.50 |
| 42's—60's | .160 | 110 | 13 | 0.50 |
| | .180 | 110 | 11 | 13.77 |
| 62's—75's | .180 | 120 | 11 | 13.77 |
| | .207 | 120 | 10 | 1.54 |
| 76's—100's | .207 | 120 | 10 | 1.54 |
| | .230 | 130 | 9 | 1.38 |

Constant =2,472

Constant÷change pinion =draft and *vice versa.*

The smaller the pinion the higher the draft. The higher the draft the better the cleaning.

The draft of the cards in the above table is based on 8-10 cards per one preparation.

The more the cards the higher the draft, and the less the speed of the doffer, the cleaner the yarn.

The less the cards per preparation the heavier the sliver or the lower the draft, the higher the speed of the doffer and hence the dirtier the yarn.

## Hank Sliver and Hank Roving.

These terms represent the number of times (or the decimal part of one time) 840 yards of sliver or roving is contained in 1 lb. Thus a .2 hank-sliver from a carding engine indicates that one-fifth of 480 yards or 168 yards of this sliver is equal to 1 lb.

7000 grains÷168 =41.6 grains per yard of sliver while a .25 hank-sliver means that one-quarter of 840 yds. or 210 yards would be required to weigh 1 lb. By dividing 7000 grains in (1 lb.) by 210 yards we find that a .25 hank-sliver will weigh 33.3 grains per yard.

For ascertaining the weight of hank or decimal part of a hank—

Divide 7000 grains (1 lb.) by 840 yards (1 hank) and the answer is dividend for 1 yard.

The weight of yards wrapped divided into constant dividend for those yards is equal to HANK.

*Example ;—*

If 3 yards of sliver weigh 120 grains what is the hank carding ?

*Ans.*—Divide the dividend for 3 yards which is 25 (*vide* page 390) by 120 = .208 hank sliver.

*Draft ;—*

The draft required in a card is determined by dividing the weight in grains of 1 yard of lap by the weight in grains of a yard of the required sliver or by dividing the counts of the sliver by the counts of the lap.

*Example* ;—

Weight of 1 yard of lap = 12.5 ozs. = 5468.75 grains
Weight in grains of 1 yard of the required sliver is 45 grains
$\therefore 5468.75 \div 45 = 121.5$ draft
*Or* counts of sliver = .16
" " Lap = .00152
$.16 \div .00152 = 105$ draft
Allowance must be made for waste say 5%

Another method is to multiply the weight per yard of scutcher lap in grains by the hank of sliver and divide by 8.33. From the result deduct the waste percentage.

*Example* ;—

| | | |
|---|---|---|
| Weight per 1 yard of scutcher lap | = | 5468.75 grains |
| Hank of sliver | = | .16 |
| Constant | = | 8.33 |

$$\text{Draft} = \frac{5468.75 \times .16}{8.33} = 90.$$

To find hank carding for draft in card proceed thus :—
Multiply draft in card by hank of lap.

*Example* ;—

Hank of Lap = .00152
Draft in card = 90
$.00152 \times 90 = .136.$

In reckoning the draft add 5% for waste.

To alter the amount of production without changing the draft the barrow wheel is changed. The larger this is, the greater the production.

In case of heavy lap, the feed should be regulated on the lighter side by regulating the side shaft bevel wheel, that is, the smaller the wheel the less the feed. The advantage is better carding result.

## TABLE OF HANK CARD.

**Hank of Lap=Draft of Czard=Hank of Card.**

The Draft varies from 80 for low class cotton to 120 for American cotton.

In working out the Draft add 5% waste.

| Hank of Lap | Draft on Card. | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 120 | 116 | 112.3 | 109.1 | 108.5 | 107.4 | 104.8 | 103.8 | 100.7 | 99.5 | 98.8 | 96.3 | 95.5 |
| | | | | | Hank Carding | | | | | | | | |
| .00119 | .142 | .138 | .134 | .130 | .129 | .128 | .125 | .124 | .120 | .118 | .118 | .115 | .114 |
| .00123 | .147 | .142 | .138 | .134 | .133 | .132 | .129 | .128 | .124 | .122 | .122 | .118 | .117 |
| .00127 | .152 | .147 | .143 | .139 | .138 | .136 | .133 | .132 | .128 | .126 | .125 | .122 | .121 |
| .00131 | .157 | .152 | .147 | .143 | .142 | .141 | .137 | .136 | .132 | .130 | .129 | .126 | .125 |
| .00136 | .163 | .157 | .153 | .148 | .148 | .146 | .143 | .141 | .137 | .155 | .134 | .131 | .130 |
| .00140 | .168 | .162 | .157 | .153 | .152 | .150 | .147 | .145 | .141 | .139 | .138 | .135 | .134 |
| .00146 | .175 | .169 | .164 | .159 | .158 | .157 | .153 | .152 | .147 | .145 | .144 | .141 | .139 |
| .00152 | .182 | .176 | .171 | .166 | .165 | .163 | .159 | .158 | .153 | .151 | .150 | .146 | .145 |
| .00158 | .189 | .183 | .177 | .172 | .171 | .170 | .166 | .164 | .159 | .157 | .156 | .152 | .151 |
| .00165 | .198 | .191 | .185 | .180 | .179 | .177 | .173 | .171 | .166 | .164 | .163 | .159 | .158 |
| .00173 | .207 | .200 | .194 | .189 | .188 | .186 | .181 | .180 | .174 | .172 | .171 | .167 | .165 |
| .00180 | .216 | .208 | .202 | .196 | .195 | .193 | .189 | .187 | .181 | .179 | .178 | .173 | .172 |
| .00190 | .228 | .220 | .213 | .207 | .206 | .204 | .199 | .197 | .191 | .189 | .189 | .183 | .181 |
| .00202 | .241 | .233 | .226 | .219 | .218 | .216 | .211 | .209 | .202 | .200 | .199 | .194 | .192 |
| .00218 | .254 | .245 | .238 | .231 | .230 | .228 | .222 | .220 | .213 | .211 | .211 | .204 | .202 |
| .00224 | .268 | .259 | .252 | .244 | .243 | .241 | .235 | .232 | .226 | .223 | .223 | .216 | .214 |
| .00238 | .285 | .276 | .267 | .260 | .258 | .256 | .249 | .247 | .240 | .237 | .237 | .229 | .227 |

## TABLE OF HANK CARD

| Hank of Lap. | Draft on Card. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 95 | 93.5 | 91.9 | 91.5 | 90.3 | 88.4 | 87.3 | 85.2 | 84.5 | 82.4 | 81.8 |
| | | | | | Hank Carding | | | | | | |
| .00119 | .113 | .111 | .109 | .109 | .107 | .105 | .104 | .101 | .101 | .098 | .097 |
| .00123 | .117 | .115 | .113 | .113 | .111 | .109 | .107 | .105 | .104 | .101 | .101 |
| .00127 | .121 | .119 | .117 | .116 | .115 | .112 | .111 | .108 | .107 | .105 | .104 |
| .00131 | .124 | .122 | .120 | .120 | .118 | .116 | .114 | .112 | .111 | .108 | .107 |
| .00136 | .129 | .127 | .125 | .124 | .123 | .120 | .119 | .116 | .115 | .112 | .111 |
| .00140 | .133 | .131 | .129 | .128 | .126 | .124 | .122 | .119 | .118 | .115 | .115 |
| .00146 | .139 | .137 | .134 | .134 | .132 | .129 | .127 | .124 | .123 | .120 | .119 |
| .00152 | .144 | .142 | .140 | .139 | .137 | .134 | .133 | .130 | .128 | .125 | .124 |
| .00158 | .150 | .148 | .145 | .145 | .143 | .140 | .138 | .135 | .134 | .130 | .129 |
| .00165 | .157 | .154 | .152 | .151 | .149 | .146 | .144 | .141 | .139 | .136 | .135 |
| .00173 | .164 | .162 | .159 | .158 | .156 | .153 | .151 | .147 | .146 | .143 | .142 |
| .00180 | .171 | .168 | .165 | .165 | .163 | .159 | .157 | .153 | .152 | .148 | .147 |
| .00190 | .181 | .178 | .175 | .174 | .172 | .168 | .166 | .162 | .161 | .157 | .155 |
| .00202 | .191 | .188 | .185 | .184 | .182 | .178 | .175 | .171 | .170 | .166 | .164 |
| .00218 | .201 | .198 | .195 | .194 | .191 | .187 | .185 | .181 | .179 | .175 | .173 |
| .00224 | .213 | .209 | .206 | .205 | .202 | .198 | .196 | .191 | .189 | .185 | .183 |
| .00238 | .226 | .223 | .219 | .218 | .215 | .210 | .208 | .203 | .201 | .196 | .194 |

## CARD PRODUCTION PER HOUR.

If the bevel wheel at the back end of the side shaft is altered the amount of production, draft, and hank sliver are all changed. The larger the wheel used, the greater is the weight produced, the smaller the draft and coarser the hank-sliver.

*26¾ Inches Doffer on wire—10% allowed for stoppages.*

| Spinning counts | up to 10's | 10's/12's | 14's/18's | 20's/26's | 28's/32's | 34's/38's | 40's/44's | 46's/60's | 60's/75's | 75's/90's | 80's/100's | Over 100's |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hank Sliver | .10 | .11 | .12 | .13 | .14 | .15 | .16 | .17 | .18 | .20 | .22 | .25 |
| Grains per Yd. | 83.3 lbs. | 75.7 lbs. | 69.4 lbs. | 64.1 lbs. | 59.5 lbs. | 55.5 lbs. | 52.08 lbs. | 49.0 lbs. | 46.2 lbs. | 41.6 lbs. | 37.8 lbs. | 33.3 lbs. |
| Revs. of Doffer | | | | Cotton | Cards | Producit | on Per | Hour. | | | | |
| 7 | 10.50 | 9.54 | 8.75 | 8.08 | 7.50 | 6.99 | 6.56 | 6.17 | 5.82 | 5.24 | 4.75 | 4.19 |
| 8 | 12.00 | 10.91 | 10.00 | 9.23 | 8.57 | 7.99 | 7.50 | 7.06 | 6.65 | 5.99 | 5.44 | 4.79 |
| 9 | 13.50 | 12.28 | 11.25 | 10.38 | 9.64 | 8.99 | 8.44 | 7.95 | 7.48 | 6.74 | 6.12 | 5.39 |
| 10 | 15.00 | 13.65 | 12.50 | 11.53 | 10.71 | 9.99 | 9.38 | 8.84 | 8.31 | 7.49 | 6.80 | 5.99 |
| 11 | 16.50 | 15.02 | 13.75 | 12.68 | 11.78 | 10.99 | 10.32 | 9.73 | 9.14 | 8.24 | 7.48 | 6.59 |
| 12 | 18.00 | 16.39 | 15.00 | 13.83 | 12.85 | 11.99 | 11.26 | 10.62 | 9.97 | 8.99 | 8.16 | 7.19 |
| 13 | 19.50 | 17.76 | 16.25 | 14.98 | 13.92 | 12.99 | 12.20 | 11.51 | 10.80 | 9.74 | 8.84 | 7.79 |
| 14 | 21.00 | 19.13 | 17.50 | 16.13 | 14.99 | 13.99 | 13.14 | 12.40 | 11.63 | 10.49 | 9.52 | 8.39 |
| 15 | 22.50 | 20.50 | 18.75 | 17.28 | 16.06 | 14.99 | 14.08 | 13.29 | 12.46 | 11.24 | 10.20 | 9.99 |
| 16 | 24.00 | 21.87 | 20.00 | 18.43 | 17.13 | 15.99 | 15.02 | 14.18 | 13.29 | 11.99 | 10.88 | 9.59 |
| 17 | 25.50 | 23.24 | 21.25 | 19.58 | 18.20 | 16.99 | 15.96 | 15.07 | 14.12 | 12.74 | 11.56 | 10.19 |
| 18 | 27.00 | 24.61 | 22.50 | 20.73 | 19.27 | 17.99 | 16.90 | 15.96 | 14.95 | 13.49 | 12.24 | 10.79 |
| 19 | 28.50 | 26.08 | 23.75 | 21.88 | 20.34 | 18.99 | 17.84 | 16.85 | 15.78 | 14.24 | 12.92 | 11.39 |
| 20 | 30.00 | 27.45 | 25.00 | 23.00 | 21.41 | 19.99 | 18.78 | 17.74 | 16.61 | 14.99 | 13.60 | 11.99 |

*Example* ;—60 Min. in an hour; 7 Revs. of Doffer; 26¾ Inches on wire ; 83.3 Grains per yd; $\frac{22}{7}$ Constant: 7000 Grains in 1 lb.; 36 Inches in a yard ; 10% less for stoppages.

$$\frac{60 \times 7 \times 26.75 \times 83.3 \times 22}{7000 \times 36 \times 7} = 11.67$$

11.67—1.16 (less 10%)

=10.50 lbs.

### Carding Calculations.

## To Find Hank Sliver or Hank Carding

| | | |
|---|---|---|
| Hank of scutcher lap | = | .00136 |
| Total Draft | = | 95 |
| Waste (5%) | = | .05 |

$$\frac{.00136 \times 95}{1-.05} = .36 \text{ Hank sliver.}$$

## To Find Total Draft between Feed and Calender Rooller.

| | | |
|---|---|---|
| Diameter of feed roller | = | 2″ |
| Side shaft wheel | = | 17 |
| Feed roller wheel | = | 120 |
| Side shaft bevel wheel | = | 22 |
| Calender shaft wheel | = | 20 |
| Diameter of calender roller | = | 3″ |
| Doffer Bevel wheel | = | 22 |

$$\frac{120 \times 22 \times 180 \times 3}{22 \times 20 \times 17 \times 2} = \frac{1620}{17} = 95 \text{ Total Draft.}$$

## Draft Constant for Howard and Bullough's Card—

| | | |
|---|---|---|
| Bevel wheel on doffer | = | 34 |
| Do. do. side shaft | = | 34 |
| Feed roller wheel | = | 120 |
| Dia. of Feed Roller | = | 2″ |
| Doffer on wire | = | 26.75 |

$$\frac{34 \times 120 \times 3.1416 \times 26.75}{34 \times 2 \times 3.1416} = 1606$$

1605+6% for waste = 1605+96 = 1701 Draft constant.

## Draft Constant for Dobson and Barlow's Card (between Feed Roller and Doffer)—

| | | |
|---|---|---|
| Bevel wheel on doffer | = | 32 |
| Do. do. side shaft | = | 26 |
| Feed roller wheel | = | 154 |
| Dia. of feed roller | = | 2.25 |
| Doffer on wire | = | 26.75 |

$$\frac{154 \times 32 \times 3.1416 \times 26.75}{26 \times 2.25 \times 3.1416} = 2250$$

2250+6% for waste = 2250+135 = 2385 Draft constant.

## Total Draft Constant for Dobson and Barlow's Card

| | | |
|---|---|---|
| Bevel wheel on doffer | = | 26 |
| Do. do. side shaft | = | 32 |
| Feed roller wheel | = | 154 |
| Dia. of lap roller | = | 6″ |
| Calender roller | = | 4″ |
| Big Doffer | = | 195 |
| Lap roller wheel | = | 59 |
| Lap roller driving wheel | = | 21 |
| End wheel on calender roller | = | 28 |

$$\frac{59 \times 154 \times 32 \times 195 \times 4}{21 \times 26 \times 28 \times 6} = 2472 \text{ Total Draft constant.}$$

Constant $\div$ side shaft wheel = Total Draft and *vice versa.*

## To Find the Draft between Doffer and Draw Box.

Wheel on end of doffer $\times$ draw box shaft wheel $\times$ diameter of back roller $\div$ draw box back roller wheel $\times$ front Shaft end wheel $\times$ diameter of doffer = draft required.

## To Find the Draft in Draw Box.

Diameter of front rollers $\times$ back roller wheel $\div$ diameter of back roller $\times$ front roller wheel = draft required.

## To Find weight of Sliver—

| | |
|---|---|
| Scutcher lap | =14 ozs. per yard |
| Card draft | =100 |
| Waste | =3% |

$$\frac{14}{16} \times 7000 = 6125 \text{ grains.}$$

$$3\% = .03$$

$$\frac{(1-.03) \times 6125}{100} = 59.41 \text{ grains per yard.}$$

## To alter Hank of Sliver—

18 teeth change wheel pinion
.16 Hank sliver
Required to produce a sliver of .12 hank.

## To Find the Change Pinion or Side Shaft Wheel.

$$\frac{.16\times18}{.12}=24 \text{ teeth side shaft wheel.}$$

*Example ;—*

If a card produces a sliver of .16 Hank with 18 teeth change wheel what will be the hank of the sliver if a 24 teeth change wheel is used ?

$$\frac{.16\times18}{24}=.12 \text{ Hank sliver.}$$

## Scutcher Lap Weight.

A card with a draft of 100 produces a sliver of .16 Hank with 6% waste what weight of scutcher lap is required for the card ?

$$\frac{100\times8.33}{.16\times(1—.06)}=5539 \text{ grain per yard}$$

$5539\div437.5$ (grains in 1 oz.)$=12.6$ ozs. per yard.

*Example ;—*

If 6 yards of card sliver weigh 17 dwts. and 20 grains, find the Hank Carding—

17 dwts, 20 grains

$=428$ grains

$50\div428=.116$ Hank carding.

## Draft for a given Hank Sliver

What draft will be required in a card making 6% waste to produce a sliver of .16 Hank from a lap weighing 16 ozs. per yard ?

Weight of sliver $\frac{8.33}{.16}=52.08$ grains per yard

Weight of Scutcher lap$=16$ ozs. or 7000 grains per yard

Waste$=.06$

$$\frac{(1—.06)\times7000}{52.08}=126 \text{ Draft approximately.}$$

*Example ;—*

If one yard of lap weighs 14 ozs. or 6125 grains and one yard of sliver from the card weighs 64 grains, what is the draft ?

$$\frac{6125}{64}=95.70 \text{ Draft.}$$

*Example* ;—

If a certain length of sliver weighs 64 grains with 19 change pinion, what change pinion will be required to change the sliver to 70 grains ?

$$\frac{19 \times 70}{64} = 21 \text{ teeth.}$$

*Example* ;—

If the diameter of the doffer is $26\frac{3}{4}''$ and if it makes 9 revolutions per minute, find the production per 10 hours of 600 minutes if one yard of sliver weighs 48 grains.

$$\frac{26.75 \times 3.1416 \times 9 \times 600 \times 48}{36 \times 7000} = 86 \text{ pounds per day.}$$

*Less* 15% = 12 „ „

74 lbs. production.

## Production per minute in lbs.

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

prod; per min. in lb.

## How to Find Production

| | | |
|---|---|---|
| Working minutes per day | = | 600 |
| Revolution of Doffer | = | 8 |
| Dia. of Doffer | = | $26\frac{3}{4}''$ |
| Weight of 1 Yd. of sliver | = | 64 grains |
| Grains in one pound | = | 7000 „ |
| Inches in a yard | = | 36 |
| Constant for finding circumference | = | $\frac{22}{7}$ |

$$\frac{600 \times 8 \times 26.75 \times 64 \times 22}{7000 \times 36 \times 7} = \frac{75328}{735} = 102 \text{ lbs.}$$

102—15% ( for waste) = 87 lbs. production.

## Constant for Finding Production

| | |
|---|---|
| Working minutes per day | = 600 |
| Rev. of Doffer | = 8 |
| Dia. of Doffer on wire | =26.75 |
| Grains in one pound | = 7000 |
| Inches in a Yard | = 36 |
| Constant for circumference | = $\frac{22}{7}$ |

$$\frac{600 \times 8 \times 26.75 \times 22}{7000 \times 36 \times 7} = \frac{2354}{1470} = 1.60 \text{ Constant.}$$

Constant × weight of sliver (1 yd.) = production.

*Example ;—*

If the diameter of the doffer is 27 inches and if it makes 16 revolutions per minute, find the production per 10 hours a day if one yard of sliver weighs 70 grains.

27″ × 3.1416 = 84.78 cir. of doffer
84.78 × 16 Revs. per min. = 1356.48
1356.48 ÷ 36″ = 37.68 Yds. per min.
37.68 × 60 (min. per hr.) = 2260.80 yds. per hour.
2260.80 × 10 hrs. per day = 22608 yds. per 10 hrs.
22608 × 70 Grs. = 1582560 Grs. per 10 hrs.
1582560 ÷ 7000 in 1 lb. = 226.08 Lbs. production per 10 hours a day

## Revolution of Cylinder—

| | |
|---|---|
| Rev. of main shaft | = 160 |
| Drum on main shaft | = 18 |
| Pulley on cylinder | = 18 |

$$\frac{160 \times 18}{18} = 160$$

*To find speed of Licqurin—*

| | |
|---|---|
| Revolution of cylinder | = 160 |
| Diameter of Pulley on cylinder driving Licqurin | = 18″ |
| Diameter of Pulley on Licqurin | = 7″ |

$$\frac{160 \times 18}{7} = 411 \text{ speed of Licqurin.}$$

**To Find Speed of Doffer (D. & B. Cards)—**

| | | |
|---|---|---|
| Speed of Licqurin | = | 411 |
| Pulley on the other side of Licqurin | = | 5″ |
| Barrow Pulley | = | 12″ |
| Wheel on 2nd Stud | | $\frac{24}{77}$ for slow motion and $\frac{37}{64}$ for fast motion. |
| Change pinion | = | 25 |
| Wheel on doffer | = | 195 |

$$\frac{411 \times 5 \times 25 \times 24}{12 \times 195 \times 77} = 6.84 \text{ speed of slow motion.}$$

$$\frac{411 \times 5 \times 25 \times 37}{12 \times 195 \times 64} = 12.69 \text{ speed of fast motion.}$$

**To Find Speed of Doffer (H. & B.)—**

| | | |
|---|---|---|
| Speed of Licqurin | = | 488 |
| Pulley on other side of Licqurin | = | 6″ |
| Dandy pulley | = | 9 |
| Wheel on Dandy pulley | = | 26 |
| Wheel on 2nd stud | = | 104 |
| Change pinion | = | 22 |
| Wheel of Doffer | = | 180 |

$$\frac{488 \times 6 \times 26 \times 22}{9 \times 104 \times 180} = \frac{17446}{1755} = 9 \text{ Revs.}$$

**Revolutions of Feed Roller—**

| | | |
|---|---|---|
| Revolution of Doffer | = | 12 |
| Bevel on do. | = | 26 |
| Do. on side shaft | = | 32 |
| Wheel do. do. | = | 26 |
| Feed Roller wheel | = | 154 |

$$\frac{12 \times 26 \times 26}{32 \times 154} = 1.64 \text{ Rev. of Feed roller.}$$

**Speed of Lap Roller—**

| | | |
|---|---|---|
| Speed of Doffer | = | 12 |
| Bevel wheel on doffer | = | 26 |
| Do. do. side shaft | = | 32 |
| Wheel on side shaft | = | 26 |
| Feed roller wheel | = | 154 |
| Wheel on other end of Roller | = | 21 |
| Wheel on Lap Roller | = | 59 |

$$\frac{12 \times 26 \times 26 \times 21}{32 \times 154 \times 59} = .58$$

**Length of Lap Fed to Licqurin Feed Rollor—**

| | | |
|---|---|---|
| Revolutions of Feed roller | = | 1.64 |
| Diameter of Feed Roller | = | 2.25 |

$$1.64 \times 2.25 \times \frac{22}{7} = 11.59''.$$

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## Settings.

The settings that will be actually adopted in any particular case will depend on (1) the cotton that is being used, (2) on the nature of the work and the finish required, (3) on the personal judgment and experience of the carder. Then again, for similar conditions, different cards may require different treatment and adjustment in order to produce the same results. The quality of work produced by a card is judged by examining the web, as it comes from the front of the doffer, to see whether it is tree free from specks, neps, motes, leaf, thick and thin places, dulness and cloudiness.

The card, even when cotton and counts remain the same, must have constant attention, or the quality of the yarn will gradually deteriorate.

## Supervision.

The card must be stripped every few hours; ground every few days; and reset every few weeks.

## Hints on Carding.

(1) To card well is to spin well. (2) Bad carding is generally attributable to overloading the machine or neglecting to strip. (8) When carding good cotton, the cylinders should be stripped three times a day and also the doffer. For poor cotton five times

a day. (4) In clothing a carding engine care should be taken to have the tension uniform, and the winding on should proceed steadily so as not to rupture the wire fillet. Special machines are made for this purpose. It is absolutely essential that the cylinder and doffers should be covered in such a manner that the fillet will not slip or blister, through change of atmosphere, working strain, or other causes. (6) Never overload the cylinder as this will cause neppy cotton. (7) Keep the flats as clean as possible and they should be ground and well cleaned once a month. (8) The fillets prior to being placed on the doffer or cylinder should be stretched for 24 hours at a tension of 250 pounds for the doffer and 350 pounds for the cylinder. (9) Burnishing brush should be applied to the cylinder and doffer once a month for half an hour for straightening the wire. (10) Burnishing brush may also be applied to the flats for half a day once a month or the dead roller for a day once a month. (11) The cylinder, doffer, and flats must be lightly ground every three weeks for about one day until the points are sharp enough. (12) When the cards are being stripped and brushed out if great care is not used a constant drag in pulling the wire causes it to fall forward or pulls the wire points beyond what they should be. The chief reason of this is the everlasting grinding, and insisting on so much of this, and so much of the other, being done, causing this very important machine to be literally spoiled by hurry and skurry, and anything but carefulness and hence $\frac{7}{1000}$ part of an inch cannot be indulged in, when the vital part is but imperfectly cared for. (13) The sagging of the web may be due to one of many causes, such as atmospheric conditions, a dirty and sticky trumpet and dirt or waste collecting at the ends of the top calender roller and tending to prevent it from turning. This last defect prevents the roller from revolving freely when it is not positively driven while excessive sag is to be avoided, yet it must be clearly understood that the web between the doffer and the trumpet must not be taut. So long as the web continues to be stripped from the doffer without undue slack or sag, and the calender roller takes up the sliver evenly, then the conditions may be regarded as satisfactory. The web should have good selvedges. The defect is often caused by the accumulation of cotton or waste in some part of the card. The places where waste is liable to collect to produce bad selvedges are between the taker-in ends and the card sides between the cylinder ends and the framing, and between the doffer and the card sides. Bad selvedges may be caused also by allowing the fly under the taker-in and the cylinder under-casings to accumulate excessively, until there is sufficient to be pulled through in one lump by the wire. Waste sometimes accumulates between the grid bars at the ends. The card should always be stopped when it is desired to see where the waste has accumulated. The remedy is to remove the waste and blacklead the parts where the accumulation of waste occurs. Bad selvedges may sometimes be caused by defective selvedges on the lap at the back of the card, in which case the guide plates at the back of the card should be adjusted and the finisher scutcher be examined to remove the fault. A cloudy web produced from the doffer may be caused by failure to remove the fly under the taker-in and cylinder at regular and sufficiently frequent intervals. It may sometimes be traced to the bad setting of the card, allowing the cotton to be gathered together at some point and passed forwards from time to time, thus producing cloudiness. Cloudy webs may also be due to bending or bad setting of the feed plate. (14) When a card is stopped by dropping the barrow lever, the delivery of sliver ceases, but the cylinder at the taker-in continues to revolve. As a result when the card is started again, the web may break down at the front of the doffer, producing what is termed a broken web. The same defect may also appear if the doffer comb is too high or if there are dents in the wire on the doffer. A neppy web is one that contains neps or fibres rolled up giving the appearance of the specks. It is caused by dull wires, improperly ground cards or bad setting. The remedy for this fault is to grind the cards with good rollers, using the slow motion on both cylinders and doffers, and then to reset the card. It frequently happens, when starting a card in the morning that the web instead of being stripped from the doffer, breaks down. The action is usually due to the fact that the card has been standing over night or during the week-end, subjected to changes in the atmosphere and temperature of the room. French chalk may be scattered on the lap as it unrolls at the back by means of a sieve. If the comb band slips or is too slack or the doffer requires grinding, or the doffer comb is badly set, the same fault may result. When coiling the sliver in the can, the can should not be allowed to become so full that it turns with difficulty or that, when it is removed from the can dish, the sliver pushes upwards and falls over the edge on the floor. Sliver cans should be removed from the can dish systematically, and should contain just enough sliver to fill them easily. In order to ensure the greatest possible production the periods during which the card is stopped for grinding, setting and repairing of bands or belts should be as short as possible. When any parts are to be repaired or removed all the necessary tools and materials should be at hand so that the work may be done speedily, A new lap should be put on just before an old one runs out to avoid stoppage of the card. The only other method besides these of increasing the production is to speed up the card, which is usually done by increasing the size of the barrow wheel. Another method of increasing the production is to increase the size of the bevel pinion at the back and of the side shaft. In order to secure economy in the flat strippings the front plate should be set in such a manner that the flats will not take out any good cotton. The causes for irregular strippings are—(1) the working ends of some of the flats may be worn more than in others, (2) the ends of the flats may not have been kept clean, (3) flats set too high may not have been taken out and ground down by the flat levelling machine, (4) the wire on some of the flats may be in better condition than on others. The flats may not be receiving the proper cleaning by the brush. The fly beneath the card can either be increased or decreased according to style and setting of the grids under the card and the setting of the mote knives. The card room generally contains, besides the cards, drawing frames and fly frames. The temperature of the room should be well regulated. If the card rooms become too cold, the bands will grow light, the varnished leather rollers in the drawing frames will lick, and there will be difficulty at the starting in the morning. If the room becomes too hot, the waxy covering of the cotton fibre melts and causes the cotton to stick to the wire, the laps tend to lick, there is irregular production, the fibres curl, and drawing becomes difficult. During the night the temperature of the card room should be kept as near as 65° Fah. as possible and on no account should be allowed to fall to 60° Fah, as one night's neglect is often sufficient to cause rusting of the card wires.

## Cloudiness of Web.

Cloudines may occur in the web from various causes, few of the causes are as follows :—

Worn bearings disturbing the whole of the settings; one bearing of cylinder worn more than the other due to the pull of the belt 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; card left unstripped too long; badly stripped cylinder; feed roller clearer waste being taken through; 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, faulty wire on cylinder or flats, irregularity of the grinding due to differences in the character of the wire.

Neps 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 may cause a twisting up of fibres and dirt.

## OILING OF CARDING ENGINES.

All bearings must be oiled once a day, and the main bearings twice.

The eccentric box for the doffer comb must be sufficiently filled with oil.

The cards must be cleaned all through once a week.

In order to facilitate the passage of the flats, the ends of same, *i.e.*, their bearing surfaces must be touched with blacklead which has previously been mixed with turpentine to the consistency of a paste, the blacklead to be applied with a brush, under no circumstances must the ends of the flats or their bearing surfaces be oiled or greased.

The front part of the card must be cleaned every two hours. In order to keep the polished parts smooth use french chalk for cleaning same. Take out the licker-in waste four times a day, and that under the cylinder grid once a week.

The floor of the card room must be swept every two hours.

## STORES CONSUMED.

*See* under Blow Room.

## DESCRIPTION OF MACHINERY.

| Kind of Machinery. | No. | Maker. | Date | Width of Cards | Remarks. |
|---|---|---|---|---|---|
| Flat cards .. | 30 | H. & B. | 1924 | 36¼″ | |
| Union cards .. | 54 | D. & B. | 1921 | 37¾″ | |

## HANDS EMPLOYED.

| Designation. | No. | Amount. | | Per | Remarks. |
|---|---|---|---|---|---|
| | | Rs. | As. | | |
| Mistry .. .. .. | 1 | 90 | 0 | Month | |
| Head Fitter .. .. | 1 | 125 | 0 | do. | |
| Asst. Mistry .. .. | 1 | 37 | 8 | do. | |
| Do. do. .. .. | 1 | 30 | 0 | do. | |
| Card Grinder .. .. | 12 | 18 | 0 | do. | each. |
| Flat do. .. .. | 1 | 20 | 0 | do. | |
| Can Breaker .. .. | 12 | 16 | 8 | do. | each. |
| Lap Carrier .. .. | 4 | 16 | 8 | do. | ,, |
| Oilman .. .. .. | 2 | 16 | 8 | do. | ,, |
| Fly Carrier .. .. | 6 | 16 | 8 | do. | ,, |
| Spare man .. .. | 3 | 16 | 8 | do. | ,, |
| Tubular Banding Man | 1 | 20 | 0 | do. | |

## DIMENSIONS OF CARD ROOM.

| Size of Room. | | | Door. | | Windows. | | Remarks. |
|---|---|---|---|---|---|---|---|
| L. | B. | H. | No. | Size. | No. | Size. | |
| 230′ | 125′ | 12′-6″ | 3 | 8′ ×6′ | 31 | 8′-6″ | Including Drawing, Slubbing & Inter-frames. |

## CARDING, DRAWING, ROVING AND SPINNING TABLES.

The following tables show the Size, Hank and Proportion of Hank in every operation from the Lap Machine through all the various processes of Carding, Drawing, Roving and Spinning :—

### EXPLANATION AND EXAMPLES.

*Carding and Drawing Table.*—The first line is the decimal of the hank according to its length and weight, which will be found in the following manner :—

Multiply all the drafts together as far as regards the operation to be tried, whether slubbing drawing or carding, for a dividend, and all the doubling accordingly for a divisor : the quotient will be the draft ; then divide the numbers to be spun by the net draft, and the quotient will be the decimal of the hank; opposite to this in the table will be found the weight according to the length weighed.

*Examples ;*—Suppose the total draft to be 181440, the doubling 1728, and the numbers to be spun 40's; what weight will 2 yards of carding be ?

Thus: $181440 \div 1728 = 105$ then $40 \div 105 = .38$, which is the decimal of a hank; opposite to this, in the table under 2 yards will be found 1 dwt. 19.86 grains, the weight required.

Slubbing and roving tables rise progressively in 20th parts of a hank, as will be seen in the following tables.

Thus 1.05 or $1\frac{1}{20}$ and so on to 2 and 3 hanks, etc.

What will 30 yards of $2\frac{9}{10}$ hank roving weigh ? 250 is the dividend for 30 yards, which must be divided by the hank roving, and the quotient will be the weight in grains.

Thus $250 \div 2.9 = 86.2$ grains, or 3 dwts. 14.2 grains which will be found in the tables under 30 yards and opposite 2.9 in the column of the hank roving.

What will 60 yards of $3\frac{3}{4}$ or 3.75 hank roving weigh ? 500 is the dividend for 60 yards. Thus $500 \div 375 = 133.3$, or 5 dwts. 13.3 grains, the weight of a $3\frac{3}{4}$ hank roving.

If 40 yards weigh 4 dwts. 5 grains, what hank roving will it be ? 4 dwts. 5 grains $= 101$ grains. Thus $333.33 \div 101 = 3.3$ or $3\frac{3}{10}$ hank roving.

## CARDING AND DRAWING TABLE.

| | 2 Yards. | | 4 Yards. | | 6 Yards. | |
|---|---|---|---|---|---|---|
| Decl. of Hanks. | Dwts. | Grains. | Dwts. | Grains. | Dwts. | Grains. |
| .050 | 13 | 21.33 | 27 | 18.66 | 41 | 16.00 |
| .055 | 12 | 15.03 | 25 | 6.06 | 37 | 21.09 |
| .060 | 11 | 13.77 | 23 | 3.55 | 34 | 17.39 |
| .065 | 10 | 16.41 | 21 | 8.82 | 32 | 1.23 |
| .070 | 9 | 22.09 | 19 | 20.19 | 29 | 18.20 |
| .075 | 9 | 6.22 | 18 | 12.17 | 27 | 18.6 |
| .080 | 8 | 16.33 | 17 | 8.66 | 26 | 1.00 |
| .085 | 8 | 4.07 | 16 | 8.15 | 24 | 12.23 |
| .090 | 7 | 17.18 | 15 | 10.37 | 23 | 3.55 |
| .095 | 7 | 7.43 | 14 | 14.87 | 21 | 22.31 |
| .098 | 7 | 2.06 | 14 | 4.13 | 21 | 6.20 |
| .099 | 7 | 0.35 | 14 | 0.70 | 21 | 1.05 |
| .100 | 6 | 22.66 | 13 | 21.30 | 20 | 20.00 |
| .101 | 6 | 21.01 | 13 | 18.03 | 20 | 15.07 |
| .102 | 6 | 19.39 | 13 | 14.79 | 20 | 10.19 |
| .103 | 6 | 17.81 | 13 | 11.62 | 20 | 5.73 |
| .104 | 6 | 16.25 | 13 | 8.51 | 20 | .76 |
| .105 | 6 | 14.72 | 13 | 5.46 | 19 | 20.19 |
| .106 | 6 | 13.23 | 13 | 2.46 | 19 | 15.69 |
| .107 | 6 | 11.76 | 12 | 23.52 | 19 | 11.29 |
| .108 | 6 | 10.32 | 12 | 20.64 | 19 | 6.96 |
| .109 | 6 | 8.90 | 12 | 17.81 | 19 | 2.71 |
| .110 | 6 | 7.51 | 12 | 15.03 | 18 | 22.57 |
| .111 | 6 | 6.15 | 12 | 12.30 | 18 | 18.75 |
| .112 | 6 | 4.81 | 12 | 9.62 | 18 | 17.76 |
| .113 | 6 | 3.49 | 12 | 6.98 | 18 | 10.77 |
| .114 | 6 | 2.19 | 12 | 4.39 | 18 | 6.59 |
| .115 | 6 | 0.92 | 12 | 1.85 | 18 | 2.78 |
| .116 | 5 | 23.67 | 11 | 23.35 | 17 | 23.03 |
| .117 | 5 | 22.45 | 11 | 20.90 | 17 | 19.35 |
| .118 | 5 | 21.24 | 11 | 18.48 | 17 | 15.72 |

CARDING AND DRAWING TABLE.—*continued.*

| | 2 Yards. | | 4 Yards. | | 6 Yards. | |
|---|---|---|---|---|---|---|
| Decl. of Hanks. | Dwts. | Grains. | Dwts. | Grains. | Dwts. | Grains. |
| .119 | 5 | 20.05 | 11 | 16.11 | 17 | 12.16 |
| .120 | 5 | 18.18 | 11 | 13.77 | 17 | 8.66 |
| .121 | 5 | 17.74 | 11 | 11.48 | 17 | 5.22 |
| .122 | 5 | 16.61 | 11 | 9.22 | 17 | 1.83 |
| .123 | 5 | 15.50 | 11 | 7.00 | 16 | 22.50 |
| .124 | 5 | 14.40 | 11 | 4.81 | 16 | 19.22 |
| .125 | 5 | 13.33 | 11 | 2.66 | 16 | 16.00 |
| .126 | 5 | 12.27 | 11 | 0.50 | 16 | 12.82 |
| .127 | 5 | 11.23 | 10 | 22.46 | 16 | 9.70 |
| .128 | 5 | 10.20 | 10 | 20.41 | 16 | 6.62 |
| .129 | 5 | 9.19 | 10 | 18.39 | 16 | 3.59 |
| .130 | 5 | 8.20 | 10 | 16.40 | 16 | 0.60 |
| .131 | 5 | 7.22 | 10 | 14.45 | 15 | 21.67 |
| .132 | 5 | 6.26 | 10 | 12.50 | 15 | 18.78 |
| .133 | 5 | 5.31 | 10 | 10.62 | 15 | 15.93 |
| .134 | 5 | 4.37 | 10 | 8.75 | 15 | 13.13 |
| .135 | 5 | 3.45 | 10 | 6.91 | 15 | 10.37 |
| .136 | 5 | 2.55 | 10 | 5.20 | 15 | 7.74 |
| .137 | 5 | 1.65 | 10 | 3.30 | 15 | 4.96 |
| .138 | 5 | 0.77 | 10 | 1.54 | 15 | 2.31 |
| .139 | 4 | 23.90 | 9 | 23.80 | 14 | 23.70 |
| .140 | 4 | 23.00 | 9 | 22.00 | 14 | 21.00 |
| .141 | 4 | 22.20 | 9 | 20.40 | 14 | 18.60 |
| .142 | 4 | 21.37 | 9 | 18.74 | 14 | 16.11 |
| .143 | 4 | 20.55 | 9 | 17.10 | 14 | 13.65 |
| .144 | 4 | 19.74 | 9 | 15.48 | 14 | 11.22 |
| .145 | 4 | 18.94 | 9 | 13.88 | 14 | 8.82 |
| .146 | 4 | 18.15 | 9 | 12.31 | 14 | 6.46 |
| .147 | 4 | 17.37 | 9 | 10.75 | 14 | 4.13 |
| .148 | 4 | 16.61 | 9 | 9.22 | 14 | 1.83 |
| .149 | 4 | 15.85 | 9 | 7.71 | 13 | 23.57 |
| .150 | 4 | 15.11 | 9 | 6.22 | 13 | 21.33 |

CARDING AND DRAWING TABLE—*continued.*

| | 2 Yards. | | 4 Yards. | | 6 Yards. | |
|---|---|---|---|---|---|---|
| Decl. of Hank. | Dwts. | Grains. | Dwts. | Grains. | Dwts. | Grains. |
| .151 | 4 | 14.37 | 9 | 4.75 | 13 | 19.12 |
| .1525 | 4 | 13.29 | 9 | 2.57 | 13 | 15.86 |
| .153 | 4 | 12.93 | 9 | 1.86 | 13 | 14.79 |
| .155 | 4 | 11.52 | 8 | 23.05 | 13 | 10.58 |
| .157 | 4 | 10.15 | 8 | 20.31 | 13 | 6.47 |
| .1575 | 4 | 9.82 | 8 | 19.60 | 13 | 5.46 |
| .159 | 4 | 8.82 | 8 | 17.64 | 13 | 2.46 |
| .160 | 4 | 8.16 | 8 | 16.33 | 13 | 0.50 |
| .163 | 4 | 6.24 | 8 | 12.49 | 12 | 18.74 |
| .165 | 4 | 5.10 | 8 | 10.20 | 12 | 15.03 |
| .167 | 4 | 3.80 | 8 | 7.60 | 12 | 11.40 |
| .170 | 4 | 2.00 | 8 | 4.08 | 12 | 6.11 |
| .173 | 4 | 0.33 | 8 | 0.67 | 12 | 1.01 |
| .175 | 3 | 23.27 | 7 | 22.27 | 11 | 21.71 |
| .179 | 3 | 21.10 | 7 | 18.21 | 11 | 15.32 |
| .180 | 3 | 20.59 | 7 | 17.18 | 11 | 13.17 |
| .183 | 3 | 19.07 | 7 | 14.14 | 11 | 9.22 |
| .185 | 3 | 18.10 | 7 | 12.18 | 11 | 6.27 |
| .187 | 3 | 17.12 | 7 | 10.25 | 11 | 3.38 |
| .190 | 3 | 15.71 | 7 | 7.43 | 10 | 23.15 |
| .193 | 3 | 14.35 | 7 | 4.71 | 10 | 19.06 |
| .195 | 3 | 13.47 | 7 | 2.94 | 10 | 16.41 |
| .197 | 3 | 12.60 | 7 | 1.20 | 10 | 13.80 |
| .200 | 3 | 11.33 | 6 | 22.66 | 10 | 10.00 |
| .203 | 3 | 10.10 | 6 | 20.20 | 10 | 6.30 |
| .205 | 3 | 9.30 | 6 | 18.60 | 10 | 3.90 |
| .207 | 3 | 8.51 | 6 | 17.03 | 10 | 1.54 |
| .210 | 3 | 7.36 | 6 | 14.73 | 9 | 22.09 |
| .213 | 3 | 6.24 | 6 | 12.49 | 9 | 18.74 |
| .215 | 3 | 5.51 | 6 | 11.03 | 9 | 16.55 |
| .217 | 3 | 4.80 | 6 | 9.61 | 9 | 14.41 |
| .220 | 3 | 3.75 | 6 | 7.51 | 9 | 11.27 |

CARDING AND DRAWING TABLE.—*Continued.*

| | 2 Yards. | | 4 Yards. | | 6 Yards. | |
|---|---|---|---|---|---|---|
| Decl. of Hank. | Dwts. | Grains. | Dwts. | Grains. | Dwts. | Grains. |
| .223 | 3 | 2.73 | 6 | 5.46 | 9 | 8.21 |
| .225 | 3 | 2.07 | 6 | 4.14 | 9 | 6.22 |
| .227 | 3 | 1.42 | 6 | 2.84 | 9 | 4.26 |
| .230 | 3 | 0.46 | 6 | 0.92 | 9 | 1.39 |
| .233 | 2 | 23.53 | 5 | 23.06 | 8 | 22.59 |
| .235 | 2 | 22.92 | 5 | 21.84 | 8 | 20.76 |
| .237 | 2 | 22.32 | 5 | 20.64 | 8 | 18.97 |
| .240 | 2 | 21.44 | 5 | 18.88 | 8 | 16.33 |
| .243 | 2 | 20.58 | 5 | 17.17 | 8 | 13.76 |
| .245 | 2 | 20.02 | 5 | 16.05 | 8 | 12.06 |
| .247 | 2 | 19.47 | 5 | 14.95 | 8 | 10.42 |
| .250 | 2 | 18.66 | 5 | 13.33 | 8 | 8.00 |
| .253 | 2 | 17.87 | 5 | 11.75 | 8 | 5.62 |
| .255 | 2 | 17.36 | 5 | 10.71 | 8 | 4.07 |
| .257 | 2 | 16.85 | 5 | 9.70 | 8 | 2.55 |
| .260 | 2 | 16.10 | 5 | 8.20 | 8 | 0.30 |
| .263 | 2 | 15.37 | 5 | 6.74 | 7 | 22.11 |
| .265 | 2 | 14.89 | 5 | 5.78 | 7 | 20.67 |
| .270 | 2 | 13.72 | 5 | 3.45 | 7 | 17.18 |
| .275 | 2 | 12.60 | 5 | 1.21 | 7 | 13.81 |
| .280 | 2 | 11.52 | 4 | 23.04 | 7 | 10.56 |
| .285 | 2 | 10.47 | 4 | 20.95 | 7 | 7.43 |
| .290 | 2 | 9.47 | 4 | 18.94 | 7 | 4.41 |
| .295 | 2 | 8.49 | 4 | 16.99 | 7 | 1.49 |
| .300 | 2 | 7.55 | 4 | 15.11 | 6 | 22.66 |
| .305 | 2 | 6.64 | 4 | 13.28 | 6 | 19.93 |
| .310 | 2 | 5.76 | 4 | 11.52 | 6 | 17.28 |
| .315 | 2 | 4.91 | 4 | 9.82 | 6 | 14.73 |
| .320 | 2 | 4.08 | 4 | 8.16 | 6 | 12.24 |
| .325 | 2 | 3.28 | 4 | 6.56 | 6 | 9.84 |
| .330 | 2 | 2.50 | 4 | 5.01 | 6 | 7.51 |
| .335 | 2 | 1.75 | 4 | 3.50 | 6 | 5.25 |

CARDING AND DRAWING TABLE—*continued.*

| | 2 Yards. | | 4 Yards. | | 6 Yards. | |
|---|---|---|---|---|---|---|
| Decl. of Hank. | Dwts. | Grains. | Dwts. | Grains. | Dwts. | Grains. |
| .340 | 2 | 1.00 | 4 | 2.00 | 6 | 3.00 |
| .345 | 2 | 0.30 | 4 | 0.61 | 6 | 0.92 |
| .350 | 1 | 23.61 | 3 | 23.23 | 5 | 22.85 |
| .355 | 1 | 22.94 | 3 | 21.89 | 5 | 20.94 |
| .360 | 1 | 22.29 | 3 | 20.59 | 5 | 18.88 |
| .365 | 1 | 21.66 | 3 | 19.22 | 5 | 16.98 |
| .370 | 1 | 21.04 | 3 | 18.09 | 5 | 15.13 |
| .375 | 1 | 20.44 | 3 | 16.88 | 5 | 13.32 |
| .380 | 1 | 19.86 | 3 | 15.71 | 5 | 11.58 |
| .385 | 1 | 19.29 | 3 | 14.58 | 5 | 9.87 |
| .390 | 1 | 18.73 | 3 | 13.47 | 5 | 8.20 |
| .395 | 1 | 18.19 | 3 | 12.38 | 5 | 6.58 |
| .400 | 1 | 17.66 | 3 | 11.33 | 5 | 5.00 |
| .410 | 1 | 16.65 | 3 | 9.30 | 5 | 1.95 |
| .420 | 1 | 15.68 | 3 | 7.36 | 4 | 23.05 |
| .430 | 1 | 14.75 | 3 | 5.51 | 4 | 20.28 |
| .440 | 1 | 13.87 | 3 | 3.75 | 4 | 17.63 |
| .450 | 1 | 13.03 | 3 | 2.07 | 4 | 15.11 |
| .460 | 1 | 12.23 | 3 | 0.46 | 4 | 12.69 |
| .470 | 1 | 11.46 | 2 | 22.92 | 4 | 10.38 |
| .480 | 1 | 10.72 | 2 | 21.44 | 4 | 8.16 |
| .490 | 1 | 10.01 | 2 | 20.02 | 4 | 6.04 |
| .500 | 1 | 9.33 | 2 | 18.66 | 4 | 4.00 |

## CARDING AND DRAWING TABLE—*continued.*

| Decl. of Hank. | 8 Yards. Oz. | 8 Yards. Dwts. | 8 Yards. Grains. | 10 Yards. Oz. | 10 Yards. Dwts. | 10 Yards. Grains. |
|---|---|---|---|---|---|---|
| .066 | 2 | 5 | 15.1 | 2 | 16 | 3.6 |
| .067 | 2 | 5 | 0.0 | 2 | 15 | 8.7 |
| .068 | 2 | 4 | 9.4 | 2 | 14 | 14.4 |
| .069 | 2 | 3 | 19.1 | 2 | 13 | 20.7 |
| .070 | 2 | 3 | 5.3 | 2 | 13 | 3.3 |
| .071 | 2 | 2 | 15.9 | 2 | 12 | 10.7 |
| .072 | 2 | 2 | 2.9 | 2 | 11 | 18.4 |
| .073 | 2 | 1 | 14.2 | 2 | 11 | 2.5 |
| .074 | 2 | 1 | 2.0 | 2 | 10 | 11.1 |
| .075 | 2 | 0 | 13.8 | 2 | 9 | 20.1 |
| .076 | 2 | 0 | 2.2 | 2 | 9 | 5.4 |
| .077 | 1 | 17 | 20.3 | 2 | 8 | 15.2 |
| .078 | 1 | 17 | 9.2 | 2 | 8 | 1.3 |
| .079 | 1 | 16 | 22.3 | 2 | 7 | 11.8 |
| .080 | 1 | 16 | 11.8 | 2 | 6 | 22.6 |
| .081 | 1 | 16 | 1.5 | 2 | 6 | 9.8 |
| .082 | 1 | 15 | 15.5 | 2 | 5 | 21.2 |
| .083 | 1 | 15 | 5.7 | 2 | 5 | 9.0 |
| .084 | 1 | 14 | 20.1 | 2 | 4 | 21.0 |
| .085 | 1 | 14 | 10.8 | 2 | 4 | 9.3 |
| .086 | 1 | 14 | 1.6 | 2 | 3 | 21.9 |
| .087 | 1 | 13 | 16.7 | 2 | 3 | 10.8 |
| .088 | 1 | 13 | 8.0 | 2 | 2 | 23.9 |
| .089 | 1 | 12 | 23.5 | 2 | 2 | 13.3 |
| .090 | 1 | 12 | 15.2 | 2 | 2 | 2.2 |
| .091 | 1 | 12 | 7.1 | 2 | 1 | 16.7 |
| .092 | 1 | 11 | 23.1 | 2 | 1 | 6.7 |
| .093 | 1 | 11 | 15.3 | 2 | 0 | 21.0 |
| .094 | 1 | 11 | 7.7 | 2 | 0 | 11.5 |
| .095 | 1 | 11 | 0.2 | 2 | 0 | 2.1 |
| .096 | 1 | 10 | 6.9 | 1 | 17 | 22.5 |
| .097 | 1 | 10 | 9.7 | 1 | 17 | 13.6 |
| .098 | 1 | 10 | 2.7 | 1 | 17 | 4.8 |
| .099 | 1 | 9 | 19.9 | 1 | 16 | 20.2 |
| .100 | 1 | 9 | 13.1 | 1 | 16 | 1.8 |

CARDING AND DRAWING TABLE—*continued.*

| | 8 Yards. | | | 10 Yards. | | |
|---|---|---|---|---|---|---|
| Decl. of Hank. | Oz. | Dwts. | Grains. | Oz. | Dwts. | Grains. |
| .102 | 1 | 9 | 0.0 | 1 | 15 | 19.4 |
| .104 | 1 | 8 | 11.5 | 1 | 15 | 3.7 |
| .106 | 1 | 7 | 23.4 | 1 | 14 | 12.6 |
| .108 | 1 | 7 | 11.7 | 1 | 13 | 22.1 |
| .110 | 1 | 7 | 0.5 | 1 | 13 | 8.0 |
| .112 | 1 | 6 | 13.7 | 1 | 12 | 18.5 |
| .114 | 1 | 6 | 3.2 | 1 | 12 | 5.4 |
| .116 | 1 | 5 | 17.2 | 1 | 11 | 16.8 |
| .118 | 1 | 5 | 7.4 | 1 | 11 | 4.7 |
| .120 | 1 | 4 | 22.0 | 1 | 10 | 16.6 |
| .122 | 1 | 4 | 12.9 | 1 | 10 | 5.5 |
| .124 | 1 | 4 | 4.2 | 1 | 9 | 18.5 |
| .126 | 1 | 3 | 19.6 | 1 | 9 | 7.8 |
| .128 | 1 | 3 | 11.3 | 1 | 8 | 21.5 |
| .130 | 1 | 3 | 3.3 | 1 | 8 | 11.5 |
| .132 | 1 | 2 | 19.5 | 1 | 8 | 1.8 |
| .134 | 1 | 2 | 12.0 | 1 | 7 | 15.6 |
| .136 | 1 | 2 | 4.6 | 1 | 7 | 7.2 |
| .138 | 1 | 1 | 21.5 | 1 | 6 | 22.3 |
| .140 | 1 | 1 | 14.6 | 1 | 6 | 13.7 |
| .142 | 1 | 1 | 7.9 | 1 | 6 | 5.3 |
| .144 | 1 | 1 | 0.7 | 1 | 5 | 21.2 |
| .146 | 1 | 0 | 19.1 | 1 | 5 | 12.6 |
| .148 | 1 | 0 | 12.9 | 1 | 5 | 6.0 |
| .150 | 1 | 0 | 6.9 | 1 | 4 | 22.0 |
| .1525 | .. | 18 | 5.1 | 1 | 4 | 12.9 |
| .1550 | .. | 17 | 22.1 | 1 | 4 | 4.1 |
| .1575 | .. | 17 | 15.2 | 1 | 3 | 19.6 |
| .160 | .. | 17 | 8.6 | 1 | 3 | 11.3 |
| .165 | .. | 16 | 20.0 | 1 | 2 | 19.5 |
| .170 | .. | 16 | 8.1 | 1 | 2 | 4.5 |
| .175 | .. | 15 | 20.9 | 1 | 1 | 14.6 |
| .180 | .. | 15 | 10.0 | 1 | 1 | 1.4 |
| .185 | .. | 15 | 0.3 | 1 | 0 | 12.9 |
| .190 | .. | 14 | 14.8 | 1 | 0 | 1.1 |
| .195 | .. | 14 | 5.8 | .. | 17 | 10.3 |
| .200 | .. | 13 | 21.3 | .. | 17 | 8.6 |

## Combing.

Combing as an aid to improving the Spinning quality of cottons has come more and more into use in the Indian mills as is shown by the installation of an increasingly large number of combing machines. The treatment has so far been applied mostly to foreign long staple growths which respond well and owing to their large stocks, are available at cheap rates.

By combing to the extent of 20 per cent. it is possible to spin 50s to 60s counts from Indian cottons such as Punjab 289F which when carded would only spin about 30s counts. Combing has the desirable effect of reducing the degree of neppiness of yarns especially where the defect exists, to an appreciable extent, in the raw material and thus parallelizes the fibres. For coarse and medium counts of yarn, and for yarns which are not required to be of superior quality, the short fibres remaining in the carded cotton do not seriously interfere with the quality of carded yarn so long as the cotton selected originally is suitable. For warp yarns finer than 80s and weft yarn finer than 90s, and sometimes for coarse and medium yarns that must be of exceptional strength or cleanliness, it is necessary to comb the cotton. Combed yarn can be distinguished from carded yarns of similar counts by their strength, cleanliness, smooth and silky appearance; and fewer projecting ends of fibres.

The approximate amounts of waste removed are as follows :—

(1) Semi—Combed yarn—Card waste 4 or 5 per cent. comber waste 6 to 8 and even 11 per cent. This class of yarn is also known as half—combed yarn and coarse—combed yarn, being sometimes made by combining two or three combed slivers with four or three carded slivers, respectively, at the drawing frame.

(2) Ordinary—combed yarn—card waste 5 per cent. Comber waste 12 to 15 per cent.

(3) Super—combed yarn—card waste 7 per cent. Comber waste 17 or 18 per cent.

(4) Double—combed yarns—Card waste 5 per cent. first comber waste 18 per cent. second comber waste 5 to 7 per cent.

(5) Treble—combed yarns—card waste 5 per cent. first comber waste 17 per cent. second comber waste 7 per cent. third comber waste 5 per cent.

# CHAPTER XVII.

## Drawing Frames.

Several slivers which are the product of the card, are combined and attenuated to the dimensions of one.

Every step in cotton spinning has a two-fold object—the first being to carry the material a little further in the constructive process; the second to eliminate or minimize the defects of the preceding stages and thus improve the quality of the finished yarn to an inestimable degree.

The constructive part of drawing is to further perfect the parallel arrangement of the fibres contained in the sliver, which is accomplished by the different velocities at which the rollers revolve, and the proportion of which will be seen subsequently; the second is to render the sliver more perfectly uniform in its dimensions or in the number of fibres contained in a cross section, than it is when delivered from the card.

It is a very simple machine exceedingly productive and yet its use is of paramount importance in the production of a good, level and lustrous yarn. It requires proper mechanical condition and careful maintenance in order to produce uniform, strong and high-quality yarn. The parallel arrangement of the fibres in the sliver as it comes from the card is very imperfect and must be improved. This could not be accomplished satisfactorily were the single sliver to be drawn, as the attenuation or reduction of the dimension would be far too rapid, and the object would be unaccomplished when the sliver had been reduced to a fine roving.

Therefore three heads of draw frame are used. The cotton passes through three distinct draw frames, and at each frame doubling takes place. The popular number of slivers doubled together is six, and the draft in the rollers is usually about the same as the number of slivers, so that as this happens three times it will be seen that the total doublings are $6 \times 6 \times 6 = 216$, which goes to show that any error in the card sliver, is reduced to a very fine degree by the time it has passed through all the draw-frames.

On leaving the finisher drawing frame the sliver is still in too bulky a form and is of such dimension as to require further attenuation before it is sufficiently fine to be run through the machine that completes the operation of making it into yarn. The number of times the same process takes place in any one draw-frame, is known as 'DELIVERIES.' Seven or eight deliveries are quite common in one machine. A set of draw-frames seven delivery, then will mean that there are three processes of drawing, and seven deliveries in each process, or a total of twenty-one deliveries. The 'SINGLE' preventor rollers are so named as they keep the sliver tight over the spoon. The least reduction of pressure on the spoon causes it to overbalance and stop the machine. As soon as the broken or thin ends of the sliver leaves the preventor rollers the tumbler will fall, and so the machine will be at a standstill long before the end can possibly have reached the back drawing roller.

The drawing rollers have both top and botton clearers, the two usually being of the slow-moving, endless, and self-cleaning type (Ermen clearer), while the bottom may be either flat or circular clearers.

The weight-relieving motion is applied to take the weight off the top rollers when taking off a roller lap or when the machine is left standing for any length of time, in order to prevent the leather rollers from becoming flattened or marked by the flutes of the bottom rollers.

Spring weight hooks are used for the 'dead' weights on the front line of rollers to enable faster running of the front roller, and to help to increase the life of leather covering of the top roller.

The draft in the drawing should be equal to the number of ends put up at the back, or thereabouts. The top rollers should be all parallel, nicely oiled, varnished and properly weighted. If the rollers are not sufficiently weighted and set at the right distance for the staple of cotton, good work cannot be expected. When the mill stops for any length of time, all rollers should be relieved of their weights, beause rollers resting in one place with the weights on them become out of truth, and afterwards licking takes place.

It is not good to draw the cotton more than three times as it becomes soft, and licking occurs resulting in bad work. The diameters of the drawing frame rollers depend on the staple of cotton. The longer the staple the greater the diameter of rollers required.

It is usual to make the top rollers slightly less, say $\frac{1}{32}$ or $\frac{1}{16}$ inch than the bottom rollers in order to prevent the leather rollers from becoming fluted through continued contact with the bottom fluted rollers, and the flutes of the bottom steel rollers are also cut off slightly varying in pitch for the same reason. In all machines having draft rollers it is usual to have the bottom roller next to the front roller that is second from front less say $\frac{1}{8}''$ or $\frac{1}{16}$ than the others for the purpose of getting closer settings.

It must be borne in mind that short stapled cottons require small rollers as well as short distances between them. Long stapled cottons require large rollers as well as greater distances between them. If a heavy roller is being used, the distances between the centres must be greater than when a finer sliver is passing through. If the draft is rather small and the sliver is fine, the distances between the rollers can be a little less than when the draft is great and the sliver heavy. If the staple of the cotton is regular, the best thing to do is to bring out the roving as fine as possible and use easy drafts. When a heavy draft is used, the rollers should be run slowly. As the draft is lessened, a quicker speed may be used. But it should be always remembered that a large percentage of waste will result if a heavy draft and a high speed are employed together.

## TABLE SHOWING HANK, DRAFT, Etc.

The following table is prepared to give an idea for a handy working base.

A lot depends on supply and demand of the preparatory machinery.

Draft constant =460

Constant÷Draft =Change pinion and *vice versa*.

| Spinning Counts. | Hank. | Draft for the 3rd Head. | Weight of Sliver. D. | Weight of Sliver. G. | Remarks. |
|---|---|---|---|---|---|
| 6's—8's | .120 | 6 | 17 | 8.66 | |
| 10's—14's | .130 | 6 | 16 | 0.60 | |
| 16's—22's | .140 | 6 | 14 | 21 | |
| 24's—32's | .170 | 6 | 12 | 6 | |
| 34's—50's | .190 | 6 | 10 | 23.15 | |
| 52's—60's | .230 | 6 | 9 | 1.38 | |
| 62's—75's | .250 | 6 | 8 | 8 | |
| 76's—100's | .300 | 6 | 6 | 22.60 | |

2 teeth in back roller =1 tooth in change pinion. Watch wrapping and change the pinion and back roller wheel as necessary to give the hank drawing required.

## WEIGHT ON DRAFT ROLLER.

The weights on the draft rollers might be somewhat as follows :—

| | Front | 2nd. | 3rd. | Back. |
|---|---|---|---|---|
| Indian and American Cotton .. | 20 lbs. | 20 lbs. | 29 lbs. | 20 lbs. |
| Egyptian Cotton .. .. | 18 lbs. | 18 lbs. | 18 lbs. | 18 lbs. |

The above weights are single weights, suspended one on each end of the top rollers.

## FOR WEIGHT RELIEVING MOTION.

One double weight is used instead of two single weights. The standard weights are 40 lbs. 36 lbs. and 32 lbs.

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## SETTING OF ROLLERS.

*Egyptian Cotton*—

Front and 2nd $=1\frac{1}{2}''$
2nd and 3rd $=1\frac{5}{8}''$
3rd and back $=1\frac{3}{4}''$

*American Cotton*—

Front and 2nd $=1\frac{1}{4}''$
2nd and 3rd $=1\frac{3}{8}''$
3rd and back $=1\frac{3}{8}''$

*Indian Cotton*—

Front and 2nd $=1\frac{1}{8}''$
2nd and 3rd $=1\frac{3}{8}''$
3rd and back $=1\frac{1}{2}''$

## ROLLER SETTINGS.

| Counts. | Kind of Cotton. | Length of Staple. | Centre to Centre of Rollers. 1 | 2 | 3 |
|---|---|---|---|---|---|
| 50's | Uganda | $1\frac{1}{4}''$ | $1\frac{5}{16}''$ | $1\frac{3}{8}''$ | $1\frac{7}{16}''$ |
| 36's | Sind-American | $1\frac{1}{8}''$ | $1\frac{3}{16}''$ | $1\frac{3}{8}''$ | $1\frac{7}{16}''$ |
| 24's | Punjab- ,, | $\frac{7}{8}''$ | $1\frac{1}{8}''$ | $1\frac{1}{4}''$ | $1\frac{5}{16}''$ |
| 22's | ,, ,, | $\frac{7}{8}''$ | $1\frac{1}{8}''$ | $1\frac{1}{4}''$ | $1\frac{5}{16}''$. |

## Drawing Rollers.

Drawing Rollers are placed in pairs one above the other, and are of two kinds namely, common rollers and metallic rollers. The lower rollers are driven positively, as are metallic upper rollers, while common upper rollers are driven from the lower ones by frictional contact. The bottom rollers are almost always made of steel and are fluted; that is, grooves or flutes are cut lengthwise in the roller. This fluting enables the bottom rollers to obtain a good grip on the cotton as it passes between them and the top rollers.

## Diameter of Rollers.

Usually depend on the kind of cotton to be used; this of course, means the length of the staple. Bear in mind that the diameters increase as the staple becomes longer, and that the 2nd roller is the smallest and just remember that one set of rollers and add $\frac{1}{8}$ for each succeeding one; they are conveniently arranged in this methodical manner.

## Worn and Damaged Flutes.

It is necessary to have the bottom rollers refluted at times since the constant action of the cotton on the fluted will wear them very smooth on the edges and thus prevent their gripping the fibres. It is a serious matter if the flutes of the front bottom roller become damaged.

No iron picker should be used to remove a roller lap, but a picker made of brass may be used. The front roller, if damaged, will produce a bad place in the drawn sliver. It is therefore very desirable to have the front roller case hardened. It is important not to have the roller stands for the rollers too far apart, since in this case the bottom roller, due to the weight of the top roller and other weight placed on it, will be deflected out of a straight line, causing the rollers to run untrue and resulting in poor work. The bottom rollers are almost always case-hardened in the necks, or bearings, and in some cases throughout. They are thus rendered stiffer and stronger, which makes them more capable of resisting torsion, the necks wear longer, and the flutes are not so liable to become damaged by accident or by carelessness. Brass bearings should be put in the roller stands, and as these are softer than the necks, they will wear and thus save the necks.

Top rollers are constructed of iron and are made in short lengths, portions of their circumferences being afterwards covered with cloth and leather. That part of the roller used for drawing the cotton, which in common top rollers is the leather-covered portion, is known as the boss, and is always of larger diameter than the remainder of the roller. Top rollers may be made with one or two bosses, being known as single-boss rollers and double-boss rollers, respectively; the boss in both single and double-boss rollers may be detachable, when the boss of a roller is detachable, the roller is known as a loose-boss roller; when the boss is not detachable, the roller is known as a fast-boss roller. In loose-boss rollers the part that is detachable is known as the shell of the roller, while the part on which the shell rests is known as the arbor, or spindle. In the case of a fast-boss roller, the weight hook offers resistance to the turning of the roller, which is rotated by contact with the bottom roller. This action is objectionable in any cotton machine but is particularly so in a drawing frame, for the top front roller makes from 275 to 350 R.P.M. and to attain this speed by depending wholly on friction driving from the bottom roller makes it essential to have the top roller as free as possible in its bearings. If the top and bottom rollers do not have the same surface speed, the fibres between them will be cut. The loose-boss roller obviates this difficulty, as the weight hook does not touch any revolving part of the roller and there is no resistance to turning.

With a loose-boss roller only the shell revolves; consequently the neck and ends do not need oiling. When it is desired to oil the roller, the shell is removed and a few drops of cocoanut oil or other suitable oil are placed on the arbor.

As two metal rollers, one smooth and dead—or lever-weighted and the other fluted, revolving in contact would tend to crush the delicate cotton fibres, a leather covering is provided for the top rollers of the common type. The iron surface of the roller is first covered with a specially woven woollen cloth, which is cemented to the roller, giving a good, elastic foundation. When a thin leather covering that fits very lightly is drawn over this foundation, the roller is capable of gripping the fibres, and owing to the yielding quality of the leather and cloth, does not damage them. In order to secure the best results, the greatest care should be exercised in covering the rollers, and the best materials used.

The production of an even thread depends more on the quality of the cloth and the leather, the manner in which it is applied, and the care of rollers in the machine than on any other factor in the process of manufacture, with the exception of the grade of cotton used.

The cloth must be of the correct thickness, for if the cloth is too thin the leather covering will not be tight and will feel spongy. If the cloth is too thick, the leather will be unduly stretched when being drawn on and probably will burst. The cloth is generally 27 inches wide and the weight varies from 16 to 22 ozs. per yard.

### Setting of Rollers.

One of the most important points in relation to cotton machinery is the relative position of one pair of rollers to another, which position is governed by the length of the staple and bulk of cotton being used. The bad week work that will result from the improper setting of rollers can never be remedied. In setting rollers, the fundamental rule is that the distance between the centres of two pairs of rollers must always exceed the average length of the staple of the cotton being used. When the ends put up at the back are heavily twisted, the settings are wider on the same machine than when the ends fed are slightly twisted. This is due to the fact that it is more difficult to draw the fibres past each other in the former case than in the latter. Harsh, wiry cotton requires wider settings than smooth, silky cotton, because the former does not draw so easily. As the rollers are set according to the staple of the cotton used, it is evident that the roller intended to run on coarse counts, which is made from short stapled cotton, must be smaller in diameter than those intended to work longstapled cotton, in order that the centres of the rollers may be brought near enough together. Sometimes the middle roller is made smaller than the front and back rollers, where three pairs of rollers are used, so that a close setting may be made.

### Cause of Wastage.

There should be very little waste made at the drawing frame, and if a large amount is made it may be taken as an indication that some part of the frame is not properly adjusted or that the operatives are not attending to their work as they should. The drawing frames should be kept free from dirt, dust, and short fibre. Oil should not be allowed in places where it is not required. In order to ensure clean work the tenters should wipe or brush the frame, about every two hours, which takes very little of their time, but greatly helps to improve the quality of the yarn. A thorough cleaning of all parts of the frame should take place twice a week.

There is no process so important as the Draw Frame in particular and all subsequent machines in general, it is absolutely essential that all parts should be kept scrupulously clean, that all clearers both top and bottom should be picked at intervals, that all parts of the machine coming in contact with the sliver or roving should be highly polished and all tenters given opportunities to keep their hands clean so that piecings shall be as near perfect as possible. To get the best results of drafting and doubling at the draw frames it is necessary to pay particular attention to one or two mechanical details of the frame. It is essential that the stop motions whether mechanical or electrical, should operate instantaniously so that the new sliver may be pieced up to the end of the broken one and cause no gap or light sliver to pass forward.

The function of the draw-frame is well understood, and with that in mind it is generally agreed that the leather covered rollers call for considerable attention. The front line of each head should be varnished every week, and the system in operation in the card room must be very effective in this sense. The man responsible for varnishing the rollers must ensure that the varnish is evenly distributed over the whole of the leather surface, and that each roller is examined before it is placed in the roller stand, which will be in use for holding the newly varnished rollers.

Regarding the other lines of rollers, the leathers should be regularly examined and, if faulty, should be immediately replaced by a new one.

Whilst the cost of roller skin is great, it is much cheaper to scrap a badly covered roller than allow it to produce irregular sliver.

Recovering Schedule for Leather covered Rollers working 9 hours per day.

## Top Leather Rollers.

Front line, recover every 2 to 4 months.

Middle and Back lines, recover every 4 to 6 months.

## The Break Draft.

The efficient operation of rollers in the middle and lines of roving and spinning frames can still be regarded as one of the most important factors governing the uniformity of counts being spun. To trace faults in varying counts the efficient operation of middle and back lines of rollers should be one of the first items to be checked. For an example, the spinner cannot reasonably expect to obtain the best possible results if rollers slip, or if the roving is "pulling through." There should not only be a recognised difference in surface speed, but also some control of the fibres by the gripping action of the rollers. It is a mistake to transfer rollers without good reason—if a roller functions badly on the front line, it will function equally badly in the middle or back line.

Spinning to definite counts presents no extreme difficulty nowadays, but there is still a wide margin of difference not only in the characteristics of yarns spun, but also in the rate of production per spindle.

The causes are not difficult to trace, and mainly arise from a difference of opinion as to what dafts, speeds and roller setting should be employed. More attention has been given in recent years to break draft, but so long as different speeds are employed by spinning masters, according to what their experience has shown to be satisfactory, there cannot be a standard break draft to apply generally.

A medium weight roving can be attenuated without displacing the fibres to any positive extent. There is, therefore, no danger of losing the twist in roving. In short, it is the dafting system which definetly occurs at a given point—say, between the back line of rollers and the succeeding nip.

The setting here is of vital importance, as it usually exceeds in distance the average length of the long fibres in the hank. The fibre control then at this point is a condition which arises out of two factors, i.e., the twist in the roving and the resistance which the fibres offer to drafting.

Roller speeds between the back and second lines must essentially be so regulated that break draft is definetly established. There

There will possibly be no break draft at all if the surface speed of the second line is below, say, 5 per cent. that of the back line, in which case the fibres may be simply pulled through.

The condition of the rollers, carriers, etc. must be constantly examined and kept to a standard of perfection. It is better to renew coverings to ensure a proper gripping surface in the fibres than to slightly accelerate the speed in the hope of making up any deficiency. This latter experiment is bad practice which will inevitably cause variations in the yarn. More break draft is required for a short staple cotton than for a long staple, and if proper adjustments are made, to suit the roving, more satisfactory results will be obtained in unwinding.

A really good even yarn cannot be satisfactorily spun from a poor or very coarse roving, Parallalisation of fibre, correct twist, are factors which are recognised to contribute largely to the making of a good roving.

Faults at the fly frame cannot be eliminated entirely in the subsequent process, and the defective roving produced cannot be rectified by adjusting the break draft. It is not introduced for that purpose, and recourse to experiements on such lines cannot fail to become both costly and disappointing.

## Common Faults in the Drawing Process.

*Single.*—Long lengths of single occurs chiefly as a result of the single preventor motion not operating properly.

*Thin and thick places.*—Thick places in the sliver may be caused by bad piecings at the back of the machine, and thin places by sluggish action of the single preventor motion at the back, allowing the broken sliver to pass between the rollers or by roller laps.

*Uneven web.*—This will occur if the rollers are not kept in an efficient working condition, if they are out of line, or set too close or too open, or if the weighting of the rollers is unsatisfactory.

*Bad coiling.*—The sliver may be seriously damaged in coiling if the coiler speed is too high, or if the cams are not kept in good condition, or the cam-plate is incorrectly set.

*Bad Ends.*—Are frequent through bad piecing. 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.

*Scouring the rollers.*—When Scouring the rollers, care should be taken not to bend then. Place them on wood blocks at the ends and middle in V recesses. Attend to damaged ones at once. The weight—relieving motion should always be used when the machine is standing idle for week-ends etc.

## OILING & CLEANING OF DRAWING-FRAME.

Wipe down often, at least three times a day. Clean through once or twice a week. 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.

All bearings must be oiled once a day and the main bearings twice.

In mechanical stop motion, the working parts of the spoons must be kept most carefully cleaned.

In electric stop motion, the necks of the top cast iron calender rollers which make contact when a sliver breaks, must on no account be greased and the rollers themselves must be kept free from fly or dust.

The fluted rollers must be taken out four times a year and must be thoroughly cleaned in the flutes. The roller steps must be well cleaned and freshly greased. All wheels must be well oiled or greased in the bearings as well as on the teeth.

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.

When working Indian cotton, all four lines of top rollers must be freshly varnished once a week, and the top rollers of the last passage recovered with fresh leather every six weeks. When working Egyptian or African cotton, the front top rollers must be varnished twice a week, and the other three lines once a week.

In order to keep sliver funnels and the polished parts smooth and clean, use french chalk.

| | |
|---|---|
| Driving shaft .. .. | Grease cup. |
| Front Roller Bearing .. .. | ,, ,, |
| Roller Gearing .. .. .. | ,, ,, |
| Calender Roller .. .. .. | ,, ,, |
| Coiler Gearing .. .. .. | ,, ,, |

## Production.

Various cottons may require different hank slivers and speeds of front roller. As a general rule for guidance, the productions per 9 hours will be :

| | |
|---|---|
| Indian Cotton .. .. .. | 145 to 155 lbs. |
| American cotton .. .. .. | 110 to 135 lbs. |
| Egyptian cotton .. .. .. | 54 to 108 lbs. |
| Sea Islands cotton .. .. | 36 to 54 lbs. |

The hank sliver to be used also given here as a guide.

| | |
|---|---|
| Indian and low American .. | .120 to .140 |
| 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 judgement. 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.

*Production per one* ***Finishing Delivery*** *per hour at* **100%** ***Efficiency.***

***Allow*** **15 to 20%** ***for Stoppages, etc.***

| Speed of Front Roller | Diameter of Front Roller=1⅛″ | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | .10 | .11 | .12 | .13 | .14 | .15 | .16 | .17 | .18 | .19 | .20 | .21 | .22 | .23 | .24 | .25 |
| 275 | 19.3 | 17.5 | 16.1 | 14.8 | 13.8 | 12.9 | 12.0 | 11.3 | 10.7 | 10.2 | 9.6 | 9.2 | 8.8 | 8.4 | 8.0 | 7.7 |
| 300 | 21.0 | 19.1 | 17.5 | 16.1 | 15.0 | 14.0 | 13.1 | 12.4 | 11.7 | 11.1 | 10.5 | 10.0 | 9.6 | 9.1 | 8.8 | 8.4 |
| 325 | 22.8 | 20.7 | 19.0 | 17.5 | 16.3 | 15.2 | 14.2 | 13.4 | 12.7 | 12.0 | 11.4 | 10.9 | 10.4 | 0.9 | 9.5 | 9.1 |
| 350 | 24.5 | 22.3 | 20.5 | 18.9 | 17.5 | 16.4 | 15.3 | 14.4 | 13.6 | 12.9 | 12.3 | 11.7 | 11.2 | 10.7 | 10.2 | 9.8 |
| 375 | 26.3 | 23.9 | 21.9 | 20.2 | 18.8 | 17.5 | 16.4 | 15.5 | 14.6 | 13.8 | 13.1 | 12.5 | 12.0 | 11.4 | 11.0 | 10.5 |
| 400 | 28.0 | 25.5 | 23.3 | 21.6 | 20.0 | 18.7 | 17.5 | 16.5 | 15.6 | 14.8 | 14.0 | 13.4 | 12.7 | 12.2 | 11.7 | 11.2 |

| Speed of Front Roller | Diameter of Front Roller=1⅜″ | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | .10 | .11 | .12 | .13 | .14 | .15 | .16 | .17 | .18 | .19 | .20 | .21 | .22 | .23 | .24 | .25 |
| 275 | 23.6 | 23.4 | 19.6 | 18.1 | 16.8 | 15.7 | 14.7 | 13.9 | 13.1 | 12.4 | 11.8 | 11.2 | 10.7 | 10.2 | 9.8 | 9.4 |
| 300 | 25.7 | 25.3 | 21.4 | 19.8 | 18.4 | 17.1 | 16.1 | 15.1 | 14.3 | 13.5 | 12.9 | 12.2 | 11.7 | 11.2 | 10.7 | 10.3 |
| 325 | 27.9 | 27.3 | 23.2 | 21.4 | 19.9 | 18.6 | 17.4 | 16.4 | 15.5 | 14.7 | 13.9 | 13.3 | 12.7 | 12.1 | 11.6 | 11.1 |
| 350 | 30.0 | 29.2 | 25.0 | 23.1 | 21.4 | 20.0 | 18.8 | 17.7 | 16.7 | 15.8 | 15.0 | 14.3 | 13.6 | 13.0 | 12.5 | 12.0 |
| 375 | 32.2 | 31.2 | 26.8 | 24.7 | 23.0 | 21.4 | 20.1 | 18.9 | 17.9 | 16.9 | 16.1 | 15.3 | 14.6 | 14.0 | 13.4 | 12.9 |
| 400 | 34.3 | 33.2 | 28.6 | 20.4 | 24.5 | 22.9 | 21.5 | 20.2 | 19.1 | 18.1 | 17.2 | 16.7 | 15.6 | 14.9 | 14.3 | 13.7 |

## DRAWING FRAMES CALCULATIONS.

**To find daft—**

| | |
|---|---|
| Crown Wheel | = 115 |
| Back Roller .. .. .. | = 64 |
| Front ,, | = 20 |
| Change Pinion | = 66 |
| Dia. of Front Roller | $1\frac{1}{8}''$ |
| ,, Back ,, | = $1\frac{1}{8}''$ |

$$\frac{115 \times 64 \times 1.125}{20 \times 66 \times 1.125} = 5.57 \text{ Draft.}$$

**To find draft—**

| | |
|---|---|
| Ends up | = 6 |
| Hank Drawing | = .13 |
| Hank Carding | = .18 |

$$\frac{6 \times .13}{.13} = 6$$

**Constant for draft—**

| | |
|---|---|
| Crown Wheel | =115 |
| Back Roller | = 64 |
| Front Roller | = 20 |
| Dia. of ,, ,, | = $1\frac{1}{8}''$ |
| Dia. of Back ,, | = $1\frac{1}{8}''$ |

$$\frac{115 \times 64 \times 1.125}{20 \times 1.125} = 368$$

Const ÷ Pinion = Draft.

**Speed of Front Roller—**

| | |
|---|---|
| Rev. of Main Shaft | =160 |
| Drum on Main Shaft | = 24 |
| Pulley on Front End | = 13″ |
| ,, ,, Bottom Shaft (frame) | = 16″ |
| ,, ,, Frame | = 12″ |

$$\frac{160 \times 24 \times 16}{13 \times 12} = 394 \text{ Speed of Front Roller}$$

**Length in yard delivered by Front Roller per minute—**

Dia. of Front Roller = $1\frac{1}{8}''$
Speed ,, ,, =394

$$\frac{9 \times 394 \times 22}{8 \times 36 \times 7} = 38.69 \text{ Yds.}$$

**Production per hour at 100% Efficiencp.**

Circumference of Front Roller $=1\frac{3}{8}'' \times \frac{22}{7}$
Revs. of Front Roller .. .. = 200
Hours worked .. .. .. = 1
Grains per yard 83.33

$$\frac{1.375 \times 3.145 \times 200 \times 1 \text{ hr} \times 60 \text{ min.} \times 83.33}{36'' \times 7000} = \text{lbs.}$$

$$= \frac{1.375 \times 3.145 \times 200 \times 60 \times 83.33}{36'' \times 7000} = 17.145 \text{ lbs per hour at } 100\% \text{ Efficiency.}$$

**Production per day of 10 hours at 100% Delivery.—**

Dia. of Front Roller = $1\frac{1}{8}''$
Rev. ,, ,, =394
Min. per day of 10 hours =600
Hank drawing =.13
Const. for cir. $=\frac{22}{7}$ or 3.1416
Yards in a hank =840
Inches in a yard = 36

$$\frac{394 \times 9 \times 600 \times 3.1416}{8 \times 840 \times 36 \times .13} = 212 \text{ Lbs.}$$

*Less* 20% = 42
Net Production =170 Lbs.

**Constant for finding Production—**

Rev. of front Roller =394
Minutes per day =600
Dia. of front Roller = $1\frac{1}{8}''$
Constant for finding cir. $=\frac{22}{7}$
Yards in a hank =840
Inches in a yard 36

$$\frac{394 \times 600 \times 22 \times 9}{8 \times 840 \times 7 \times 36} = 27.64$$

Constant ÷ Hank = Production per delivery.

**To find change pinion when changing from one hank to another—**

Change pinion = 67
Present Hank = .13
Hank required = .17

$$\frac{67 \times .13}{.17} = \frac{8.71}{.17} = 51 \text{ Pinion.}$$

**To find change pinion that will give a required draft—**

| | |
|---|---|
| Front Roller Wheel | = 20 |
| Crown Wheel | = 115 |
| Back Roller Wheel | = 64 |
| Draft required | = 5.57 |
| Dia. of Front Roller | = $1\frac{1}{8}''$ |
| Dia. of Back Roller | = $1\frac{1}{8}''$ |

$$\frac{115 \times 64 \times 9 \times 8}{20 \times 5.57 \times 8 \times 9} = 66 \text{ Pinion.}$$

**To find hank drawing—**

Dividend for 6 yards = 50
Weight of Sliver = 16 dwts. or 384 grains.
$50 \div 384 = 13$ Hank Drawing.

To find the Hank carding, given hank drawing, and draft. Number of ends put up × hank drawing ÷ draft = hank carding required.

To find weight of drawing, given draft, number of ends put up; and weight of carding.

Number of ends × weight of carding ÷ draft = weight of drawing.

To find change pinion when changing from one weight to another.

Desired weight × change wheel at present on ÷ prsent weight of drawing = change pinion required.

To find the draft between the first and second roller wheel driven by front roller wheel × wheel on second roller × diameter of front roller ÷ diameter of second roller × wheel that drives second roller × front roller wheel = draft required.

### Total draft of 6.

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.

Square root $6 = 2.45$ the draft between the first and second cube root of $6 = 1.82$.

$$\frac{6}{2.45 \times 1.82} = 1.34 \text{ the draft between the 3rd and 4th.}$$

$\therefore 2.45 \times 1.82 \times 1.34 = 6$ Total Draft.

### Number of Drawing Processes.

For ordinary Indian and American warp and weft yarn also medium quality Egyptian or African (Uganda) single-carded yarn up to about 60's three processes.

### Gauge of framers.

The gauge is the distance from the centre of one delivery to that of the next. The distance is generally 16 ins. to 18 ins.

### Production.

The weight of sliver produced per delivery largely depends on the number of drawing frame deliveries to slubbing spindles..

### Power.

From 8 to 12 deliveries per indicated horse power.

### Testing of draw frame slivers.

Draw-frame slivers should be tested at least 3 or 4 times a day and care should be taken that the material selected for the test should not be damaged in any way, or erroneous results may be obtained. The variation from standard weight should only be small though it will vary somewhat according to weight and quality as it is most important that a high degree of uniformity in the drawn sliver shall be maintained. If this is done, little or no change of draft wheels is required subsequently except at the spinning machine.

### Recipes for pastes.

(1) A good roller-cloth paste may be made from flour and resin in the proportion of 2 pounds of best flour to ¼ pound of resin. The flour is first made into a thin paste with boiling water, all lumps

being crushed, and then it is boiled very slowly until it begins to thicken. The resin which has been melted in another vessel, is next poured in, and the boiling is continued until a paste of good texture is formed. This is allowed to cool and is used cold.

(2) 3 lbs. wheat flour.
1 lb. powdered resin.

Mis both the ingredients by adding water to a thin paste. Boi l until thickens. Stor well while boiling. Add ½ lb. turpentine oil.

(3) Isinglass 2 ozs.
Acetic acid 1 lb.

Mix both the ingredients together.

## Roller Varnishes.

(1) 1 lb. of fish glue.
1 lb. American cement.
14 ozs. chrome yellow.
14 ozs. dry red paint.
8 ozs. gum arabic.
1 oz. sal-ammoniac.
6 ozs. blacklead.

Steep glue and gum arabic, along with the cement, in 4 qts. of vinegar for 3 days, grind the chrome yellow, red paint, and blacklead into the finest powder. Then mix into a paste with water. Boil the glue and gum arabic together and, when boiling, add the paste. Boil together for about 6 hours and then sieve it through a fine sieve, after which it will be ready for use. If it thicknens, add a little water to bring it, to the thickness of paste required.

(2) 9 ozs. of fish glue.
2 qts. of acetic acid.
2 teaspoonfuls of oil of origanum.

This mixture should stand for about 2 days in order that the glue may be thoroughly dissolved, after which it may be thickened with fine powdered paint of any colour that may be desired.

(3) 3 pints of acetic acid.
3 pints of water.
2 lbs. of fish glue.
½ ,, sheet gelatine.
4 ozs. of oil of origanum.
6 ozs. of methylated spirit.

The acetic acid, water, glue, and gelatine should be put together in a vessel and slightly warmed until the solids are disolved, and then the oil of origanum, venetian red and methylated spirit should be added. The whole should be well mixed and stirred at a slight heat. It will set when cold and must be slightly warned before using..

(4) 8 ozs. glue.
4 ozs gum-arabic.
8 ozs. Chromate of lead.
3 ozs. of dry red paint.

Soak the glue and gum in one pint of cold water for 24 hours, afterwards make up the glue and gum into 2 quarts and melt slowly, thoroughly grind the other materials into a fine powder and mix to a paste with cold water and add to the glue. This will set into a jelly when cold and requires heating before ues. It should be applied with a fine Camel hair brush in a thin even layer.

(5) ¼ lb. of Gelatine Glue.
¼ lb. of Pulverized Glue.
1 Quart of Acetic Acid.
1 Table Spoonful of Origanum oil.
1 Teaspoonful of Brown Sugar.

Varnish must be put perfectly level and must dry smooth. The slightest signs of cracking are an indication for revarnishing, otherwise good fibres will be detached from the sliver 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. 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.

LEATHER COVERED ROLLERS MUST BE LOOKED AFTER.

## DRAWING DEPARTMENT.

| | |
|---|---|
| Speed of Counter Shaft .. .. .. | 160 |
| Drum on ,, ,, .. .. .. | 24″ |
| Pulley on Cross Shaft .. .. .. | 16″ |
| Speed of Cross Shaft .. .. .. | 295 |
| Pulley on ,, ,, .. .. .. | 16″ |
| Pulley on Front Roller .. .. .. | 12″ |
| Speed of Front Roller .. .. .. | 391 |
| Dia. of Front Roller .. .. .. | $1\frac{1}{8}''$ |
| Dia. of second ,, .. .. .. .. | $\frac{7}{8}''$ |
| Dia. of third ,, .. .. .. .. | $1\frac{1}{8}''$ |
| ,, Back ,, .. .. .. .. | $1\frac{1}{8}''$ |
| Crown Wheel .. .. .. .. | 115 |
| Front Roller Wheel .. .. .. | 20 |
| Total Draft .. .. .. .. | 6 |
| Slivers per delivery .. .. .. | 6 |
| Length of Can .. .. .. .. | 3 feet |
| Dia. of Can .. .. .. .. | 10″ |
| No. of heads in each .. .. .. | 2 |
| No. of Deliveries per head .. .. | 5 deliveries |
| Weight on each Roller .. .. .. | 10 Lbs. |
| Length in yard delivered by Front Roller per minute .. .. .. | 38.69 |
| Production in ten hours of 1 Drawing Frame .. .. .. .. | 1874 Lbs. |
| Constant for finding Production .. | 27.64 |
| ,, ,, ,, Draft .. .. | 368 |

## DESCRIPTION OF MACHINERY.

| Description. | No. of Frames. | Date. | Maker. | Heads. | Delivery. |
|---|---|---|---|---|---|
| **Drawing Frame** | 6 | 1921 | D. & B. | 3 | 10 |

## DIMENSIONS OF THE ROOM.

*(Included in the card room)*

### HANDS EMPLOYED.

| Designation. | No. | Amount. Rs. | As. | P. | Per. | |
|---|---|---|---|---|---|---|
| Drawing Piecers .. | 18 | 0 | 2 | 9 | Hank. | |
| Spare Man .. .. | 1 | 16 | 8 | 0 | M | |
| Mochi .. .. .. | 1 | 20 | 0 | 0 | ,, | |

## ROLLER COVERING DEPARTMENT.

| Description. | Quantity No. | Lbs. | Per. | Remarks. |
|---|---|---|---|---|
| Roller Skins .. .. | 63 | | M | |
| ,, Cloth .. .. | 4½ yds. | | ,, | |
| Isinglass .. .. .. | | 1¾ | ,, | |
| Glue (common) .. .. | | 3 | ,, | |
| Soda ash .. .. .. | | ½ | ,, | |
| Alkali .. .. .. | | ½ | ,, | |
| Acid Acetic .. .. .. | | 1 | ,, | |
| Flannel Sizing .. .. | 4 yds. | | ,, | |
| Sand-paper .. .. .. | 1 ,, | | ,, | |
| Linseed oil (unboiled) .. | | ¼ | ,, | |

# CHAPTER XVIII.

## SLUBBING, INTERMEDIATE AND ROVING FRAMES.

In passing through the slubbing frames the sliver from the finisher drawing is not doubled, but doubling is resorted to in all succeeding fly frames so as to ensure the production of an even roving by arranging the irregularities of several slivers. At all frames after the slubbing frame, doubling is carried out to the extent of feeding 2 ends to each spindle for incorporation into 1 end, thus assisting to procure uniformity in the final product. For coarse counts it is usual to see two kinds of machines, *viz.*, slubber and roving frame. For the fine counts the machinery consist of Slubber, Inter, and Roving frame.

For very fine counts the machinery consist of Slubber, Inter, Roving frame and fine Jack frame.

At each stage a slight twist is imparted to the sliver. It is necessary to twist the strand as it is delivered from the front rollers of each fly frame, since by its gradual attenuation, the number of fibres in the cross-section of the sliver is correspondingly reduced and the strand becomes weaker, hence it must be twisted to enable it to hold together during the following process. The twisting is effected by securely holding the strand of cotton at two points, *viz*,. at the nip of the front drawing rollers and at the bobbin on which the material is wound, the sliver passing from one point to the other through the flyer which by revolving rapidly imparts the necessary twist.

The slubbing, intermediate and roving frames are sometimes called the speed or fly frames.

In starting a series of fly frames one of the first points to be considered is the arrangement of the drafts in the series. To produce from the drawing frame sliver or roving of the desired fineness and it is essential for the draft in each succeeding fly frame to be slightly greater than in the preceding one. It is not always possible, however, to arrange a series of fly frames so as to give the best theoretical drafts, since one process must keep up with another, and it is customary for those in charge to change the drafts until the production of one nicely balances that of the other; that is, if the slubbers are making two many bobbins for the intermediate, the draft of the slubber is increased so as to make a fine hank, and the draft in the intermediate decreased because finer hank is fed at the back, thus making the same hank at the front as in the former case, but using a greater length of slubbing at the back.

In mills producing *fine hank roving*, more variation in the drafts will be experienced, because the conditions in these mills vary more than in mills where coarse and medium spinning is carried on.

In making any change of hank it should be clearly understood that changing to finer hank roving means reduced production, not only on account of the reduced weight per yard of the roving, but also because the speed of the front roller must be reduced in order to obtain the extra twist that is required for the finer hank. In such a case an increase in the spindle speed by reducing the size of the pulley should not be resorted to because it will not work well and hence the production will be reduced unless there is room for it. The amount of twist inserted in the slubbing, intermediate, or roving affects not only the production of that frame, but also the process that follows. If too little or too much twist is inserted in any one process, the effects at the successive processes may be serious, so that great care and experience are necessary in estimating the amount of twist to be inserted.

The amount of twist in the roving depends on the relation between the speed of the spindles and the speed of the front rollers, and it may be increased either by increasing the speed of the spindle or by decreasing the speed of the front rollers. Any great increase in the speed of the frame will cause the cotton to work badly. Whenever it is desired to insert more twist in the roving it is the usual practice to decrease the speed to the front rollers by putting on a smaller twist wheel. If less twist is required, the opposite procedure is followed. No more twist than it is absolutely necessary should be placed in the roving at any frame, to allow the roving to be wound on the bobbin and to the drawn off well at the next process without stretching or breaking. Any increase in twist above what is necessary not only decrease the production but also affects the spun yarn adversely, while the cost of manufacture is increased also. It is still worse if the roving is under twisted, as it will result in the production of faulty yarn, and such procedure will prove very expensive because of the troubles subsequently involved.

In case of a poor mixing or a low grade of cotton, an extra tooth or two in the twist wheel will make a great deal of improvement in the final yarn, especially if it is twist yarn. Also it will be necessary to increase the twist slightly should it be found not spinning well owing to soft rovings, to minimise the breakages.

The coarser the roving, the smaller will be the amount of twist required. Thus a 3-hank roving would require less twist, to give it the necessary cohesion and strength, than would a 4-hank roving made from the same cotton. Short-stapled cotton requires more twist than long-stapled. The higher the grade of cotton used, the less will be the twist necessary.

The heavier the bobbin, the greater will be the amount of twist required in the roving, in order that it may be strong enough to pull the bobbin round when unwinding during the next process. If the skewers or pegs are badly worn, especially at the bottom, or if the pots or footsteps are rough, the bobbin will offer more resistance to being turned round, hence more twist must be placed in the roving, to prevent if from stretching or breaking. The holes in the rails in which the skewer tops rest should be smooth and should be kept free from any accumulation of waste. It is best to build bobbins hard and firm.

In order to obtain a well-built bobbin, the coil in the first layer should be laid so that the wood of the bobbin can barely be seen between them. Should the first experimental bobbin show the coils either closer or farther apart than this, the lifter wheel should be changed accordingly.

In the fly frames there are three main factors to deal with, namely, drawing rollers, the spindles, and the bobbins. The two former revolves at a constant speed , and the latter at a constantly varying one, that is, with a bobbin lead arrangement it commences at its maxinum rate which is slightly diminished every time a layer of rove is deposited upon it until the bobbin is filled when its rate of revolution is very nearly reduced to that of the spindle.

It is very important that flyers should be smooth inside and outside at all points where cotton passes, and should fit well on the tops of the spindles so as to obviate the necessity of hammering them down and thus making them rough on the top. When the presser on the flyer leg works stiffly and does not exert sufficient pressure on the bobbin, it causes a spongy bobbin, and probably the roving will break repeatedly when being unwound at the next process, thus causing annoyance and bad spinning at the final operation.

The breakage of ends between the front rollers and the bobbins results from the following causes :—(1) Breakage or slipping of twist wheel or other roller wheels, (2) wheels set too deeply in gear or odd teeth broken out, (3) slipping of top cone wheel, (4) loose cone drums, (5) broken cone belt, (6) drawing rollers loose at the joints, (7) loose spindles shaft or bobbin shaft couplings, (8) loose or broken drawing wheels at the head of the bobbin or spindle shafts, (9) loose or broken bobbin, bobbin shaft, spindle or spindle shaft wheels, (10) or any obstruction preventing the proper traverse of the bobbin rail.

Breaking down of individual ends may be caused by (1) bad piecings when creeling, (2) by allowing one of the two ends at the back to run out, (3) by excessive drafts in rollers,, (4) by bad condition of the roller leather on the top rollers, (5) by cutting of the material in any of the previous processes, (6) by rough surfaces with which the slubbing, intermediate or roving comes in contact, and by the formation of laps on the back and middle rollers.

Thin places in spun yarn are due to (*i*) cut slubbing, intermediate or roving which may be caused (*ii*) by bad piecings in the leather covers on the rollers, (*iii*) a broken tooth in the draft wheel or other gearing. (*iv*) loose socket and spigot connections of the rollers, (*v*) accumulation of dirt on some of the roller wheels, (*vi*) bad setting of the rollers or overdrafting. If thin places appear at regular intervals in the roving, they are almost certain to be the result of cutting by the rollers.

Excess of twist in the roving would prevent any further drawing in the subsequent machines.

The building motion is sometimes called the 'Box of Tricks.'. It has two-fold functions. It regulates the movement of the belt on the cones and also shortens the traverse, so that a double conical bobbin is built.

Should it be required to change the roving from one hank to another or portion of a hank, change all the wheels in proportion to he change made. The wrapping at these machines should be as accurate as practicable to get the right draft wheel and do not allow a few grains over or under. If the wrapping does not come satisfactorily at the slubber, there must be something wrong at the drawing frame which should be set right at once.

The general rule in changing to finer counts is :—

Smaller change pinion.
Smaller twist wheel.
Smaller lifter wheel.
Larger rack wheel.

The best maximum drafts for these frames are as follows :—

| | |
|---|---|
| Slubbing .. | 4 to 4.25 |
| Intermediate .. .. .. | 4.5 to 4.75 |
| Roving .. .. .. .. | 5 to 5.50 |

It must be noted that the amount of draft can be increased according to the quality of cotton. A good quality of cotton will stand more draft than inferior cotton. The first and second rollers should be set from centre to centre, one eight of an inch further apart than the length of the staple of cotton used. There is no hard and fast rule for putting the amount of twists in the roving, because the different qualities of cotton require different amount of twist. The usual rules for determining the amount of twist per inch for these processes are :—

Slubbing turns per inch = Square root of hank $\times 1.2$
Intermediate turns per inch = Square root of hank $\times 1.5$
Roving turns per inch = Square root of hank $\times 1.7$.

When changing the whole of the preparation from one hank to another in all the frames—slubber, intermediate and rover—care must be exercised. In the slubbing frame as many cans should be empty as possible at the particular doffing time when the change is to be made, so that the piecing up of 'bits' is reduced. In cases when these bits pieced up and made into full cans cannot be used up on other frames, due to difference in hank or quality, the best method is to split up the full cans, so that the maximum number of spindles can be actually producing.

In the intermediate and roving frames the bobbins in the creel should be as small as possible when breaking–out takes place at doffing time, although in the case of ring spinning mills, the roving frames may be doffed, with the rovings half full without detriment due to the method of creeling in the spinning–room.

Most carders prefer to have full and half bobbins in the creel alternate, and this certainly gives the best results; the end from a full bobbin should, however, pass along with the end from a half bobbin, and two top rows, that is the back top row and the front row, which is creeled from the front of the frame, should feed the back line of spindles.

Very often the roller settings require readjusting when a change of this description is made, so that whilst the new hank of creel bobbins is being put in the creel the rollers should be set, the following being a satisfactory method :—

The draft wheel, or pinion, should be put out of gear, and the broad carrier driving from the back to middle roller taken out of gear. The top rollers should be unweighted, and the rollers put upon the lifter, which should be wiped down previously; an assistant can then slacken the set screws, which hold the bottom roller slides, and since one of these screws holds both back and middle roller slides, both these lines must be set together.

The size or thickness of gauges to be used may be determined by subtracting the sum of half the diameters of the two rollers from the distance from nip to nip the rollers are to be set to, this latter depending on the length of the staple, whether self or dead–weighted rollers, and if the latter the weight applied, the hank of material and its character so far as regards harshness and twist inserted, etc. The type of gauge to be used varies; it may be a solid piece of metal with a short spindle passed through to hold it in position between the fluted portions of the rollers, or a four–winged gauge, in which each of the wings is $\frac{1}{32}$ in. thicker than the preceding one, thus combining four gauges or thicknesses in one, and at the same time being self—supporting, or a sheaf of gauges $\frac{1}{32}$ in. thick the same shape as the first–mentioned type. Commencing at the gearing end, the gauges should be inserted and the rollers adjusted so that one can just feel the gauges held slightly, and the screw for the slides tightened. Afterwards the third stand should be set and then the fifth, and so on, commencing again at the gearing end with second following to the fourth and so on. The end supports for the middle and back rollers should be made secure and the broad carrier put into gear. The cap nebs will follow, and it is helpful if these are slackened previous to setting. The gauge generally used is an angle gauge fitted with studs which are a tolerably good fit into the nebs. The off-end nebs may be set to the required distances with a steel rule, the front nebs being slightly in advance of the bottom roller, so that the tendency of the front top rollers to roll backwards when the frame is stopped is avoided. Afterwards the gauge may be set to these nebs, and the whole of the nebs on the frame set. These completed, the ends of roving can be drawn over the bottom rollers and the top rollers put in and weighted up and the frame started. Each frame should be stopped when a sufficient length has been put upon the bobbins for wrapping or testing in order to ensure that the correct hank is being made. With regard to the wheels to be used for twist and those concerned in the building of the bobbin—i.e., rack and lifter wheels—only previous experience of the cotton to be used or a trial on a particular frame can determine them. Generally, however, lower class cottons require a higher twist co-efficient, and wide differences exist in these, as given by various authorities. To give the same co-efficient for all the frames is certainly wrong, just in the same way as giving one for American cotton. What is sufficient twist for low American is too much for good American, the same reasoning applying to other growths of cottons. The safe minimum twist, however, should be inserted in a mill having 40 roving frames with a 40-twist wheel on, to insert another tooth of twist when unnecessary is to reduce the production one-fortieth equal to the stoppage of one frame.

The differences in the characteristics of the cotton affect the lifter and rack wheels to a limited extent, the property of some cottons to lie closer or be less oozy causes these types to require smaller lifter wheels and larger rack wheels, and no rule can be given for calculating these wheels under such circumstances. The responsible person or carder in charge must decide these.

## The Maintenance of Speed Frames, Etc.

The speed frame flyers must be perfectly balanced, and it is desirable to wipe them down at half bobbin and at doffing time. The number of times the rove is wrapped round the presser bears an important part in determining the hardness of the bobbin. It is usual to wrap the rove twice round the presser on the slubber, three times on intermediates, rovers and jack frames. Clearers should be kept clean, both flat and round underclearers, the frequency of cleaning depending on the class of work, say, once every 2 hours. It is good practice to allow four new rollers per week on the frames, but if more are necessary, and no defect is ascertainable, then more may be allowed. It is necessary to scour the stud rollers once every twelve months, placing the rollers on special stands on the roller beam. Care should be taken that the rollers are not strained, in replacing the rollers the settings may be tried and any worn brasses attended to. At the same time all the gearing may be gone over and the differential motion taken out and thoroughly cleaned. Also many practical men make a point of resetting the traverse motion on these occassions. One box of spindles should be cleaned each week and the bearings greased.

## RECOVERING SCHEDULE FOR LEATHER COVERED ROLLERS.

Flyer frame rollers—working 9 hours per day—recover every 16 months—the middle and back lines rather less frequently.

### PARTICULARS OF ROLLERS ETC.

| Description. | Slubbing. | Inter. | Roving. | Remarks. |
|---|---|---|---|---|
| Dia. of Front Roller | $1\frac{1}{8}''$ | $1\frac{1}{8}''$ | $1\frac{1}{8}''$ | |
| ,, Middle ,, | $1''$ | $\frac{7}{8}''$ | $\frac{7}{8}''$ | |
| ,, Back ,, | $1\frac{1}{8}''$ | $1\frac{1}{8}''$ | $1\frac{1}{8}''$ | |
| Weight on front ,, | 18 | 16 | 18 | |
| ,, ,, middle ,, | 24 | 20 | 24 | |
| Weight on back roller | Saddle & Bridle | Saddle & Bridle | Saddle & Bridle | |
| Dia. of full bobbin | $5\frac{3}{4}''$ | $4\frac{3}{4}''$ | $3\frac{3}{4}''$ | |
| Lift of full bobbin | 10 | 10 | 7 | |
| Speed of spindles | 550 | 750 | 1100 | |
| Weight of full bobbin | 30 ozs. | 24 ozs. | 11 ozs. | |
| Time lost in doffing per set | 14 min. | 14 min. | 13 min. | |

Average Roller Settings for Slubbing Frames and may require varying slightly to suit individual cottons.

| Style of Cotton. | Diameters of Rollers Front to Back | | | Roller centres Front of Back. | |
|---|---|---|---|---|---|
| Inches. | | Inches. | | Inches. | |
| $\frac{3}{4}$ | 1, | $\frac{7}{8}''$ | 1 | $3\frac{31}{32}$, | $1\frac{3}{32}$ |
| $\frac{7}{8}$ | 1, | $1\frac{15}{16}$, | 1. | 1, | $1\frac{1}{8}$ |
| 1 | $1\frac{1}{8}$, | 1, | $1\frac{1}{8}$ | $1\frac{3}{32}$, | $1\frac{1}{4}$ |
| $1\frac{1}{16}$ | $1\frac{1}{4}$, | 1, | $1\frac{1}{4}$ | $1\frac{3}{16}$, | $1\frac{9}{16}$ |
| $1\frac{1}{8}$ | $1\frac{1}{4}$, | 1, | $1\frac{1}{4}$ | $1\frac{7}{32}$, | $1\frac{9}{16}$ |
| $1\frac{3}{16}$ | $1\frac{1}{4}$, | 1, | $1\frac{1}{4}$ | $1\frac{1}{4}$ | $1\frac{5}{8}$ |
| $1\frac{1}{4}$ | $1\frac{1}{4}$, | $1\frac{1}{8}$, | $1\frac{1}{4}$ | $1\frac{5}{16}$ | $1\frac{11}{16}$ |
| $1\frac{3}{8}$ | $1\frac{3}{8}$ | $1\frac{1}{8}$, | $1\frac{3}{8}$ | $1\frac{7}{16}$ | $1\frac{13}{16}$ |
| $1\frac{1}{2}$ | $1\frac{3}{8}$, | $1\frac{1}{4}$, | $1\frac{3}{8}$ | $1\frac{5}{8}$ | $1\frac{7}{8}$ |
| $1\frac{3}{4}$ | $1\frac{1}{2}$, | $1\frac{1}{4}$, | $1\frac{1}{2}$ | 2, | 2 |

## SLUBBING FRAME.

*Multiples for Twist or Turns per inch, etc.*

| Spg. Counts. | Hank. | Draft. | Weight of Sliver 15 Yards. | | Turns per inch. | Twist Constant. | Sq. Root. Root | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | D. | G. | | | | |
| 6's—8's | .45 | 3.7 | 11 | 13.7 | .87 | 1.3 | 0.671 | |
| 10's—14's | .50 | 4.00 | 10 | 10 | .91 | 1.3 | 0.707 | |
| 16's—22's | .56 | 4.00 | 9 | 7.2 | .96 | 1.3 | 0.748 | |
| 24's—32's | .70 | 4.10 | 7 | 10.6 | 1.08 | 1.3 | 0.837 | |
| 34's—50's | .80 | 4.20 | 6 | 12.2 | 1.03 | 1.15 | 0.894 | |
| 52's—60's | 1.00 | 4.30 | 5 | 5 | 1.15 | 1.15 | 1.0 | |
| 62's—75's | 1.20 | 4.80 | 3 | 18 | .99 | 0.90 | 1.095 | |
| 76's–100's | 1.50 | 5.00 | 3 | 3 | 1.10 | 0.90 | 1.224 | |

**Draft constant** = 189
**Constant÷draft** =change pinion and *vice versa.*
**Twist const.** = 42.91
**Constant÷twist wheel**=turns per inch and *vice versa.*

## INDIAN COTTON.

*Twist Constant.*

Square root of hank ×1.3 and 1.5=turns per inch.
1.3 for Surat Cotton.
1.5 for Bengal Cotton.

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## AMERICAN COTTON.

Square root of hank × 1.15 = turns per inch.
" " " × 1.00 " " "

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## EGYPTIAN COTTON.

Square root of hank × .67 = turns per inch.
" " " × .90 = " " "

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## PARTICULARS OF SLUBBING FRAME (D. & B.)

| | | |
|---|---|---|
| Speed of line shaft | | 220 |
| Drum on line shaft | | 24 |
| Jack shaft wheel | | 56 |
| Jack shaft speed | | 377 |
| Frame shaft pulley | | 14 |
| Top Cone Drum wheel | | 24 |
| Off end cone drum wheel | | 43 |
| Large front roller wheel | | 115 |
| Crown wheel | | 90 |
| Small front roller wheel | | 20 |
| Spindle shaft wheel | | 58 |
| Bobbin shaft wheel | | 56 |
| Spindle wheel | | 26 |
| Bobbin wheel | | 50 |
| Speed of spindles | | 700 |
| Bottom cone drum wheel | | 21 |
| Lifter wheel | for 50's | 21 |

| | |
|---|---|
| Skew gear wheel .. .. .. .. .. .. .. | 50 |
| Diameter of front roller .. .. .. .. .. .. | $1\frac{1}{8}''$ |
| Diameter of Middle roller .. .. .. .. .. | 1″ |
| Diameter of Back roller .. .. .. .. .. | $1\frac{1}{8}''$ |
| Lift of Bobbin .. .. .. .. .. .. .. | 10″ |
| Revolutions of spindle for one of driving pulley on frame .. | 1.85 |
| Diameter of Bobbin when full .. .. .. .. .. | $7\frac{1}{2}''$ |
| Thread per boss .. .. .. .. .. .. .. | 1 |
| Lines of weights .. .. .. .. .. .. .. | 2 |
| Space of spindles .. .. .. .. .. .. .. | 10″ |
| Diameter of spindle .. .. .. .. .. .. | $\frac{3}{4}''$ |
| Diameter of barrel of bobbin .. .. .. .. .. | $1\frac{1}{2}''$ |
| Weights .. .. .. .. .. .. .. Front 18B | =24 |
| (Bobbin to lead) | |

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## SLUBBING MACHINERY.

| Description. | No. | Date. | Maker. | No. of Spindles. | Remarks. |
|---|---|---|---|---|---|
| Slubbing Frame | 6 | 1921 | D. & B. | 106 each | Overhauled one at a time weekly. |

## HANDS EMPLOYED.

| Designation | No. | Amount | | | Per | Remarks. |
|---|---|---|---|---|---|---|
| | | Rs. | As. | Ps. | | |
| Piecers | 6 | Piece | work | | | 8 Annas per Hank. |
| Spare ,, | 1 | 16 | 8 | 0 | M | |

## FLY-FRAMES.

The production in hanks on the FLY-FRAMES should be totalled and recorded daily. Every month, these productions should be worked out in pound, according to the hank roving being made in order to find out any discrepancies in this direction. It must be taken into account that fluctuations are likely to occur between the productions of the ring frame and the calculated production of the fly frames because the stock of bobbins itself is constantly fluctuating, but say in three months, the productions should agree. For checking purposes the best thing to do is to take actual monthly stock so that any substantial difference in production of ring frames and fly frames may be traced.

Roving frame must also be tested regularly, particularly the Rovers and Jacks—whichever of these machines precedes the ring frame. It is very essential in mills that consume their own yarn in the loom. A constant check on variations of counts of yarn must strictly be kept. If irregularities be allowed to go on for a length of time then they are bound to show up in the cloth, and thus, there will be a difference in the feel, texture of the cloth etc. If the yarn is allowed to run coarse by one or more counts due to lack of strict supervision, then the cloth is bound to weigh heavier than its normal weight, and thus the manufacturer will be giving away extra weight of yarn gratis. This discrepency, if not checked in time then it is bound to result in very series losses.

### Causes of Bad Work.

Bad work may be traced to the following causes, viz: (*a*) Faults in the mechanism are to be seen in broken teeth, too much back-lash in gearing, loosened brackets, and slippage of wheels on their shafts, (*b*) Faulty setting of rollers, improper speeds, etc., give rise to a lot of hard work which at first is not essily traceable to the real cause. 'Draft and Twist' are very important points which require attention in getting the best results from the cotton and the machine, (*c*) Long piecing are a distinct evil. Roller laps increase or decrease the draft and so alter the hank slightly. Slippage of the cone drum strap occurs through slackness or allowing oil to run on it. Slippage of the bobbins and also the momentary slippage of the flyer occur when it has not dropped into its slot before the machine is started.

Carelessness in previous operations naturally passes the evil to all future processes.

## Causes of Single and Double.

(1) Piecing full bobbins to the wrong end when creeling. (2) Bobbins running empty quicker than the tenter can replace with full bobbins. (3) An end broken at the front rollers and carried by the air current so that it is attached to an adjacent end passing through another flyer. (4) The tenter carelessly allowing the ends to overlap for inches, and even feet, when creeling. (5) A defective top roller or a rough place on one of the bottom rollers, causing lapping. (6) Single or double in drawing-frame sliver, slubbing or intermediate. (7) Insufficient twist in the slubbing or intermediate. (8) All single or double which may have been wound on the bobbin at the front of the frame should be removed by the tenter, who must be punished very severely in failing to do so.

## Cut Roving.

This fault indicates that the roving has a thin place at intervals. The causes are :—

(i) Rollers set too close ;
(ii) Bottom roller strained ;
(iii) Roller gearing in a dirty condition or meshed too deeply.

## Effect of Twist in Roving.

It is very essential to insert just sufficient twist to enable the slubbing, intermediate or roving to be wound on the bobbin without either stretching or breaking, and also permit the material to be unwound at the next process without either of the faults mentioned taking place.

## Influence of Dimension of Bobbins on Twist.

The longer the lift the greater the amount of twist required because of the increased angle occupied by the roving from the extremities of the lift to the guide rod, especially when unwinding the few final layers.

## Effect of Hank Roving on Twist.

The finer the hank slubbing, roving, etc., from the same cotton, the more is the twist required to obtain sufficient strength.

## Effect of Insufficient Twist.

The front rollers revolve quicker by using a larger twist change wheel, but production may actually be less, owing to an excessive number of ends breaking.

Whereas an increase in the amount of twist reduces the production as the speed of the front rollers is reduced; if insufficient twist was previously inserted, however, the production would very probably actually increase by inserting a little more twist, as there would be fewer breakages and stoppages.

In case of excessive twist the roving will be more difficult to draft at the next process, and may necessitate the rollers being set wider.

It is better, however, to err on the side of a trifle too much twist than on too little twist.

## Ends Breaking Down.

(1) Couplings of spindle and bobbin shafts worked loose. (2) Drawing rollers and traverse guide badly set. (3) Driving wheels at the end of bobbins and spindle horizontal shafts worked loose, or teeth broken out. (4) Cone drum loose. (5) Insufficient twist. (6) Roving wrapped too often or not often enough.

## Slack Ends.

(1) Ratchet wheel too small, (2) coils too widely spaced, (3) bobbin rails racks binding in the slides, (4) spindle collars short of oil or clogged with waste and dirt. (5) the collars not correctly adjusted, (6) roving wrapped too often round the presser arm.

## Defective Winding.

The chief essential in winding is to be as easy as possible consistent with keeping ends up as far as practicable. Defective winding, is caused by wrong star wheel, irregular diameter of bobbins, varying reaction to cone drums strap caused by collars binding spindles, racks and lifter slides binding particularly at ends of lift, inferior drum straps.

Tight winding on first row leads to breakages in subsequent unwinding. It is essential that standard wheels be employed, a·

tooth less on lay wheel or larger on wheel at end of bottom cone drum although correcting first layer would give tighter winding afterwards.

## Oiling and Cleaning.

All bearings must be oiled once a day, and the bearings of quickly running shafts twice. The spindle collars are to be oiled twice weekly and the spindle footsteps if provided with oil reservoir once a month. The spindle collars must be thoroughly cleaned inside every nine months. The chains and chain-bowls for the balance weights as also the rail slides must be oiled and greased once a week. It is exceedingly important that the bobbin and spindle shaft steps be constantly provided with grease and in addition to this they be oiled once a day.

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

The differential motion should be oiled every two days. On fly frames with electric stop motion do not omit to oil the steps and necks of the stop motion rollers every day. This may be easily overlooked, as they are in the creel. Also see that the bowls on weight levers (if applied) are well oiled once a week.

The whole of the gearing must be oiled or greased from time to time.

The fly frame should be cleaned through every three to six months according to need. On this occasion the drawing rollers should be taken out and the flutes of same thoroughly cleaned, the roller steps should also be freshly greased.

If the middle and back top rollers are weighted by weights, the necks should be treated every two days with a mixture of oil and fat applied with a brush. The necks of the top rollers, if self-weighted must neither be oiled nor greased, at the most they may only be treated with black-lead, mixed with water to the consistency of a paste, and applied with a brush. The centres of the front top rollers must be oiled once a week, and care must be taken that too much oil is not applied, and that it does not get on the leather covering of the rollers.

The top roller leathers must be periodically examined, and either recovered or ground up again. The front top rollers must be revarnished once a week. Also, the traverse motions must be kept in good condition, as this ensures a considerable economy in leather. Care must be taken that the middle and back self-weighted top rollers do not vibrate, i.e., move backwards and forwards on the fluted bottom rollers, as this would cause cut and uneven yarn. This vibration can be avoided by setting the top rollers back on the fiuted rollers. On doffing each set the fly should be wiped off the roller beam, the roller stands, iron flats, creel and spindle and bobbin wheel casing plates. The slots at top of spindles must be cleaned once a month.

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

All rollers must be cleaned once a week. The fly must be taken off the top cleaners, if stationary, five times a day, and off the under-cleaners once a day.

The flyers should be wiped twice during each set, viz., once when bobbin is half full and once when the bobbin is full.

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 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; cotton wound round the skewer end; choked traverse guides; top support of skewer end chocked. etc., etc.

*The Principal Parts Requiring Lubrication.*

| | |
|---|---|
| Loose Boss Top Rollers .. .. .. .. | Hand oiled. |
| Fast ,, ,, .. .. .. .. .. | ,, ,, |
| Bobbin Wheels .. .. .. .. .. | ,, ,, |
| Spindles .. .. .. .. .. .. | ,, ,, |
| Differential Motion (oil chamber) .. .. | ,, ,, |
| Spindles Foot Steps ,, ,, .. .. .. | ,, ,, |
| Loose Driving Pulleys .. .. .. .. | ,, ,, |
| All Shaft Bearings .. .... .. .. | ,, ,, |
| Bobbin and Spindle Shaft Bearings .. .. | Grease cup. |
| Off End Top Cone Socket .. .. .. | ,, ,, |
| Bottom Steel Rollers .. .. .. .. | Greased Bearings. |

## CIRCUMFERENCE OF ROLLERS.

| | | | |
|---|---|---|---|
| $\frac{7}{8}$ in. dia. | =2.7489 cir. | $1\frac{1}{8}$ in. dia. | =3.5343 cir. |
| $\frac{15}{16}$ ,, ,, | =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 ,, |

## INTERMEDIATE FRAMES.

*Multiples for Twist or Turns per Inch, etc.*

| Spg. Counts. | Hank. | Draft. | Weight of Sliver 15 Yards. | | Turns per inch. | Twist Constant. | Sq. Root. | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | D. | C. | | | | |
| 6's—8's | .88 | 4 | 5 | 22 | 1.10 | 1.2 | 0.938 | |
| 10's—14's | 1.00 | 4 | 5 | 5 | 1.20 | 1.2 | 1.0 | |
| 16's—22's | 1.20 | 4.20 | 3 | 18 | 1.31 | 1.2 | 1.095 | |
| 24's—32's | 1.80 | 5 | 2 | 18 | 1.61 | 1.2 | 1.342 | |
| 34's—50's | 2.00 | 5 | 2 | 14.5 | 1.62 | 1.15 | 1.414 | |
| 32's—60's | 2.50 | 5 | 2 | 2 | 1.81 | 1.15 | 1.581 | |
| 62's—75's | 3.00 | 5.40 | 1 | 17 | 1.65 | .95 | 1.732 | |
| 76's-100's | 4.00 | 5.00 | 1 | 7 | 1.90 | .95 | 2.0 | |

Draft constant =184.5
Draft constant ÷ Draft =change pinion and *vice versa.*
Twist constant =51.78
,, ,, ÷ turns per inch = twist wheel.

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## INDIAN COTTON.

*Twist constant.*

**Square root of Hank × 1.2 = turns per inch.**
**1.2 and 1.4 for Surat cotton.**
**1.8 for Bengal cotton.**

## AMERICAN COTTON

Square root of Hank × 1.15 = turns per inch.

## EGYPTIAN COTTON.

Square root of Hank × 0.80 = turns per inch.
" " " × 0.95 = turns per inch.

## ROVING FRAME.

*Multiples for Twist or Turns per Inch, etc.*

| Spg. Counts. | Hank. | Draft. | Weight of Sliver 30 Yards. D. | G. | Turns per inch. | Twist Con-stant. | Sq. Root. | Remarks |
|---|---|---|---|---|---|---|---|---|
| 6's—8's | 1.75 | 4 | 5 | 22.8 | 1.98 | 1.5 | 1.323 | |
| 10's—14's | 2.50 | 5 | 4 | 4 | 2.37 | 1.5 | 1.581 | |
| 16's—22's | 3.00 | 5 | 3 | 11.3 | 2.59 | 1.5 | 1.732 | |
| 24's—32's | 4.75 | 5.20 | 2 | 5.2 | 3.27 | 1.5 | 2.18 | |
| 34's—40's | 5.50 | 5.5 | 1 | 21.4 | 3.27 | 1.23 | 2.345 | |
| 42's—60's | 7.50 | 6.0 | 1 | 20.40 | 3.36 | 1.25 | 2.738 | |
| 62's—75's | 9.00 | 6.00 | 1 | 3 | 3.45 | 1.15 | 3.00 | |
| 76's-100's | 12.00 | 6.0 | 1 | 3.77 | 3.97 | 1.15 | 3.464 | |

Draft constant =238
Draft constant ÷Draft=change pinion and *vice versa.*
Twist constant =99.59
" " ÷Turns per Inch=twist wheel.

## INDIAN COTTON

*Twist Constant.*

Square root of Hank × 1.5 = turns per inch.
1.5 for Surat cotton.
2.0 for Bengal cotton.

## AMERICAN COTTON.

Square root of Hank × 1.09 = turns per inch.
" " " × 1.25 = " " "

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## EGYPTIAN COTTON.

Square root of Hank × .94 = turns per inch.
" " " " × 1.15 = turns per inch.

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## PARTICULARS OF INTERMEDIATE FRAME (D. & B.)

| | | |
|---|---|---|
| Speed of line shaft | | 220 |
| Drum on line shaft | | 24 |
| Pulley on frame | | 14½ |
| Speed of Jack shaft | | 364 |
| Top Cone Drum wheel | | 35 |
| Off end cone drum wheel | | 43 |
| Large front roller wheel | | 115 |
| Crown wheel | | 90 |
| Small front roller wheel | | 20 |
| Spindle shaft wheel | | 54 |
| Bobbin shaft wheel | | 50 |
| Spindle wheel | | 26 |
| Bobbin wheel | | 50 |
| Skew gear wheel | | 50 |
| Bottom cone drum wheel | | 21 |
| Lifter wheel | for 50's | 18 |
| Speed of spindle | | 726 |
| Wheel on Jack shaft | | 56 |
| Diameter of front roller | | 1⅛″ |
| Diameter of middle roller | | 1″ |
| Diameter of back roller | | 1⅛″ |
| Lift of Bobbin | | 10 |
| Revolutions of spindles for one of Driving Pulley on frame | | 2 |
| Diameter of bobbin when full | | 5 |
| Thread per boss | | 2 |
| Lines per weight | | 2 |
| Space of spindles | | 6″ |
| Diameter of spindle | | ¾″ |
| Diameter of barrel of bobbin | | 1½″ |
| Weights (Bobbin to lead) | Front 16 | B = 20 |

## PARTICULARS OF ROVING FRAME (D. & B.)

| | | |
|---|---|---|
| Speed of line shaft | | 250 |
| Drum on line shaft | | 24 |
| Pulley on Frame | | 12 |
| Speed of Jack shaft | | 500 |
| Top cone drum wheel | | 40 |
| Off end cone drum wheel | | 37 |
| Large front roller wheel | | 130 |
| Crown wheel | | 90 |
| Small front roller wheel | | 20 |
| Spindle shaft wheel | | 50 |
| Spindle shaft Driver | | 56 |
| Bobbin shaft wheel | | 50 |
| Spindle wheel | | 22 |
| Bobbin wheel | | 50 |
| Skew gear wheel | | 50 |
| Bobbin cone drum wheel | | 15 |
| Lifter wheel | for 50's | 16 |
| Speed of spindle | | 1272 |
| Diameter of front roller | | 1″ |
| Diameter of middle roller | | $\frac{7}{8}$″ |
| Diameter of back roller | | 1″ |
| Lift of bobbin | | 7″ |
| Revolutions of spindle for one of driving pulley on frame | | 2.54 |
| No. of spindles | | 168 |
| Diameter of bobbin when full | | $3\frac{3}{8}$″ |
| Diameter of barrel of bobbin | | $1\frac{1}{4}$″ |
| Line of weights | | 2 |
| Space of spindles | | $4\frac{1}{2}$″ |
| Diameter of spindles | | $\frac{5}{8}$″ |
| Weights | Front 18 | B = 24 |
| (Bobbin to lead) | | |

## INTERMEDIATE FRAME.

| Description. | No. | Date. | Maker. | No. of Spindles. | Remarks. |
|---|---|---|---|---|---|
| Intermediate Frame | 13 | 1921 | D.&B. | 132 each. | Overhauled one at a time weekly |

## ROVING FRAME.

| Description. | No. | Date. | Maker. | No. of Spindles. | Remarks. |
|---|---|---|---|---|---|
| Roving Frames. | 39 | 1921 | D.&B. | 168 each. | Overhauled one at a time daily. |

## HANDS EMPLOYED.

*Intermediate Department.*

| Designation | No. | Amount. Rs. | as. | p. | Per | Remarks. |
|---|---|---|---|---|---|---|
| Piecers | 13 | Piece work | | | | 3 Annas per Hank. |
| Spare men | 2 | 16 | 8 | 0 | M. | |
| Doffers | 8 | 12 | 0 | 0 | M. | Each (also doff the slubbers). |
| Sweepers | 3 | 11 | 0 | 0 | M. | ,, |
| Bobbin carrier | 2 | 18 | 0 | 0 | M. | ,, |

## HANDS EMPLOYED.

*Roving Department.*

| Designation. | No. | Amount. Rs. | as. | p. | Per. | Remarks. |
|---|---|---|---|---|---|---|
| Piecers | 39 | Piece work | | | | 3 Annas per Hank. |
| Doffers | 18 | 12 | 0 | 0 | M. | Each |
| Sweepers | 8 | 11 | 0 | 0 | M. | ,, |
| Bobbin carrier | 6 | 18 | 0 | 0 | M. | ,, |

## STORE CONSUMPTION.

(See under Blow room).

*Dimensions of Roving Room.*

| Size of Room. | | | Door. | | Windows. | | |
|---|---|---|---|---|---|---|---|
| L. | B. | H. | No. | Size. | No. | Size. | Remarks. |
| 166′ | 94′ | 11′—6′ | 1<br>2<br>1 | 3′ ×7′-6″<br>3′ ×7′-0″<br>8′ ×8′ | 16<br>2 | 8′ ×6″<br>6′ ×4′ | |

## SLUBBING TO ROVING TABLE.

| 15 Yards. | | | 15 Yards. | | | 20 Yards. | | |
|---|---|---|---|---|---|---|---|---|
| Decl.of Hank. | Dwts. | Grains. | Decl.of Hank. | Dwts. | Grains. | Decl.of Hank. | Dwts. | Grains. |
| .40 | 13 | 0.5 | .70 | 7 | 10.6 | .50 | 13 | 21.2 |
| .41 | 12 | 16.9 | .71 | 7 | 8.1 | .51 | 13 | 14.8 |
| .42 | 12 | 9.7 | .72 | 7 | 5.6 | .52 | 13 | 8.4 |
| .43 | 12 | 2.6 | .73 | 7 | 3.2 | .53 | 13 | 2.4 |
| .44 | 11 | 20.0 | .74 | 7 | 0.9 | .54 | 12 | 20.6 |
| .45 | 11 | 13.7 | .75 | 6 | 22.7 | .55 | 12 | 15.0 |
| .46 | 11 | 7.7 | .76 | 6 | 20.5 | .56 | 12 | 9.6 |
| .47 | 11 | 1.9 | .77 | 6 | 18.3 | .57 | 12 | 4.4 |
| .48 | 10 | 20.4 | .78 | 6 | 16.2 | .58 | 11 | 23.2 |
| .49 | 10 | 15.1 | .79 | 6 | 14.2 | .59 | 11 | 18.4 |
| .50 | 10 | 10.0 | .80 | 6 | 12.2 | .60 | 11 | 13.6 |
| .51 | 10 | 5.1 | .81 | 6 | 10.3 | .62 | 11 | 4.8 |
| .52 | 10 | 0.4 | .82 | 6 | 8.4 | .64 | 10 | 20.4 |
| .53 | 9 | 19.8 | .83 | 6 | 6.6 | .66 | 10 | 12.0 |

SLUBBING TO ROVING TABLE—*continued.*

| 15 Yards. | | | 15 Yards. | | | 20 Yards. | | |
|---|---|---|---|---|---|---|---|---|
| Decl.of Hank. | Dwts. | Grains. | Decl.of Hank | Dwts. | Grains. | Decl.of Hank. | Dwts. | Grains. |
| .54 | 9 | 15.5 | .84 | 6 | 4.8 | .68 | 10 | 5.0 |
| .55 | 9 | 11.3 | .85 | 6 | 3.0 | .70 | 9 | 22.0 |
| .56 | 9 | 7.2 | .86 | 6 | 1.3 | .72 | 9 | 15.2 |
| .57 | 9 | 3.3 | .87 | 5 | 23.7 | .74 | 9 | 9.2 |
| .58 | 8 | 23.5 | .88 | 5 | 22.0 | .76 | 9 | 3.2 |
| .59 | 8 | 19.9 | .89 | 5 | 20.4 | .78 | 8 | 21.6 |
| .60 | 8 | 16.3 | .90 | 5 | 18.9 | .80 | 8 | 16.2 |
| .61 | 8 | 12.9 | .91 | 5 | 17.3 | .81 | 8 | 13.7 |
| .62 | 8 | 9.6 | .92 | 5 | 15.8 | .82 | 8 | 11.2 |
| .63 | 8 | 6.4 | .93 | 5 | 14.4 | .83 | 8 | 8.8 |
| .64 | 8 | 3.3 | .94 | 5 | 13.0 | .84 | 8 | 6.4 |
| .65 | 8 | 0.3 | .95 | 5 | 11.6 | .85 | 8 | 4.0 |
| .66 | 7 | 21.4 | .96 | 5 | 10.2 | .86 | 8 | 1.8 |
| .67 | 7 | 18.6 | .97 | 5 | 8.9 | .87 | 7 | 23.5 |
| .68 | 7 | 15.8 | .98 | 5 | 7.5 | .88 | 7 | 21.4 |
| .69 | 7 | 13.1 | .99 | 5 | 6.3 | .89 | 7 | 19.2 |
| | | | | | | .90 | 7 | 17.2 |
| | | | | | | .91 | 7 | 15.1 |
| | | | | | | .92 | 7 | 13.2 |
| | | | | | | .93 | 7 | 11.2 |
| | | | | | | .94 | 7 | 9.2 |
| | | | | | | .95 | 7 | 7.3 |
| | | | | | | .96 | 7 | 5.6 |
| | | | | | | .97 | 7 | 3.8 |
| | | | | | | .98 | 7 | 2.0 |
| | | | | | | .99 | 7 | 0.3 |

SLUBBING TO ROVING TABLE—*continued.*

| | 20 Yards. | | 30 Yards. | | 40 Yards. | | 60 Yards. | |
|---|---|---|---|---|---|---|---|---|
| Hank. Roving | Dwts. | Grains. | Dwts. | Grains. | Dwts. | Grains. | Dwts. | Grains. |
| 1.00 | 6 | 22.6 | 10 | 10.0 | 13 | 21.3 | 22 | 14.5 |
| 1.05 | 6 | 14.7 | 9 | 22.0 | 13 | 5.4 | 21 | 14.7 |
| 1.10 | 6 | 7.5 | 9 | 11.2 | 12 | 15.0 | 20 | 17.0 |
| 1.15 | 6 | 0.9 | 9 | 1.3 | 12 | 1.8 | 18 | 2.7 |
| 1.20 | 5 | 18.8 | 8 | 16.3 | 11 | 13.7 | 17 | 8.6 |
| 1.25 | 5 | 13.3 | 8 | 8.0 | 11 | 2.6 | 16 | 16.0 |
| 1.30 | 5 | 8.2 | 8 | 0.3 | 10 | 16.4 | 16 | 0.6 |
| 1.35 | 5 | 3.4 | 7 | 17.1 | 10 | 6.9 | 15 | 10.3 |
| 1.40 | 4 | 23.0 | 7 | 10.5 | 9 | 22.0 | 14 | 21.1 |
| 1.45 | 4 | 18.9 | 7 | 4.4 | 9 | 13.8 | 14 | 8.8 |
| 1.50 | 4 | 15.1 | 6 | 22.6 | 9 | 6.2 | 13 | 21.3 |
| 1.55 | 4 | 11.5 | 6 | 17.2 | 8 | 23.0 | 13 | 10.5 |
| 1.60 | 4 | 8.1 | 6 | 12.2 | 8 | 16.3 | 13 | 0.5 |
| 1.65 | 4 | 5.1 | 6 | 7.6 | 8 | 10.2 | 12 | 15.0 |
| 1.70 | 4 | 2.0 | 6 | 3.0 | 8 | 4.0 | 12 | 6.1 |
| 1.75 | 3 | 23.9 | 5 | 22.8 | 7 | 22.4 | 11 | 21.7 |
| 1.80 | 3 | 20.6 | 5 | 18.8 | 7 | 17.1 | 11 | 13.7 |
| 1.85 | 3 | 18.0 | 5 | 15.1 | 7 | 12.1 | 11 | 6.2 |
| 1.90 | 3 | 15.7 | 5 | 11.5 | 7 | 7.4 | 10 | 23.1 |
| 1.95 | 3 | 13.4 | 5 | 8.2 | 7 | 2.9 | 10 | 16.4 |
| 2.00 | 3 | 11.3 | 5 | 5.0 | 6 | 22.6 | 10 | 10.0 |
| 2.05 | 3 | 9.3 | 5 | 1.9 | 6 | 18.6 | 10 | 3.8 |
| 2.10 | 3 | 7.3 | 4 | 23.0 | 6 | 14.7 | 9 | 22.0 |
| 2.15 | 3 | 5.5 | 4 | 20.2 | 6 | 11.0 | 9 | 16.4 |
| 2.20 | 3 | 3.7 | 4 | 17.6 | 6 | 7.5 | 9 | 11.3 |
| 2.25 | 3 | 2.0 | 4 | 15.1 | 6 | 4.1 | 9 | 6.2 |
| 2.30 | 3 | 0.4 | 4 | 12.6 | 6 | 0.9 | 9 | 1.3 |
| 2.35 | 2 | 22.9 | 4 | 10.3 | 5 | 21.8 | 8 | 10.6 |
| 2.40 | 2 | 21.4 | 4 | 8.1 | 5 | 18.8 | 8 | 16.2 |
| 2.45 | 2 | 20.0 | 4 | 6.0 | 5 | 16.0 | 8 | 12.0 |
| 2.50 | 2 | 18.6 | 4 | 4.0 | 5 | 13.3 | 8 | 8.0 |
| 2.55 | 2 | 17.3 | 4 | 2.0 | 5 | 10.7 | 8 | 4.0 |

## SLUBBING TO ROVING TABLE—*continued.*

| | 20 Yards. | | 30 Yards. | | 40 Yards. | | 60 Yards. | |
|---|---|---|---|---|---|---|---|---|
| Hank Roving | Dwts. | Grains. | Dwts. | Grains. | Dwts. | Grains. | Dwts. | Grains. |
| 2.60 | 2 | 16.1 | 4 | 0.1 | 5 | 8.2 | 8 | 0.3 |
| 2.65 | 2 | 14.9 | 3 | 22.3 | 5 | 5.7 | 7 | 20.6 |
| 2.70 | 2 | 13.7 | 3 | 20.6 | 5 | 3.4 | 7 | 17.2 |
| 2.75 | 2 | 12.6 | 3 | 18.9 | 5 | 1.2 | 7 | 13.8 |
| 2.80 | 2 | 11.5 | 3 | 17.2 | 4 | 23.0 | 7 | 10.5 |
| 2.85 | 2 | 10.4 | 3 | 15.7 | 4 | 20.9 | 7 | 7.4 |
| 2.90 | 2 | 9.4 | 3 | 14.2 | 4 | 18.9 | 7 | 4.4 |
| 2.95 | 2 | 8.5 | 3 | 12.7 | 4 | 17.0 | 7 | 1.5 |
| 3.00 | 2 | 7.5 | 3 | 11.3 | 4 | 15.1 | 6 | 22.6 |
| 3.05 | 2 | 6.6 | 3 | 9.9 | 4 | 13.2 | 6 | 19.9 |
| 3.10 | 2 | 5.7 | 3 | 8.6 | 4 | 11.5 | 6 | 16.3 |
| 3.15 | 2 | 4.9 | 3 | 7.3 | 4 | 9.8 | 6 | 14.7 |
| 3.20 | 2 | 4.0 | 3 | 6.1 | 4 | 8.1 | 6 | 12.2 |
| 3.25 | 2 | 3.2 | 3 | 4.9 | 4 | 6.5 | 6 | 9.8 |
| 3.30 | 2 | 2.5 | 5 | 3.7 | 4 | 5.0 | 6 | 7.5 |
| 3.35 | 2 | 1.7 | 3 | 2.6 | 4 | 3.5 | 6 | 5.2 |
| 3.40 | 2 | 1.0 | 3 | 1.5 | 4 | 2.0 | 6 | 3.0 |
| 3.45 | 2 | .03 | 3 | 0.4 | 4 | 0.6 | 6 | 0.9 |
| 3.50 | 1 | 23.6 | 2 | 23.4 | 3 | 22.2 | 5 | 22.8 |
| 3.55 | 1 | 22.9 | 2 | 22.4 | 3 | 21.9 | 5 | 20.8 |
| 3.60 | 1 | 22.3 | 2 | 21.4 | 3 | 20.6 | 5 | 18.8 |
| 3.65 | 1 | 21.6 | 2 | 20.5 | 3 | 19.3 | 5 | 16.9 |
| 3.70 | 1 | 21.0 | 2 | 19.5 | 3 | 18.1 | 5 | 15.1 |
| 3.75 | 1 | 20.4 | 2 | 18.6 | 3 | 16.8 | 5 | 13.3 |
| 3.80 | 1 | 19.8 | 2 | 17.7 | 3 | 15.7 | 5 | 11.5 |
| 3.85 | 1 | 19.2 | 2 | 16.9 | 3 | 14.5 | 5 | 9.9 |
| 3.90 | 1 | 18.7 | 2 | 16.1 | 3 | 13.4 | 5 | 8.2 |
| 3.95 | 1 | 18.1 | 2 | 15.3 | 3 | 12.4 | 5 | 6.6 |
| 4.00 | 1 | 17.6 | 2 | 14.5 | 3 | 11.3 | 5 | 5.0 |
| 4.10 | 1 | 16.6 | 2 | 12.9 | 3 | 9.3 | 5 | 1.9 |

## SLUBBING TO ROVING TABLE.—(*contd.*)

| | 20 Yards. | | 30 Yards. | | 40 Yards. | | 60 Yards. | |
|---|---|---|---|---|---|---|---|---|
| Hank Roving | Dwts. | Grains. | Dwts. | Grains. | Dwts. | Grains. | Dwts. | Grains. |
| 4.20 | 1 | 15.7 | 2 | 11.5 | 3 | 7.3 | 4 | 23.0 |
| 4.30 | 1 | 14.7 | 2 | 10.1 | 3 | 5.5 | 4 | 20.2 |
| 4.40 | 1 | 13.8 | 2 | 8.8 | 3 | 3.7 | 4 | 17.6 |
| 4.50 | 1 | 13.0 | 2 | 7.5 | 3 | 2.0 | 4 | 15.1 |
| 4.60 | 1 | 12.2 | 2 | 6.3 | 3 | 0.4 | 4 | 12.7 |
| 4.70 | 1 | 11.4 | 2 | 5.2 | 2 | 22.9 | 4 | 10.4 |
| 4.80 | 1 | 10.7 | 2 | 4.1 | 2 | 21.4 | 4 | 8.1 |
| 4.90 | 1 | 10.0 | 2 | 3.0 | 2 | 20.0 | 4 | 6.0 |
| 5.00 | 1 | 9.3 | 2 | 2.0 | 2 | 18.6 | 4 | 4.0 |
| 5.25 | 1 | 7.6 | 1 | 23.6 | 2 | 15.2 | 3 | 23.2 |
| 5.50 | 1 | 6.3 | 1 | 21.4 | 2 | 12.6 | 3 | 18.9 |
| 5.75 | 1 | 4.9 | 1 | 19.5 | 2 | 9.9 | 3 | 15.0 |
| 6.00 | 1 | 3.7 | 1 | 17.6 | 2 | 7.5 | 3 | 11.3 |
| 6.25 | 1 | 2.6 | 1 | 16.0 | 2 | 5.3 | 3 | 8.0 |
| 6.50 | 1 | 1.6 | 1 | 14.4 | 2 | 3.2 | 3 | 4.9 |
| 6.75 | 1 | 0.6 | 1 | 13.0 | 2 | 1.3 | 3 | 2.0 |
| 7.00 | 0 | 23.8 | 1 | 11.7 | 1 | 23.6 | 2 | 23.4 |
| 7.25 | 0 | 22.9 | 1 | 10.4 | 1 | 21.9 | 2 | 20.9 |

| | 30 Yards. | | 40 Yards. | | 60 Yards. | | 120 Yards. | |
|---|---|---|---|---|---|---|---|---|
| Hank Roving. | Dwts. | Grains. | Dwts. | Grains. | Dwts. | Grains. | Dwts. | Grains. |
| 7.50 | 1 | 9.3 | 1 | 20.40 | 2 | 18.6 | 5 | 13.30 |
| 7.75 | 1 | 8.2 | 1 | 19.00 | 2 | 16.5 | 5 | 9.00 |
| 8.00 | 1 | 7.2 | 1 | 17.60 | 2 | 14.5 | 5 | 5.00 |
| 8.25 | 1 | 6.3 | 1 | 16.40 | 2 | 12.6 | 5 | 1.20 |
| 8.50 | 1 | 5.4 | 1 | 15.20 | 2 | 10.8 | 4 | 21.60 |
| 8.75 | 1 | 4.5 | 1 | 14.10 | 2 | 9.1 | 4 | 18.20 |
| 9.00 | 1 | 3.7 | 1 | 13.00 | 2 | 7.5 | 4 | 15.10 |
| 9.25 | 1 | 3.0 | 1 | 12.00 | 2 | 6.0 | 4 | 12.00 |

SLUBBING TO ROVING TABLE.—*contd.*

| | 30 Yards. | | 40 Yards | | 60 Yards. | | 120 Yards. | |
|---|---|---|---|---|---|---|---|---|
| Hank Roving. | Dwts. | Grains. | Dwts. | Grains. | Dwts. | Grains. | Dwts. | Grains. |
| 9.50 | 1 | 2.3 | 1 | 11.10 | 2 | 4.6 | 4 | 9.20 |
| 9.75 | 1 | 1.6 | 1 | 10.10 | 2 | 3.2 | 4 | 6.40 |
| 10.00 | 1 | 1.0 | 1 | 9.33 | 2 | 2.0 | 4 | 4.00 |
| 10.25 | 1 | 0.39 | 1 | 8.52 | 2 | 0.78 | 4 | 1.56 |
| 10.50 | .. | 23.81 | 1 | 7.73 | 1 | 23.62 | 3 | 23.23 |
| 10.75 | .. | 23.26 | 1 | 7.00 | 1 | 22.52 | 3 | 21.04 |
| 11.00 | .. | 22.72 | 1 | 6.30 | 1 | 22.15 | 3 | 18.90 |
| 11.25 | .. | 22.22 | 1 | 5.62 | 1 | 20.44 | 3 | 16.88 |
| 11.50 | .. | 21.73 | 1 | 4.98 | 1 | 19.47 | 3 | 14.95 |
| 11.75 | .. | 21.27 | 1 | 4.33 | 1 | 18.55 | 3 | 13.10 |
| 12.00 | .. | 20.83 | 1 | 3.77 | 1 | 17.66 | 3 | 11.33 |
| 12.25 | .. | 20.40 | 1 | 3.20 | 1 | 16.81 | 3 | 9.60 |
| 12.50 | .. | 20.00 | 1 | 2.66 | 1 | 16.00 | 3 | 8.00 |
| 12.75 | .. | 19.60 | 1 | 2.14 | 1 | 15.21 | 3 | 6.43 |
| 13.00 | .. | 19.23 | 1 | 1.64 | 1 | 14.46 | 3 | 4.92 |
| 13.25 | .. | 18.86 | 1 | 01.16 | 1 | 13.73 | 3 | 0.347 |
| 13.50 | .. | 18.51 | 1 | 00.69 | 1 | 13.03 | 3 | 02.07 |
| 13.75 | .. | 18.18 | 1 | 00.24 | 1 | 12.36 | 3 | 00.72 |
| 14.00 | .. | 17.85 | .. | 23.80 | 1 | 11.71 | 2 | 23.42 |
| 14.25 | .. | 17.54 | .. | 23.39 | 1 | 11.08 | 0 | 22.17 |
| 14.50 | .. | 17.24 | .. | 22.98 | 1 | 10.48 | 2 | 20.96 |
| 14.75 | .. | 16.94 | .. | 22.89 | 1 | 9.89 | 2 | 19.79 |
| 15.00 | .. | 16.66 | .. | 22.22 | 1 | 9.33 | 2 | 18.66 |
| 15.25 | .. | 16.39 | .. | 21.85 | 1 | 8.78 | 2 | 17.57 |
| 15.50 | .. | 16.12 | .. | 21.52 | 1 | 8.25 | 2 | 16.57 |
| 15.75 | .. | 15.87 | .. | 21.16 | 1 | 7.74 | 2 | 15.49 |
| 16.00 | .. | 15.62 | .. | 20.83 | 1 | 7.25 | 2 | 14.50 |
| 16.50 | .. | 15.15 | .. | 20.20 | 1 | 6.30 | 2 | 12.60 |
| 17.00 | .. | 14.70 | .. | 19.60 | 1 | 5.41 | 2 | 10.82 |
| 17.50 | .. | 14.28 | .. | 19.05 | 1 | 4.57 | 2 | 9.14 |
| 18.00 | .. | 13.88 | .. | 18.51 | 1 | 3.77 | 2 | 7.55 |
| 18.50 | .. | 13.51 | .. | 18.01 | 1 | 3.02 | 2 | 6.05 |

# SQUARE ROOTS OF COUNTS.

| No. | Square Root. | No. | Square Root. | No. | Square Root. | No. | Square Root. | No. | Square Root. | No. | Square Root. | No. | Square Root. | No. | Square Root. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0625 | 0.250 | 0.48 | 0.693 | 0.74 | 0.860 | 1.0 | 1.0 | 4.50 | 2.121 | 18.5 | 4.301 | 46 | 6.782 | 75 | 8.660 |
| 0.125 | 0.353 | 0.49 | 0.700 | 0.75 | 0.866 | 1.10 | 1.049 | 4.75 | 2.179 | 19.0 | 4.358 | 47 | 6.855 | 76 | 8.717 |
| 0.1875 | 0.433 | 0.50 | 0.707 | 0.76 | 0.872 | 1.25 | 1.066 | 5.0 | 2.236 | 19.5 | 4.416 | 48 | 6.928 | 77 | 8.774 |
| 0.25 | 0.500 | 0.51 | 0.714 | 0.77 | 0.878 | 1.20 | 1.095 | 6.5 | 2.345 | 20. | 4.472 | 49 | 7.0 | 78 | 8.831 |
| 0.26 | 0.510 | 0.52 | 0.721 | 0.78 | 0.883 | 1.25 | 1.118 | 6.0 | 2.449 | 21 | 4.582 | 50 | 7.071 | 79 | 8.888 |
| 0.27 | 0.520 | 0.53 | 0.728 | 0.79 | 0.889 | 1.30 | 1.140 | 6.5 | 2.550 | 22 | 4.690 | 51 | 7.141 | 80 | 8.944 |
| 0.28 | 0.529 | 0.54 | 0.735 | 0.80 | 0.894 | 1.375 | 1.172 | 7.0 | 2.645 | 23 | 4.795 | 52 | 7.211 | 81 | 9.0 |
| 0.29 | 0.539 | 0.55 | 0.742 | 0.81 | 0.900 | 1.40 | 1.183 | 7.5 | 2.739 | 24 | 4.898 | 53 | 7.280 | 82 | 9.055 |
| 0.30 | 0.548 | 0.56 | 0.748 | 0.8125 | 0.901 | 1.50 | 1.224 | 8.0 | 2.828 | 25 | 5.0 | 54 | 7.348 | 83 | 9.110 |
| 0.31 | 0.557 | 0.5625 | 0.750 | 0.82 | 0.906 | 1.60 | 1.265 | 8.5 | 2.915 | 26 | 5.099 | 55 | 7.416 | 84 | 9.165 |
| 0.3125 | 0.559 | 0.57 | 0.755 | 0.83 | 0.911 | 1.625 | 1.274 | 9.0 | 3.0 | 27 | 5.196 | 56 | 7.483 | 85 | 9.219 |
| 0.32 | 0.566 | 0.58 | 0.762 | 0.84 | 0.917 | 1.70 | 1.304 | 9.5 | 3.082 | 28 | 5.291 | 57 | 7.549 | 86 | 9.273 |
| 0.33 | 0.574 | 0.59 | 0.768 | 0.85 | 0.922 | 1.75 | 1.322 | 10.0 | 3.162 | 29 | 5.385 | 58 | 7.615 | 87 | 9.327 |
| 0.34 | 0.583 | 0.60 | 0.775 | 0.86 | 0.927 | 1.80 | 1.342 | 10.5 | 3.243 | 30 | 5.477 | 59 | 7.681 | 88 | 9.380 |
| 0.35 | 0.592 | 0.61 | 0.781 | 0.87 | 0.933 | 1.875 | 1.369 | 11.0 | 3.316 | 31 | 5.567 | 60 | 7.745 | 89 | 9.433 |
| 0.36 | 0.600 | 0.62 | 0.787 | 0.875 | 0.935 | 1.90 | 1.378 | 11.5 | 3.391 | 32 | 5.656 | 61 | 7.810 | 90 | 9.486 |
| 0.37 | 0.608 | 0.625 | 0.790 | 0.88 | 0.938 | 1.95 | 1.396 | 12.0 | 3.464 | 33 | 5.744 | 62 | 7.874 | 91 | 9.539 |
| 0.375 | 0.612 | 0.63 | 0.794 | 0.89 | 0.943 | 2.0 | 1.414 | 12.5 | 3.535 | 34 | 5.830 | 63 | 7.937 | 92 | 9.591 |
| 0.38 | 0.616 | 0.64 | 0.800 | 0.90 | 0.949 | 2.20 | 1.483 | 13.0 | 3.605 | 35 | 5.916 | 64 | 8.0 | 93 | 9.643 |
| 0.39 | 0.624 | 0.65 | 0.806 | 0.91 | 0.954 | 2.25 | 1.5 | 13.5 | 3.674 | 36 | 6.0 | 65 | 8.062 | 94 | 9.695 |
| 0.40 | 0.632 | 0.66 | 0.812 | 0.92 | 0.959 | 2.40 | 1.549 | 14.0 | 3.741 | 37 | 6.082 | 66 | 8.124 | 95 | 9.746 |
| 0.41 | 0.640 | 0.67 | 0.819 | 0.93 | 0.964 | 2.50 | 1.581 | 14.5 | 3.807 | 38 | 6.164 | 67 | 8.185 | 96 | 9.797 |
| 0.42 | 0.648 | 0.68 | 0.825 | 0.9375 | 0.968 | 2.75 | 1.658 | 15.0 | 3.872 | 39 | 6.245 | 68 | 8.246 | 97 | 9.848 |
| 0.43 | 0.656 | 0.6875 | 0.829 | 0.94 | 0.970 | 3.00 | 1.732 | 15.5 | 5.937 | 40 | 6.324 | 69 | 8.306 | 98 | 9.899 |
| 0.4375 | 0.661 | 0.69 | 0.831 | 0.95 | 0.975 | 3.25 | 1.802 | 16.0 | 4.0 | 41 | 6.403 | 70 | 8.366 | 99 | 9.949 |
| 0.44 | 0.663 | 0.70 | 0.837 | 0.96 | 0.980 | 3.50 | 1.870 | 16.5 | 4.062 | 42 | 6.480 | 71 | 8.426 | 100 | 10.000 |
| 0.45 | 0.671 | 0.71 | 0.843 | 0.97 | 0.985 | 3.75 | 1.936 | 17.0 | 4.123 | 43 | 6.557 | 72 | 8.485 | | |
| 0.46 | 0.678 | 0.72 | 0.849 | 0.98 | 0.990 | 4.00 | 2.0 | 17.5 | 4.183 | 44 | 6.633 | 73 | 8.544 | | |
| 0.47 | 0.686 | 0.73 | 0.854 | 0.99 | 0.995 | 4.25 | 2.061 | 18.0 | 4.242 | 45 | 6.708 | 74 | 8.602 | | |

**TABLE OF MULTIPLES OF TWIST.**

| COTTON. | | SLUBBING. | | | INTER. | | | ROVING. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INDIAN<br>AMERICAN<br>EGYPTIAN | | 1.30<br>1.10 to 1.20<br>0.90 | | | 1.20<br>1.10 to 1.20<br>0.95 | | | 1.50<br>1.20 to 1.25<br>1.15 | | | | |
| Hanks. | Square root. | Twist Constant. | | | Twist Constant. | | | Twist Constant. | | | | |
| | | .90 | .95 | 1.10 | 1.15 | 1.20 | 1.25 | 1.30 | 1.40 | 1.50 | 1.80 | 2.00 |
| .20 | .447 | .40 | .42 | .49 | .51 | .54 | .56 | .58 | .63 | .67 | .80 | .89 |
| .25 | .500 | .45 | .48 | .55 | .58 | .60 | .63 | .65 | .70 | .75 | .90 | 1.00 |
| .30 | .548 | .49 | .52 | .60 | .63 | .66 | .69 | .71 | .77 | .82 | .98 | 1.09 |
| .35 | .592 | .53 | .56 | .65 | .68 | .71 | .74 | .77 | .83 | .89 | 1.06 | 1.18 |
| .40 | .632 | .57 | .60 | .69 | .73 | .76 | .79 | .82 | .88 | .95 | 1.14 | 1.26 |
| .45 | .671 | .60 | .64 | .74 | .77 | .81 | .84 | .87 | .94 | 1.01 | 1.21 | 1.34 |
| .50 | .707 | .64 | .67 | .78 | .81 | .85 | .88 | .92 | .99 | 1.06 | 1.27 | 1.41 |
| .55 | .742 | .67 | .70 | .82 | .85 | .89 | .83 | .96 | 1.04 | 1.11 | 1.34 | 1.48 |
| .60 | .775 | .70 | .74 | .85 | .89 | .93 | .97 | 1.01 | 1.08 | 1.16 | 1.40 | 1.55 |
| .65 | .806 | .73 | .77 | .80 | .93 | .97 | 1.01 | 1.05 | 1.13 | 1.21 | 1.45 | 1.61 |
| .70 | .837 | .75 | .80 | .92 | .96 | 1.00 | 1.05 | 1.09 | 1.17 | 1.26 | 1.51 | 1.67 |
| .75 | .866 | .78 | .82 | .95 | 1.00 | 1.04 | 1.08 | .113 | 1.21 | 1.30 | 1.56 | 1.73 |
| .80 | .894 | .80 | .85 | .98 | 1.03 | 1.07 | 1.12 | 1.16 | 1.25 | 1.34 | 1.61 | 1.79 |
| .85 | .922 | .83 | .88 | 1.01 | 1.06 | 1.11 | 1.15 | 1.20 | 1.29 | 1.38 | 1.66 | 1.84 |
| .90 | .949 | .85 | .90 | 1.04 | 1.10 | 1.14 | 1.19 | 1.23 | 1.33 | 1.42 | 1.71 | 1.90 |
| .95 | .975 | .88 | .93 | 1.07 | 1.12 | 1.17 | 1.22 | 1.27 | 1.37 | 1.46 | 1.76 | 1.95 |
| 1.00 | 1.000 | .90 | .95 | 1.10 | 1.15 | 1.20 | 1.25 | 1.30 | 1.40 | 1.50 | 1.80 | 2.00 |
| 1.05 | 1.025 | .92 | .97 | 1.13 | 1.18 | 1.23 | 1.28 | 1.33 | 1.44 | 1.54 | 1.85 | 2.05 |
| 1.10 | 1.049 | .94 | 1.00 | 1.15 | 1.21 | 1.26 | 1.31 | 1.36 | 1.47 | 1.57 | 1.89 | 2.09 |
| 1.15 | 1.073 | .97 | 1.02 | 1.18 | 1.23 | 1.29 | 1.34 | 1.39 | 1.50 | 1.61 | 1.93 | 2.14 |
| 1.20 | 1.095 | .99 | 1.04 | 1.20 | 1.26 | 1.31 | 1.37 | 1.42 | 1.53 | 1.64 | 1.97 | 2.19 |
| 1.25 | 1.118 | 1.01 | 1.06 | 1.23 | 1.29 | 1.34 | 1.40 | 1.45 | 1.57 | 1.68 | 2.01 | 2.24 |
| 1.30 | 1.140 | 1.03 | 1.08 | 1.25 | 1.31 | 1.37 | 1.43 | 1.48 | 1.60 | 1.71 | 2.05 | 2.28 |

**Table of Multiples of Twist**—contd.

| COTTON | | SLUBBING. | | | INTER. | | | ROVING. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Indian<br>American<br>Egyptian | | 1.30<br>1.10 to 1.20<br>0.90 | | | 1.20<br>1.10 to 1.20<br>0.95 | | | 1.50<br>1.20 to 1.25<br>1.15 | | | | |
| Hanks. | Square root. | Twist Constant. | | | Twist Constant. | | | Twist Constant. | | | Twist Constant. | |
| | | .90 | .95 | 1.10 | 1.15 | 1.20 | 1.25 | 1.30 | 1.40 | 1.50 | 1.80 | 2.00 |
| 1.35 | 1.162 | 1.05 | 1.10 | 1.28 | 1.34 | 1.39 | 1.45 | 1.51 | 1.63 | 1.74 | 2.09 | 2.32 |
| 1.40 | 1.183 | 1.06 | 1.12 | 1.30 | 1.36 | 1.42 | 1.48 | 1.54 | 1.65 | 1.77 | 2.13 | 2.37 |
| 1.45 | 1.204 | 1.08 | 1.14 | 1.32 | 1.38 | 1.44 | 1.51 | 1.37 | 1.69 | 1.80 | 2.17 | 2.41 |
| 1.50 | 1.225 | 1.10 | 1.16 | 1.34 | 1.41 | 1.47 | 1.53 | 1.59 | 1.72 | 1.84 | 2.21 | 2.45 |
| 1.55 | 1.245 | 1.12 | 1.18 | 1.37 | 1.43 | 1.49 | 1.56 | 1.62 | 1.74 | 1.87 | 2.24 | 2.49 |
| 1.60 | 1.265 | 1.14 | 1.20 | 1.39 | 1.46 | 1.52 | 1.58 | 1.64 | 1.77 | 1.90 | 2.28 | 2.53 |
| 1.65 | 1.285 | 1.16 | 1.22 | 1.41 | 1.48 | 1.54 | 1.61 | 1.67 | 1.80 | 1.93 | 2.31 | 2.57 |
| 1.70 | 1.304 | 1.17 | 1.24 | 1.43 | 1.50 | 1.56 | 1.63 | 1.70 | 1.83 | 1.96 | 2.35 | 2.61 |
| 1.75 | 1.323 | 1.19 | 1.26 | 1.46 | 1.52 | 1.60 | 1.65 | 1.72 | 1.85 | 1.98 | 2.38 | 2.65 |
| 1.80 | 1.342 | 1.21 | 1.27 | 1.48 | 1.54 | 1.61 | 1.68 | 1.74 | 1.88 | 2.01 | 2.42 | 2.68 |
| 1.85 | 1.360 | 1.22 | 1.29 | 1.50 | 1.56 | 1.63 | 1.70 | 1.77 | 1.90 | 2.04 | 2.45 | 2.72 |
| 1.90 | 1.378 | 1.24 | 1.31 | 1.52 | 1.58 | 1.65 | 1.72 | 1.79 | 1.93 | 2.07 | 2.48 | 2.76 |
| 1.95 | 1.397 | 1.26 | 1.33 | 1.54 | 1.61 | 1.68 | 1.75 | 1.82 | 1.96 | 2.10 | 2.51 | 2.79 |
| 2.00 | 1.414 | 1.27 | 1.34 | 1.56 | 1.63 | 1.70 | 1.77 | 1.84 | 1.98 | 2.12 | 2.55 | 2.83 |
| 2.05 | 1.432 | 1.29 | 1.36 | 1.58 | 1.65 | 1.72 | 1.79 | 1.86 | 2.00 | 2.15 | 2.58 | 2.86 |

## CONSTANT MULTIPLIERS FOR TWIST.

| Hanks. | Square root. | TWIST CONSTANT. Twist per inch. | | | TWIST CONSTANT. Twist per inch. | | | TWIST CONSTANT. Twist per inch. | | | Twist Constant Twist per inch. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | .90 | .95 | 1.10 | 1.15 | 1.20 | 1.25 | 1.30 | 1.40 | 1.50 | 1.80 | 2.00 |
| 2.10 | 1.449 | 1.30 | 1.38 | 1.59 | 1.67 | 1.74 | 1.81 | 1.88 | 2.03 | 2.17 | 2.61 | 2.90 |
| 2.15 | 1.467 | 1.32 | 1.39 | 1.61 | 1.69 | 1.76 | 1.83 | 1.91 | 2.05 | 2.20 | 2.64 | 2.93 |
| 2.20 | 1.483 | 1.33 | 1.41 | 1.63 | 1.71 | 1.78 | 1.85 | 1.93 | 2.08 | 2.22 | 2.67 | 2.97 |
| 2.25 | 1.500 | 1.35 | 1.43 | 1.65 | 1.72 | 1.80 | 1.88 | 1.95 | 2.10 | 2.25 | 2.70 | 3.00 |
| 2.30 | 1.515 | 1.36 | 1.44 | 1.67 | 1.74 | 1.82 | 1.89 | 1.97 | 2.12 | 2.27 | 2.73 | 3.03 |
| 2.35 | 1.535 | 1.38 | 1.46 | 1.69 | 1.77 | 1.84 | 1.92 | 2.00 | 2.15 | 2.30 | 2.76 | 3.07 |
| 2.40 | 1.549 | 1.39 | 1.47 | 1.70 | 1.78 | 1.86 | 1.94 | 2.01 | 2.17 | 2.32 | 2.79 | 3.10 |
| 2.45 | 1.565 | 1.41 | 1.49 | 1.72 | 1.80 | 1.88 | 1.96 | 2.03 | 2.19 | 2.35 | 2.82 | 3.13 |
| 2.50 | 1.581 | 1.42 | 1.50 | 1.74 | 1.82 | 1.90 | 1.98 | 2.06 | 2.21 | 2.37 | 2.85 | 3.16 |
| 2.55 | 1.597 | 1.44 | 1.52 | 1.76 | 1.84 | 1.92 | 2.00 | 2.08 | 2.24 | 2.40 | 2.87 | 3.19 |
| 2.60 | 1.611 | 1.45 | 1.53 | 1.77 | 1.85 | 1.93 | 2.01 | 2.00 | 2.26 | 2.42 | 2.90 | 3.22 |
| 2.65 | 1.630 | 1.47 | 1.55 | 1.79 | 1.87 | 1.96 | 2.04 | 2.12 | 2.28 | 2.45 | 2.93 | 3.26 |
| 2.70 | 1.643 | 1.48 | 1.56 | 1.81 | 1.89 | 1.97 | 2.05 | 2.14 | 2.30 | 2.46 | 2.96 | 3.29 |
| 2.75 | 1.658 | 1.49 | 1.58 | 1.82 | 1.91 | 1.99 | 2.07 | 2.16 | 2.32 | 2.49 | 2.98 | 3.32 |
| 2.80 | 1.673 | 1.51 | 1.59 | 1.84 | 1.92 | 2.01 | 2.09 | 2.17 | 2.34 | 2.51 | 3.01 | 3.35 |
| 2.85 | 1.688 | 1.52 | 1.60 | 1.86 | 1.94 | 2.03 | 2.11 | 2.19 | 2.36 | 2.53 | 3.04 | 3.38 |
| 2.90 | 1.703 | 1.53 | 1.62 | 1.87 | 1.96 | 2.04 | 2.13 | 2.21 | 2.38 | 2.55 | 3.07 | 3.41 |
| 2.95 | 1.718 | 1.55 | 1.63 | 1.89 | 1.98 | 2.06 | 2.15 | 2.23 | 2.41 | 2.58 | 3.09 | 3.44 |
| 3.00 | 1.732 | 1.56 | 1.65 | 1.91 | 1.99 | 2.08 | 2.17 | 2.25 | 2.42 | 2.60 | 3.12 | 3.46 |
| 3.10 | 1.760 | 1.58 | 1.67 | 1.94 | 2.02 | 2.11 | 2.20 | 2.29 | 2.46 | 2.64 | 3.17 | 3.52 |
| 3.20 | 1.789 | 1.61 | 1.70 | 1.97 | 2.06 | 2.15 | 2.24 | 2.33 | 2.50 | 2.68 | 3.22 | 3.58 |
| 3.30 | 1.817 | 1.64 | 1.73 | 2.00 | 2.09 | 2.18 | 2.27 | 2.36 | 2.54 | 2.73 | 3.27 | 3.63 |
| 3.40 | 1.844 | 1.66 | 1.75 | 2.02 | 2.12 | 2.21 | 2.31 | 2.40 | 2.58 | 2.77 | 3.32 | 3.69 |
| 3.50 | 1.870 | 1.68 | 1.78 | 2.06 | 2.15 | 2.24 | 2.34 | 2.43 | 2.62 | 2.81 | 3.37 | 3.74 |
| 3.60 | 1.897 | 1.71 | 1.80 | 2.09 | 2.18 | 2.28 | 2.37 | 2.47 | 2.66 | 2.85 | 3.41 | 3.79 |
| 3.70 | 1.924 | 1.73 | 1.83 | 2.12 | 2.21 | 2.31 | 2.41 | 2.50 | 2.69 | 2.89 | 3.46 | 3.85 |
| 3.80 | 1.949 | 1.76 | 1.85 | 2.15 | 2.24 | 2.34 | 2.44 | 2.54 | 2.73 | 2.92 | 3.51 | 3.90 |
| 3.90 | 1.975 | 1.78 | 1.88 | 2.17 | 2.27 | 2.37 | 2.47 | 2.57 | 2.77 | 2.96 | 3.56 | 3.95 |
| 4.00 | 2.000 | 1.80 | 1.90 | 2.20 | 2.30 | 2.40 | 2.50 | 2.60 | 2.80 | 3.00 | 3.60 | 4.00 |
| 4.10 | 2.025 | 1.82 | 1.92 | 2.23 | 2.33 | 2.43 | 2.53 | 2.63 | 2.84 | 3.04 | 3.65 | 4.05 |
| 4.20 | 2.049 | 1.84 | 1.95 | 2.25 | 2.36 | 2.46 | 2.56 | 2.66 | 2.87 | 3.07 | 3.69 | 4.10 |
| 4.30 | 2.074 | 1.87 | 1.97 | 2.28 | 2.39 | 2.49 | 2.59 | 2.70 | 2.90 | 3.11 | 3.73 | 4.15 |
| 4.40 | 2.097 | 1.89 | 1.99 | 2.31 | 2.41 | 2.52 | 2.62 | 2.73 | 2.94 | 3.15 | 3.77 | 4.19 |
| 4.50 | 2.121 | 1.91 | 2.01 | 2.33 | 2.44 | 2.55 | 2.65 | 2.76 | 2.97 | 3.18 | 3.82 | 4.24 |

**Constant Multipliers for Twist**—contd.

| Hanks. | Square root. | TWIST CONSTANT. .90 Twist per inch | .95 | 1.10 | TWIST CONSTANT. 1.15 Twist per inch. | 1.20 | 1.25 | TWIST CONSTANT. 1.30 Twist per inch. | 1.40 | 1.50 | TWIST CONSTANT 1.80 Twist per inch. | 2.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4.60 | 2.145 | 1.93 | 2.04 | 2.36 | 2.47 | 2.57 | 2.68 | 2.79 | 3.00 | 3.22 | 3.86 | 4.29 |
| 4.70 | 2.167 | 1.95 | 2.06 | 2.38 | 2.49 | 2.60 | 2.71 | 2.82 | 3.03 | 3.25 | 3.90 | 4.33 |
| 4.80 | 2.191 | 1.97 | 2.08 | 2.41 | 2.52 | 2.63 | 2.74 | 2.85 | 3.07 | 3.29 | 3.94 | 4.38 |
| 4.90 | 2.213 | 1.99 | 2.10 | 2.43 | 2.54 | 2.66 | 2.77 | 2.86 | 3.10 | 3.32 | 3.98 | 4.43 |
| 5.00 | 2.236 | 2.01 | 2.12 | 2.46 | 2.57 | 2.68 | 2.80 | 2.91 | 3.13 | 3.35 | 4.02 | 4.47 |
| 5.10 | 2.259 | 2.03 | 2.15 | 2.48 | 2.60 | 2.71 | 2.82 | 2.94 | 3.16 | 3.39 | 4.07 | 4.52 |
| 5.20 | 2.280 | 2.05 | 2.17 | 2.51 | 2.62 | 2.74 | 2.85 | 2.96 | 3.19 | 3.42 | 4.10 | 4.36 |
| 5.30 | 2.302 | 2.07 | 2.19 | 2.53 | 2.65 | 2.76 | 2.88 | 2.99 | 3.22 | 3.45 | 4.14 | 4.60 |
| 5.40 | 2.324 | 2.09 | 2.21 | 2.56 | 2.67 | 2.79 | 2.91 | 3.02 | 3.25 | 3.49 | 4.18 | 4.65 |
| 5.50 | 2.345 | 2.11 | 2.23 | 2.58 | 2.70 | 2.81 | 2.93 | 3.05 | 3.28 | 3.52 | 4.22 | 4.69 |
| 5.60 | 2.367 | 2.13 | 2.25 | 2.60 | 2.72 | 2.84 | 2.96 | 3.08 | 3.31 | 3.55 | 4.26 | 4.73 |
| 5.70 | 2.387 | 2.15 | 2.27 | 2.63 | 2.75 | 2.86 | 2.99 | 3.10 | 3.34 | 3.58 | 4.30 | 4.77 |
| 5.80 | 2.408 | 2.17 | 2.29 | 2.65 | 2.77 | 2.89 | 3.01 | 3.13 | 3.37 | 3.61 | 4.33 | 4.82 |
| 5.90 | 2.429 | 2.19 | 2.31 | 2.67 | 2.79 | 2.91 | 3.04 | 3.16 | 3.40 | 3.64 | 4.37 | 4.86 |
| 6.00 | 2.449 | 2.20 | 2.33 | 2.69 | 2.82 | 2.94 | 3.06 | 3.18 | 3.43 | 3.67 | 4.41 | 4.90 |
| 6.10 | 2.470 | 2.22 | 2.35 | 2.72 | 2.84 | 2.96 | 3.09 | 3.21 | 3.46 | 3.71 | 4.45 | 4.94 |
| 6.20 | 2.490 | 2.24 | 2.37 | 2.74 | 2.86 | 2.99 | 3.11 | 3.24 | 3.49 | 3.74 | 4.48 | 4.98 |
| 6.30 | 2.510 | 2.26 | 2.38 | 2.76 | 2.89 | 3.01 | 3.14 | 3.26 | 3.52 | 3.77 | 4.52 | 5.02 |
| 6.40 | 2.530 | 2.28 | 2.40 | 2.78 | 2.91 | 3.04 | 3.16 | 3.29 | 3.51 | 3.80 | 4.55 | 5.00 |
| 6.50 | 2.549 | 2.29 | 2.42 | 2.80 | 2.93 | 3.06 | 3.19 | 3.32 | 3.57 | 3.81 | 4.59 | 5.10 |
| 6.60 | 2.570 | 2.31 | 2.44 | 2.83 | 2.96 | 3.08 | 3.21 | 3.34 | 3.60 | 3.85 | 4.63 | 5.14 |
| 6.70 | 2.588 | 2.33 | 2.46 | 2.85 | 2.98 | 3.11 | 3.24 | 3.30 | 3.62 | 3.88 | 4.66 | 5.18 |
| 6.80 | 2.608 | 2.35 | 2.48 | 2.87 | 3.00 | 3.13 | 3.26 | 3.39 | 3.65 | 3.91 | 4.69 | 5.22 |
| 6.90 | 2.627 | 2.36 | 2.50 | 2.89 | 3.02 | 3.15 | 3.28 | 5.42 | 3.68 | 3.94 | 4.73 | 5.25 |
| 7.00 | 2.645 | 2.38 | 2.51 | 2.91 | 3.04 | 3.17 | 3.31 | 3.44 | 3.70 | 3.97 | 4.76 | 5.29 |
| 7.10 | 2.665 | 2.40 | 2.53 | 2.93 | 3.07 | 3.20 | 3.33 | 3.46 | 3.73 | 4.00 | 4.80 | 5.33 |
| 7.20 | 2.683 | 2.41 | 2.55 | 2.95 | 3.09 | 3.22 | 3.35 | 3.49 | 3.76 | 4.02 | 4.83 | 5.37 |
| 7.30 | 2.702 | 2.43 | 2.57 | 2.97 | 3.11 | 3.24 | 3.38 | 3.51 | 3.78 | 4.05 | 4.86 | 5.40 |
| 7.40 | 2.720 | 2.45 | 2.58 | 2.99 | 3.13 | 3.26 | 3.40 | 3.53 | 3.81 | 4.08 | 4.90 | 5.44 |
| 7.50 | 2.739 | 2.47 | 2.60 | 3.01 | 3.15 | 3.29 | 3.42 | 3.56 | 3.83 | 4.11 | 4.93 | 5.48 |
| 7.60 | 2.759 | 2.48 | 2.62 | 3.03 | 3.17 | 3.31 | 3.44 | 3.58 | 3.86 | 4.14 | 4.97 | 5.52 |
| 7.70 | 2.775 | 2.50 | 2.64 | 3.05 | 3.19 | 3.33 | 3.47 | 3.61 | 3.89 | 4.16 | 5.00 | 5.55 |
| 7.80 | 2.793 | 2.51 | 2.65 | 3.07 | 3.21 | 3.35 | 3.49 | 3.63 | 3.91 | 4.19 | 5.03 | 5.59 |
| 7.90 | 2.810 | 2.53 | 2.67 | 3.09 | 3.23 | 3.37 | 3.51 | 3.65 | 3.94 | 4.22 | 5.06 | 5.62 |

**Constant Multipliers for Twist**—contd.

| Hanks. | Square root. | TWIST CONSTANT. .90 Twist per inch. | .95 | 1.10 | TWIST CONSTANT. 1.15 Twist per inch. | 1.20 | 1.25 | TWIST CONSTANT. 1.30 Twist per inch. | 1.40 | 1.50 | TWIST CONSTANT 1.80 Twist per inch. | 2.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.00 | 2.823 | 2.54 | 2.69 | 3.11 | 3.25 | 3.39 | 3.54 | 3.68 | 3.96 | 4.24 | 5.09 | 5.66 |
| 8.25 | 2.872 | 2.58 | 2.73 | 3.16 | 3.30 | 3.45 | 3.59 | 3.73 | 4.02 | 4.31 | 5.13 | 5.74 |
| 8.50 | 2.915 | 2.62 | 2.77 | 3.21 | 3.35 | 3.50 | 3.64 | 3.79 | 4.08 | 4.37 | 5.17 | 5.83 |
| 8.75 | 2.958 | 2.66 | 2.81 | 3.25 | 3.40 | 3.55 | 3.70 | 3.85 | 4.14 | 4.44 | 5.21 | 5.92 |
| 9.00 | 3.000 | 2.70 | 2.85 | 3.30 | 3.45 | 3.60 | 3.75 | 3.90 | 4.20 | 4.50 | 5.25 | 6.00 |
| 9.25 | 3.041 | 2.74 | 2.89 | 3.35 | 3.50 | 3.65 | 3.80 | 3.95 | 4.26 | 4.56 | 5.29 | 6.08 |
| 9.50 | 3.082 | 2.77 | 2.93 | 3.39 | 3.54 | 3.70 | 3.85 | 4.00 | 4.31 | 4.62 | 5.33 | 6.16 |
| 9.75 | 3.122 | 2.81 | 2.97 | 3.43 | 3.59 | 3.75 | 3.90 | 4.06 | 4.37 | 4.68 | 5.37 | 6.24 |
| 10.00 | 3.162 | 2.85 | 3.00 | 3.48 | 3.64 | 3.79 | 3.95 | 4.11 | 4.43 | 4.74 | 5.41 | 6.32 |
| 10.25 | 3.202 | 2.88 | 3.04 | 3.52 | 3.68 | 3.84 | 4.00 | 4.16 | 4.48 | 4.80 | 5.45 | 6.40 |
| 10.50 | 3.240 | 2.92 | 3.08 | 3.56 | 3.73 | 3.89 | 4.05 | 4.21 | 4.54 | 4.86 | 5.48 | 6.48 |
| 10.75 | 3.278 | 2.95 | 3.11 | 3.61 | 3.78 | 3.93 | 4.10 | 4.26 | 4.59 | 4.92 | 5.52 | 6.56 |
| 11.00 | 3.316 | 2.98 | 3.15 | 3.65 | 3.81 | 3.98 | 4.15 | 4.31 | 4.64 | 4.97 | 5.55 | 6.63 |
| 11.25 | 3.555 | 3.02 | 3.19 | 3.69 | 3.86 | 4.03 | 4.19 | 4.36 | 4.70 | 5.03 | 5.59 | 6.71 |
| 11.50 | 3.391 | 3.05 | 3.22 | 3.73 | 3.90 | 4.07 | 4.24 | 4.41 | 4.75 | 5.09 | 5.63 | 6.78 |
| 11.75 | 3.438 | 3.09 | 3.27 | 3.78 | 3.95 | 1.11 | 4.28 | 4.46 | 4.80 | 5.16 | 6.19 | 6.88 |
| 12.00 | 3.464 | 3.12 | 3.29 | 3.81 | 3.98 | 4.16 | 4.33 | 4.50 | 4.85 | 5.20 | 6.24 | 6.93 |
| 12.50 | 3.500 | 3.15 | 3.33 | 3.85 | 4.03 | 4.24 | 4.42 | 4.60 | 4.95 | 5.30 | 6.30 | 7.00 |
| 13.00 | 3.606 | 3.25 | 3.43 | 3.97 | 4.15 | 4.33 | 4.51 | 4.69 | 5.04 | 5.41 | 6.49 | 7.21 |
| 13.50 | 3.674 | 3.31 | 3.49 | 4.04 | 4.23 | 4.41 | 4.59 | 4.78 | 5.14 | 5.51 | 6.61 | 7.35 |
| 14.00 | 3.741 | 3.37 | 3.55 | 4.12 | 4.30 | 4.49 | 4.68 | 4.88 | 5.24 | 5.62 | 6.73 | 7.48 |
| 14.50 | 3.810 | 3.43 | 3.62 | 4.19 | 4.38 | 4.57 | 4.76 | 4.95 | 5.33 | 5.72 | 6.86 | 7.62 |
| 15.00 | 3.873 | 3.49 | 3.68 | 4.26 | 4.45 | 4.65 | 4.84 | 5.03 | 5.42 | 5.81 | 6.97 | 7.75 |
| 15.50 | 3.937 | 3.54 | 3.74 | 4.33 | 4.53 | 4.73 | 4.92 | 5.12 | 5.51 | 5.91 | 7.09 | 7.87 |
| 16.00 | 4.000 | 3.60 | 3.80 | 4.40 | 4.60 | 4.80 | 5.00 | 5.20 | 5.60 | 6.00 | 7.20 | 8.00 |
| 16.50 | 4.062 | 3.66 | 3.86 | 4.47 | 4.67 | 4.87 | 5.08 | 5.28 | 5.69 | 6.09 | 7.31 | 8.12 |
| 17.00 | 4.123 | 3.71 | 3.92 | 4.54 | 4.74 | 4.95 | 5.15 | 5.36 | 5.77 | 6.18 | 7.42 | 8.25 |
| 17.50 | 4.183 | 3.77 | 3.97 | 4.60 | 4.81 | 5.02 | 5.23 | 5.44 | 5.86 | 6.27 | 7.53 | 8.37 |
| 18.00 | 4.242 | 3.81 | 4.03 | 4.67 | 4.88 | 5.09 | 5.30 | 5.51 | 5.94 | 6.36 | 7.64 | 8.48 |
| 18.50 | 4.301 | 3.87 | 4.09 | 4.73 | 4.95 | 5.16 | 5.38 | 5.59 | 6.02 | 6.45 | 7.74 | 8.60 |
| 19.00 | 4.358 | 3.92 | 4.14 | 4.79 | 5.01 | 5.23 | 5.45 | 5.67 | 6.10 | 6.54 | 7.84 | 8.72 |
| 19.50 | 4.416 | 3.97 | 4.20 | 4.86 | 5.08 | 5.30 | 5.52 | 5.74 | 6.18 | 6.62 | 7.95 | 8.83 |
| 20.00 | 4.472 | 4.02 | 4.25 | 4.92 | 5.14 | 5.37 | 5.59 | 5.81 | 6.26 | 6.71 | 8.05 | 8.94 |

## PRODUCTION.

*Slubbing Frame.*

| Hank Roving | Twist per Inch. | Revolutions of Front Roller. | Hanks per spindle per Hour. | Pounds per spindle per Hour. | Remarks. |
|---|---|---|---|---|---|
| .40 | .76 | 234 | 1.086 | 2.715 | Frames with 10″ lift 4 spindles in 17½″ dia. of front roller 1¼″. speed of flyer 700 Revs. per minute, size of full bobbins 10″×5¾″ and weight 24 ozs using American cotton. |
| .50 | .85 | 212 | 1.071 | 2.142 | |
| .60 | .93 | 192 | 1.058 | 1.764 | |
| .70 | 1.00 | 177 | 1.031 | 1.474 | |
| .80 | 1.07 | 166 | 1.013 | 1.267 | |
| .90 | 1.14 | 156 | 0.986 | 1.096 | |
| 1.00 | 1.20 | 148 | 0.967 | 0.967 | |
| 1.10 | 1.26 | 141 | 0.951 | 0.865 | Twist per inch=1.2× √—Hank. |
| 1.20 | 1.31 | 134 | 0.930 | 0.775 | |

## PRODUCTION.

*Intermediate Frame.*

| Number of Roving. | Twist per Inch. | Revolutions of Front Roller | Hanks per spindle per Hour. | Pounds per spindle per Hour. | Remarks. |
|---|---|---|---|---|---|
| .80 | 1.07 | 190 | 1.124 | 1.405 | Frames with 10″ Lift. 6 spindle, in 21 inches or 6 in 19½ inchies diameter of front roller 1¼ n. speed of flyer 800 Revs. per minute. size of full bobbin 10 in. × 5 in. and weight 24 ozs. using American cotton. |
| .90 | 1.14 | 178 | 1.093 | 1.215 | |
| 1.00 | 1.20 | 169 | 1.071 | 1.071 | |
| 1.10 | 1.26 | 161 | 1.053 | 0.957 | |
| 1.20 | 1.31 | 155 | 1.036 | 0.864 | |
| 1.30 | 1.37 | 149 | 1.015 | 0.781 | |
| 1.40 | 1.42 | 143 | 0.987 | 0.705 | |
| 1.50 | 1.47 | 136 | 0.963 | 0.642 | |
| 1.60 | 1.52 | 131 | 0.940 | 0.588 | Twist per inch=1.2× √--Hank. |
| 1.70 | 1.56 | 127 | 0.909 | 0.534 | |
| 1.80 | 1.61 | 123 | 0.890 | 0.496 | |
| 1.90 | 1.65 | 120 | 0.871 | 0.458 | |
| 2.00 | 1.70 | 118 | 0.858 | 0.428 | |
| 2.10 | 1.74 | 114 | 0.828 | 0.394 | |
| 2.20 | 1.78 | 112 | 0.821 | 0.373 | |
| 2.30 | 1.82 | 109 | 0.798 | 0.347 | |
| 2.40 | 1.86 | 107 | 0.787 | 0.326 | |
| 2.50 | 1.90 | 105 | 0.777 | 0.310 | |

## PRODUCTION.

*Roving Frame*

| Hank Roving | Twist per Inch. | Revolutions of Front Roller. | Hanks per Spindle per hour. | Pounds per Spindle per hour. | Remarks. |
|---|---|---|---|---|---|
| 2.00 | 1.69 | 184 | 1.028 | .514 | Frame with 7″ Lift. Spindles in 20½ inches; diameter of front roller 1⅛ inch Speed of flyer 1100 R. P. M. size of full bobbin 7 in × 3¾ inches and weight 10½ ozs. using American cotton. |
| 2.50 | 1.90 | 163 | .975 | .390 | |
| 3.00 | 2.07 | 150 | .936 | .312 | |
| 3.50 | 2.24 | 139 | .878 | .251 | |
| 4.00 | 2.40 | 130 | .824 | .206 | |
| 4.50 | 2.54 | 122 | .796 | .177 | |
| 5.00 | 2.67 | 115 | .765 | .153 | |
| 5.50 | 2.80 | 110 | .731 | .133 | |
| 6.00 | 2.92 | 106 | .708 | .118 | |

## POWER.

### Slubbing Frame—

About 45 Spindles per H. P. exclusive of power for line shafting and friction.

### Intermediate Frame.

About 55 Spindles per H. P. exclusive of power for line shafting and friction.

### Roving Frame—

About 65 Spindles per H. P. exclusive of power for line shafting and friction.

### Electric Drive.

The arrangement of driving to be adopted in preparatory department should be the same as in card department. The motor size, horse power and speed should be the same so as to facilitate interchangeability and spare motor grouping of machinery to be as follows :—

One 100 B. H. P. motor to drive the following machinery :—

6 Drawing Frames of 3 heads and 10 deliveries.
6 Slubbing Frames of 106 Spindles each at 700 R.P.M.
18 Intermediate Frames of 132 Spindles each at 726 R.P.M.
One 100 B. H. P. motor to drive the following machinery.
39 Roving Frames of 168 Spindles at 1272 R.P.M.

## CALCULATIONS—FLY FRAMES.

### Draft—

| | |
|---|---|
| Crown wheel | = 90 |
| Back Roller | = 42 |
| Front Roller | = 20 |
| Change pinion | = 55 |
| Dia. of Front Roller | = $1\frac{1}{8}$ inch. |
| Dia. of Back Roller | = $1\frac{1}{8}$ inch. |

$$\frac{90 \times 42 \times 9 \times 8}{8 \times 20 \times 55 \times 9} = \frac{189}{55} = 3.4$$

## Draft Constant—

| | |
|---|---|
| Crown wheel | = 90 |
| Back Roller wheel | = 42 |
| Front Roller wheel | = 20 |

$$\frac{90 \times 42}{20} = 189$$

Constant ÷ Pinion = Draft.

SPEED OF FRONT ROLLER—

| | |
|---|---|
| Speed of line shaft | = 220 |
| Drum on main shaft | = 24 |
| Pulley on Frame | = 19 |
| Twist wheel | = 35 |
| Wheel on top Cone Drum | = 24 |
| Wheel on other End of Top Cone Drum | = 43 |
| Wheel on End of Front Roller | = 115 |

$$\frac{220 \times 24 \times 35 \times 43}{115 \times 24 \times 19} = 155.05$$

## Constant for Speed of Front Roller—

| | |
|---|---|
| Speed of Main Shaft | = 220 |
| Drum on Main Shaft | = 24 |
| Wheel on other End of Top Cone Drum | = 43 |
| Wheel on End of Front Roller | = 115 |
| Wheel ontop Cone Drum | = 24 |
| Pulley on Frame | = 19 |

$$\frac{220 \times 24 \times 43}{19 \times 24 \times 115} = 4.43$$

Constant × Twist Wheel = Speed of Front Roller.

## Speed of Spindles—

| | |
|---|---|
| Revolution of Main Shaft | = 220 |
| Drum on Main Shaft | = 24 |
| Pulley on Frame | = 19 |
| Wheel on Driving Shaft of Frame | = 56 |
| Wheel on Spindle Shaft End | = 58 |
| Wheel on Spindle Shaft or Skew Bevel | = 50 |
| Wheel on Spindle | = 26 |

$$\frac{220 \times 24 \times 56 \times 50}{19 \times 58 \times 26} = 516$$

**Constant for Speed of Spindles—**

| | |
|---|---|
| Revolution of Main Shaft | = 220 |
| Drum on Main Shaft | = 24 |
| Wheel on Driving Shaft of Frame | = 56 |
| Skew Bevel | = 50 |
| Wheel on Spindle Shaft End | = 58 |
| Wheel on Spindle | = 26 |

$$\frac{220 \times 24 \times 56 \times 50}{58 \times 26} = 9803$$

Constant÷Dia. of Pulley =Speed of Spindle and *vice versa.*

**Turns per inch—**

| | |
|---|---|
| Wheel on Driving Shaft of Frame | = 56 |
| Skew Bevel | = 50 |
| Wheel on Top Cone Drum | = 24 |
| Do. do. Spindle Shaft | = 58 |
| Spindle Wheel | = 26 |
| Twist Wheel | = 35 |
| Wheel on other end of Top Cone Drum | = 43 |
| Circumference of Front Roller | = 3.53 |

$$\frac{56 \times 50 \times 24 \times 115}{58 \times 26 \times 55 \times 43 \times 3.53} = .96$$

**Turns per inch—**

| | |
|---|---|
| Speed of Spindle | = 516 |
| Delivary in Inches | = 547.92 |
| 516÷547.92 | = .96 |

**Constant for Turns per inch—**

| | |
|---|---|
| Wheel on End of Front Roller | = 115 |
| Do. Top Cone Drum | = 24 |
| Do. Driving Shaft of Frame | = 56 |
| Skew Bevel | = 50 |
| Wheel on Spindle Shaft end | = 58 |
| Wheel on other End of Top Cone Drum | = 48 |

Spindle Wheel = 26
Circumference of Front Roller = 3.53

$$\frac{115 \times 24 \times 56 \times 50}{43 \times 58 \times 26 \times 3.53} = 33.78$$

Constant ÷ Twist Wheel = Turns per inch.

## Length of Yarn Delivered by Front Roller per min.

Speed of Front Roller = 155
Dia. of do. do. = $1\frac{1}{8}$ inch.

$$\frac{155 \times 9 \times 3.1416}{8 \times 36} = 15.22 \text{ Yards.}$$

## How to Find Production—

| | |
|---|---|
| Speed of Spindle | = 516 |
| No. of Min. in total working hours | = 600 |
| No. of Spindles in a frame | = 105 |
| Hank...... | = .50 |
| Turns per inch | = .96 |
| Yards in a Hank | = 840 |
| Inches to the yard | = 36 |

$$\frac{516 \times 600 \times 105}{840 \times 36 \times 50 \times .96} = 2239 \text{ lbs.}$$

*Less* 12% for Stoppage = 268 ,,

1971 ,,

## Constant for Finding Production—

| | |
|---|---|
| Speed of Spindles | = 516 |
| Working min. per day | = 600 |
| No. of Spindles on frame | = 105 |
| Yards in a Hank | = 840 |
| Inches in a yard | = 36 |

$$\frac{516 \times 600 \times 105}{840 \times 36} = 1075 \text{ constant}$$

Multiply Hank by Turns per inch and divide it into Constant thus—

| | |
|---|---|
| Hank | = .50 |
| Turns per inch | = .96 |
| .50 × .96 | = .4800 |

1075 ÷ .4800 = 2239 less 12% for stoppages = lbs. 1971 Production.

## No. of Turns of Spindle lo one of Front Roller—

| | | |
|---|---|---|
| Spindle Wheel | = | 26 |
| Skew Bevel | = | 50 |
| Wheel on Spindle Shaft end | = | 50 |
| Twist Wheel | = | 35 |
| Wheel on Top Cone Drum | = | 24 |
| ,, other end of Top Cone Drum | = | 43 |
| ,, End of Front Roller | = | 115 |
| ,, Driving Shaft of Frame | = | 56 |

$$\frac{50 \times 56 \times 24 \times 115}{26 \times 50 \times 35 \times 43} = 3.94$$

## To Find Twist Wheel that will give correct Twist to the Bobbin

| | | |
|---|---|---|
| Spindle Wheel | = | 26 |
| Skew Bevel | = | 50 |
| Wheel on Spindle Shaft end | = | 50 |
| Wheel on Driving Shaft of Frame | = | 56 |
| Wheel on Top Cone Drum | = | 24 |
| Wheel on other End of top Cone Drum | = | 43 |
| Wheel on End of Front Roller | = | 115 |
| Revolution of Spindle to one of Front Roller | = | 3.94 |

$$\frac{50 \times 56 \times 24 \times 115}{26 \times 50 \times 43 \times 3.94} = 35 \text{ Twist Wheel.}$$

## To Find Twist Wheel.

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

The twist 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.

To find Twist Wheel when changing from one Hank to another—

| | |
|---|---|
| Twist Wheel | = 35 Squared. |
| Present Hank | = .50 |
| Hank required | = .66 |

$$\frac{35 \times 35 \times .50}{.66} = 928$$

Now find the square root of 928 = 30 Twist Wheel.

## To Find Change Pinion when Changing from one Weight to another—

| | |
|---|---|
| Change pinion | = 50 |
| Present weight of Sliver | = 250 grains. |
| Required ,, ,, | = 189 grains. |

$$\frac{50 \times 189}{250} = 37 \text{ Change Pinion;}$$

## To Find length of Silver contained in a Slubbing Bobbin—

| | |
|---|---|
| Net weight of Sliver on a Slubbing Bobbin | = 1 lb. 8 ozs. |
| Hank Slubbing | = .50 |
| No. of yards in a Hank | = 840 |
| Constant | = .6 |

$$1.5 \times .50 \times 840 \times .6 = 396 \text{ yards.}$$

## To Find Change Pinion when changing from one Hank to another

| | |
|---|---|
| Change pinion | = 50 |
| Present Hank | = .50 |
| Hank required | = .66 |

$$\frac{50 \times .50}{.66} = 37 \text{ Change Pinion.}$$

## To Find Lifter Wheel—

| | |
|---|---|
| Lifter Wheel | = 22 squared. |
| Present Hank | = .50 |
| Hank required | = .66 |

$$\frac{22 \times 22 \times .50}{.66} = 366$$

Now find the square root of 366 = 18 Lifter Wheel.

**To Find Lifter Wheel—**

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

The lifter wheel 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 hank.

**To find Ratched Wheel—**

| | | |
|---|---|---|
| Ratchet Wheel | = | 15 Squared. |
| Present Hank | = | .50 |
| Hank required | = | .66 |

$$\frac{15 \times 15 \times .66}{.50} = 297$$

Now find the square root of 297 = 17 Ratchet Wheel.

**To Find Ratchet Wheel or Star Wheel—**

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

The ratchet wheel 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. More teeth must be in the wheel for thin rovings than for coarse hanks.

**To Find the number of Coils—**

If a bobbin of .66 hank has 64 coils how many will there be if .50 hank is intended to be spun ?

$$\frac{64 \times 64 \times .50}{.66} = 3109$$

Now find the square root of 3109 = 55 Coils.

**To Find the number of Coils.—**

Find the numer of coils per inch, if a 3-hank roving bobbin has 109 coils in 6 inches.

$109 \div 6 = 18.16$ coils per inch.

## Constant for finding the number of coils.

Divide the number of coils by the Sq. root of count.

$$\sqrt{3} = 1.732$$

$$\frac{18.16}{\sqrt{3}} = \frac{18.16}{1.732} = 10.5 \text{ constant practically.}$$

Multiply the Sq. root of the hank by 10.5 = number of coils of roving per inch.

## Time required in minutes to build a Bobbin—

| | | |
|---|---|---|
| Weight of bobbin | = | 18 ozs. |
| Yards in a Hank | = | 840 |
| Twist per inch | = | 1.42 |
| Hank | = | 1.20 |
| Speed of Spindle | = | 726 |

$$\frac{18 \times 840 \times 36 \times 1.42 \times 1.20}{726 \times 16} = 79 \text{ minutes.}$$

Allow 10 minutes for doffing $= \frac{10}{89}$ ,, = 1 hr. 29 min.

## To find the length of time one Bobbin lasts on a Creel—

| | | |
|---|---|---|
| Weight of Bobbin | = | 24 ozs. |
| Hank | = | .50 |
| Draft | = | 6.50 |
| Constant | = | 1890 |
| Revolution of Front Roller | = | 124.48 |
| Cir. of Front Roller | = | 3.53 |

$$\frac{24 \times .50 \times 6.5 \times 1890}{124.48 \times 3.53} = 335 \text{ minutes.}$$

=5 hrs. 35 minutes a slubbing bobbin lasts on an intermediate creel.

## To find No. of Sets in 10 hours—

$$\frac{600 \text{ minutes}}{\text{minutes to build bobbin} \times \text{time for doffing.}}$$

Pounds per day of 10 hours = sets in 10 hours × weight of bobbins in lbs.

Hanks per day of 10 hours = pounds per day × hank roving

$$\text{Hank roving} = \frac{7000 \times \text{number of yards taken}}{840 \times \text{weight in grains}}$$

Q. What draft will 6 hank roving require when hank inter is 2 ?

A. Half of 2 = 1

6 ÷ 1 = 6 of a draft.

Q. What draft will a 2 hank inter require when hank slubbing is .64.

A. Take half of .64 and divide it into 2

2 ÷ 32 = 6 draft.

Q. What twist will be required on the slubbing frame if .50 hank is being spun ?

A. Square root of hank × 1.4

.707 × 1.4 = .98 twist per inch.

# CHAPTER XIX.

## SPINNING.

There are two chief methods of spinning yarn; (1) 'Mule Spinning' and (2) 'Ring Spinning.'

The spinning room is the heart of a cotton mill for it is here where the cotton roving is converted into yarn and it is one of the great industries of the world, and out of purely manual operation it has developed into an almost perfect automatic method of production by mechanical means.

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. One good method to adopt is the constant use of a note-book wherein records and informations can be refered to with the least possible delay. Note-books, like experience, will be worthless unless organised and arranged on some system that enables reason to be applied to their contents.

### Ring Spinning Frame.

Ring spinning was first constructed in America ndn was brought to general attention by the Paris Exhibition of 1878.

The term Spinning, when refering to the final process in the production of cotton yarn,. indicates the operation of finally alternating the roving to the desired extent and also sufficiently twisting the drafted strand of fibres so as to ensure the fibres having that cohesion to produce yarn possessing the required strength. The use of ring frame is very popular and hence there are many more rings than nules. But up to now it has not been found possible to spin as fine on the rings as mules. The mule yarn is more even than ring yarn.

The ring frame possesses several advantages over the mule, such as economy in wages, reduction in floor space occupied for the same number of spindles, less risk of fire, and a greater production per spindle. The ring frame has an advantage over the mule up to 50's counts, but beyond that the advantage is lost.

The creel and rollers are somewhat on the same principle as the roving frame. Like fly frames, the spinning of yarns on ring frames is continuous, i.e., the roving is drawn out, twisted and wound on the bobbin simultaneously, and this is made possible by the use of a hardened steel ring and traveller which encircles the spindle. The ring frame is a double sided frame and each side contains a long row of spindles suitably spaced and carried by strong rails, known as the ring rails.

## Characteristics of Good Yarn.

There is an exceedingly marked variation in characteristics and also as to the amount of faults in the large quantity of yarn produced.

Good yarn possesses a satisfactory standard of perfection in the following manner :—

(*a*) Evenness in diameter, strength, roundness, weight and colour ;

(*b*) freedom from slubs, stains snarls, cuts and nep ;

(*c*) the yarn must possess plenty of elasticity which is very essential for the purpose of good weaving.

Absolute microscope equality in the diameter of cotton yarn is unobtainable, but at any rate an evenness is attainable which meets the practical requirements of the trade. To produce yarn with a diameter as even as possible, the fibres must necessarily be equal in length and diameter, together with an even number of fibres at all parts of the yarn, and the strand evenly twisted at all points. The latter is very important.

## Determining Method of Spinning Cotton Yarns.

In determining the classification by an examination of the yarn itself, mule—Spun yarn can generally be distinguished by its being more even or level, elastic, oozy, porous, fibrous, and feels fuller in the hand than ring-spun yarn. Compared with ring–spun yarn, cloth woven from mule–Spun yarn has a fuller appearance, the oozy character of the yarn enables it to absorb the size better during the sizing process, and owing to its elasticity there is less contraction during weaving.

**Ring-Spun** yarn is usually harder twisted, say 5 to 10 per cent, and is not so even compared with mule—spun yarn. Ring yarn is usually spun in coarse to medium counts. In India, all cotton warp and weft yarns are ring—spun up to 80s.

**The objects of the ring frames are as follows:—**

(1) The attenuation of the roving to the desired and final extent suitable for the required counts of yarn ;

(2) the twisting of drafted strand of fibres to produce yarn of the required strength ;

(3) the winding of the yarn on a bobbin or in some form suitable for the next process.

In accomplishing these objects, the roving is attenuated by three pairs of suitably arranged drawing rollers, and in some cases the principle of doubling is adopted to ensure more regular yarn. The finally drafted strand of fibres is then twisted as it passes through what is known as a traveller, which is loosely clipped on and evolves at an enormous speed around a ring. The use of these rings is the reason of the frame being known as the ring frame.

The slow delivery of the attenuated strand of fibres is sufficiently twisted by the rapidly rotating traveller to produce yarn of the necessary strength. The winding of the yarn is effected by the traveller revolving at a slightly less speed than the bobbin, the latter being fitted on a very rapidly rotating spindle, the centre of which is in the centre of the ring. The yarn is built up into suitable shape by the ring with its traveller having a slow vertical reciprocating motion, while the bobbin revolves in stationary position.

The yarn is shaped on the bobbins by the movements of the ring rail which receives an upward and downward movement through the medium of a 'heart' cam. This movement is slow upwards and fast going down, the fast downward movement being given to put binding coils of yarn on to the bobbin, and so help to make the yarn easy to unwind at the next process.

The traveller is the medium by which winding is effected. It also keeps the yarn tight so that there may not be snarls. The traveller also puts twist in the yarn. A stationary traveller would give the maximum of winding but no twisting. If the traveller makes the same revolutions as the spindle, it would give maximum amount of twisting but no winding on. Hence it may be noted that the speed of the traveller and not of the spindle that determines the amount of twist. Sometimes heavier travellers are used to produce hard bobbins and to prevent balooning. The counts of travellers depend upon the following conditions:—

(1) The pull of the yarn from the bobbin to the traveller is always at a tangent to the ring;

(2) Any increase in the length delivered from the front rollers decreases the speed of the traveller;

(3) A reduction in the balloon of the yarn accompanied by a slightly greater tension on the yarn;

(4) The larger the ring the greater the centrifugal force of the yarn and traveller, also the greater the friction between the traveller and inside of the ring, accompanied by a slower traveller speed;

(5) The spindle and the bobbin have an equal and constant speed throughout the building of a set.

(6) The slower the speed of the traveller the less the twist in the yarn;

(7) When spinning fine counts, the lightness of the travellers often causes them to fly off the rings: hence the shape and counts of traveller and speed of spindles must all be very carefully considered;

(8) The smaller the diameter of the ring the lighter the traveller;

(9) The more the speed of the spindle the lighter the traveller

(10) The smaller the diameter of the bobbin the lighter the traveller;

(11) The drier the temperature the lighter the traveller;

(12) The poorer the mixing the lighter the traveller.

## The Traveller.

The traveller of a ring frame is a small piece of steel bent and shaped thus  and is connected to the ring by one end of the curl, while the thread as it comes down from the rollers through the guide wire passes through the curl at the opposite end of the traveller on its way to the bobbin on the spindle. The function of the traveller is to put twist into the yarn and guide it on to the bobbin. One revolution of the traveller is one twist in the yarn between the spindle and the rollers; and if it were not for the tilted position occupied by the rollers, it would be impossible for the twist to rise to the nip of the rollers and the consequence would be excessive breakages of the threads.

## Speed of Traveller.

*Example ;—*

Speed of spindles =9257 Revs. per min.
Surface speed of front roller =3.78 in. per min.
Diameter of bobbin =1 in.

$$\textit{Answer.}\text{—}9257-\left(\frac{378}{1\times 3.1416}\right)=9136.68 \text{ Revs. per min.}$$

Therefore the traveller lags behind the spindle to the extent of 120.32 revs. per min. in order that the length delivered from the front roller may be wound on the bobbin.

## Counts of Ring Traveller.

*Travellers are graded as follows ;—*

18,17,16,1,1..0, 2..0, 18..0, 19..0, 20..0, and so on
The first being the heaviest and working down lighter, and of course, the finer the counts the lighter the traveller will have to be used. The strength of the yarn twist being put on, etc., will also affect the size of traveller to be used.

The travellers for Sea Island cotton require to be five to six grades heavier than those given in the table. Higher speed of Spindles will require lighter travellers. The following table is given as a guide to select travellers required, but will, of course, vary according to circumstances.

Travellers although so small, are perhaps the most important item on the ring—frame. Iregularities in shape, weight and temper are prolific sources of bad spinning. An inferior traveller may save one a small sum of money per year in capital expenditure, but at the same time more than ten times that amount may be lost through bad spinning, waste, and loss of production. The "Ring and the Traveller are the key to good Spinning."

| | American and Egyptian Cotton. | | | | | Indian Cotton. |
|---|---|---|---|---|---|---|
| Counts of Yarn. | Dia. of Ring $1\frac{1}{2}''$ Counts of Traveller. | Dia. of Ring $1\frac{1}{2}''$ Counts of Traveller. | Dia. of Ring $1\frac{5}{8}''$ Counts of Traveller. | Dia. of Ring $1\frac{3}{4}''$ Counts of Traveller. | Dia. of Ring $1\frac{3}{4}''$ Counts of Traveller. | Dia. of Ring $1\frac{3}{4}''$ Counts of Traveller. |
| 2 | 16's | 16's | 15's | 15's | 18's | 12's |
| 4 | 14's | 14's | 13's | 13's | 16's | 8's |
| 6 | 12's | 12's | 11's | 11's | 14's | 6's |
| 8 | 11's | 10's | 9's | 10's | 12's | 4's |
| 10 | 9's | 8's | 7's | 8's | 8's | 2's |
| 12 | 8's | 7's | 6's | 7's | 7's | 1's |
| 14 | 7's | 6's | 5's | 6's | 7's | 1/0's |
| 16 | 6's | 5's | 4's | 5's | 6's | 2/0's |
| 18 | 5's | 4's | 3's | 4's | 5's | 3/0's |
| 20 | 4's | 3's | 2's | 3's | 4's | 4/0'sRinh $= 1\frac{5}{8}''$ |
| 22 | 3's | 2's | 1's | 2's | 3's | 3/0's |
| 24 | 2's | 1's | 1/0's | 1's | 1's | 6/0's |
| 26 | 1's | 1/0's | 2/0's | 1/0's | 1/0's | 7/0's |
| 28 | 1/0's | 2/0's | 3/0's | 2/0's | 1/0's | 8/0's |
| 30 | 2/0's | 3/0's | 4/0's | 3/0's | 2/0's | 9/0's |
| 32 | 3/0's | 4/0's | 5/0's | 4/0's | 3/0's | 10/0's |
| 34 | 4/0's | 5/0's | 6/0's | 5/0's | 3/0's | 11/0's |
| 36 | 5/0's | 6/0's | 7/0's | 6/0's | 3/0's | 12/0's |
| 38 | 6/0's | 7/0's | 8/0's | 7/0's | 3/0's | 13/0's |
| 40 | 7/0's | 8/0's | 9/0's | 8/0's | 4/0's | 14/0's |
| 42 | 8/0's | 9/0's | 10/0's | 9/0's | 4/0's | 14/0's |
| 44 | 8/0's | 10/0's | 11/0's | 10/0's | 5/0's | 14/0's |
| 46 | 9/0's | 11/0's | 12/0's | 10/0's | 6/0's | 15/0's |
| 48 | 10/0's | 12/0's | 13/0's | 11/0's | 7/0's | 15/0's |
| 50 | 11/0's | 13/0's | 14/0's | 12/0's | 8/0's | 15/0's |
| 52 | 12/0's | 14/0's | 15/0's | 13/0's | 9/0's | 15/0's |
| 54 | 13/0's | 15/0's | 16/0's | 14/0's | 10/0's | 16/0's |
| 56 | 14/0's | 16/0's | 17/0's | 15/0's | 11/0's | 16/0's |
| 38 | 15/0's | 17/0's | 18/0's | 16/0's | 12/0's | 16/0's |
| 60 | 16/0's | 18/0's | 19/0's | 17/0's | 13/0's | 16/0's |

## 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 120s 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 6 and 9 for single roving, and between 10 and 12 for double roving.

## The Draft Roller.

One of the chief features of the ring frame is its system of draft rollers, as it is the only frame which has inclined roller stands, and the whole of the rollers are in this way tilted from the horizontal.

This is done to allow the twist to run up the yarn as near as possible to the 'nip' of the front drawing rollers, and so to make the yarn as strong as possible, and reduce the number of broken ends.

It is necessary to adjust the lines of rollers to the correct distance from centre to centre in order to have the space from one roller nip to the adjacent roller nip suitable for cotton, and the conditions under which it has to be spun. Before the distance between the nips of the respective rollers can be decided upon, several factors must be given careful consideration which are as follows :—

(1) The length of staple ;
(2) Hank roving ;
(3) Amount of draft ;
(4) Turns per inch ;
(5) Speed of rollers ;
(6) Method of weighting rollers ;
(7) Whether the cotton is inclined to be harsh or smooth.

## Roller Settings.

The matter of roller settings is one of great interest and importance to the practical man, and particularly so in the final spinning frame.

For the purpose of roller setting, the length of staple is ascertained either by taking a number of strands of roving or from the sliver as it leaves the finisher drawing frame. It is necessary to remember that the distance between the nips of two adjacent pairs of rollers, when dead or lever weighted, must be greater than the average length of staple being worked.

The longer the length of staple, the greater must be the distance between the centres and nips of adjacent pairs of rollers and *vice versa*.

Bottom rollers are made of diameters to suit the staple of the cotton. The diameter of the front middle and back rollers might be as follows :—

**Indian :—$\frac{7}{8}''$, $\frac{3}{4}''$, $\frac{7}{8}''$.**
**American :—$1''$, $\frac{7}{8}''$, $1''$.**
**Egyptian :—$1\frac{1}{8}''$, $1''$, $1\frac{1}{8}''$.**

The relative speed of each line of rollers must be such as will permit the drawing action to be accomplished as perfectly as possible under the prevailing conditions. Roller revolving rapidly must have wider settings to enable the forward pair of rollers (first and second pairs) to draw the front ends of the fibres from the mass of fibres, some of which are held by the adjacent pair of rollers nearer the back of the frame, without weakening or breaking the fibres.

## Rollers.

Rollers should be correctly set and constantly tested to see that the settings are maintained. There are special gauges for both top and bottom rollers which are indispensable for accurate setting. They are self-contained, easy to manupulate, and save much time in the operation.

## Weighting of Rollers.

There are two chief methods of weighting the rollers :—
(1) dead weighting, and (2) lever weighting.

It is the general practice now to have the middle and back top rollers on a ring frame self weighted, and the front top rollers dead-weighted. The front top rollers are leather covered, while the middle and back top rollers are not covered.

## Tin Rollers.

A ring frame may have one or two lines of tin rollers, which are supported side by side in the same horizontal plane and each extends along the entire length of the ring rails. The surfaces of the roller, which are only about ½ in. apart, move upwards so that when facing the spindles on either side of the frame the nearest surface of the tin roller moves downward. This direction of motion is known as "running outwardly." Only one tin roller is positively driven, the other tin roller being driven by the cotton yarn hands which impart motion to the spindles by passing from the wharve of one spindle over the top of the nearest tin roller and on round the farthest tin roller, and then round a wharve on a spindle on the opposite side of the machine. It must be understood very clearly that one string drives two spindles.

The driving of the machine takes place through one of the tin roller shafts which extends a little outside the machine, known as the gearing end of the machine, and upon this shaft are the fast and loose pulleys which receive their motion from the line shaft. The second tin roller is usually driven by the frictional contact of the spindle bands.

## The Thread Boards.

The thread guide is a curled piece of wire which is screwed into a V-shaped piece of wood, that is hinged to the thread board, or it may be screwed into a steel thread rail and locked in position by a nut. The curled wire or thread guide, when fixed in position, should be exactly over the centre of the spindle. The thread guide being over the centre of the spindle must be moved out of the way for doffing purposes. The thread wires are about 5 in. below the roller nip and about 2 in. above the spindle top.

## Spindles and Spindles Rails.

The spindle rail runs the length of the frame on both sides and is drilled to receive all the spindles and poker bars.

The spindles which must be set absolutely concentric with the rings in the ring rails, are self-contained, the footsteps and bolster bearings being in one piece which is secured to the spindle rail. An inner tube fits into the bolster, and the spindle then fits into the inner tube. However well a spindle is made with regard to both quality of steel and finish, it cannot be expected to last long, or to produce good results, if the arrangements for lubrication are defective and the spindle-bearing is not well protected from dirt and grit.

## Spindle Band.

Ring frame spindle band is usually tubular and $\frac{1}{8}''$ in diameter, but now tape driving has been introduced, one endless tape driving four spindles, two on each side of the frame.

Spindle banding should have the stretch taken out of it before being put in use. It will give more length for the same cost, and does away with soft and irregular twist caused by slack bands not keeping perfect cohesion round the spindle wharves. By splicing the banding (the banding must be stretched first) instead of tying knots, one can cut down the consumption by 50 per cent.

## Spindle Speed.

Spindle speeds vary from about 4,500 to 11,000. Test the 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. The tension on the spindle band should not be too much, otherwise extra power will cause excessive slips and irragular twisting. Four pounds tension is a good average.

## The Ring.

The ring is made of forged steel and is carefully turned and casehardened. It is carried by, and secured to, a ring rail by a set screw. The ring rail is mounted on the poker bars which are coupled to the building motion, and by the action of the 'heart' cam, the ring rail is made to move up and down, and so shape the yarn on the bobbin. The ring rail is made in pieces, each piece being drilled to receive a certain number of rings.

The working "life" of spinning rings varies according to conditions of spinning and the classes of yarn being spun; but the time arrives ultimately when spinning faults necessitate the renewal of the rings.

Spinning rings must in some cases withstand a bearing pressure of 200 lbs. per sq. inch. which is intensified by the very small contacting surfaces, and this localised pressure is at once seriously affected by even the smallest irregularity. Care in maintenance is, therefore, amply repaid.

After many years of use, and due to the wear of the traveller, a 'wave' develops in the crust, or outer case of the ring–which possesses the requisite hardness and wear resisting properties, and differs from the body of the material lying underneath it-causing the traveller to jump, and vary the tension on the yarn. Additionally, rings become dirty on the inside and at the flange corners, affecting the cleanliness of the yarn and interfering further with the smooth passage of the travellers.

In many instances these blemishes in the spinning rings may cause them to be discarded ; whereas if the outer cases-on which the "life" of the ring depends–are not too much worn, a new lease of life may be given to them, by means of regrinding and repolishing operations. By these processes, the 'wave' is in many instances almost entirely eliminated, and the cleaned and repolished rings are given a further reasonable and satisfactory lease of life.

As spinning rings are one of the most important contributory factirs in economical and efficient yarn production, the question of prolonging their useful life is deserving of careful consideration.

## Diameter of Rings.

| Counts of Yarn. | Diameter of Rings. | Space. | Lift. | Balloon plate or Separator. |
|---|---|---|---|---|
| 6s to 10's warp | 2″ | $2\frac{7}{8}$″ | 6 to 7 | Yes. |
| 12's to 15's ,, | $1\frac{3}{4}$ or $1\frac{7}{8}$″ | $2\frac{3}{4}$″ | 6 to 7 | ,, |
| 16's to 24's ,, | $1\frac{3}{4}$″ | $2\frac{5}{8}$″ or $2\frac{1}{2}$″ | 6 | ,, |
| 25's to 40's ,, | $1\frac{5}{8}$″ | $2\frac{5}{8}$″ | 5 | ,, |
| 42's to 60's ,, | $1\frac{1}{2}$″ | $2\frac{1}{2}$″ | 5 | No. |
| 62's to 80's ,, | $1\frac{3}{8}$″ | $2\frac{3}{8}$″ | 5 | ,, |

## DIAMETER OF RINGS USED IN AMERICAN MILLS.

| Counts. | Traverse. | Ring Diameter. |
|---|---|---|
| 1s to 10s | 9 in. | 3 in. |
| 11s to 15s | 8 in. | $2\frac{1}{2}$ in. |
| 16s to 20s | 8 in. | $2\frac{1}{4}$ in. |
| 21s to 26s | $7\frac{1}{2}$ in. | 2 in. |
| 27s to 32s | 7 in. | $1\frac{3}{4}$ in. |
| 33s to 50s | $6\frac{1}{2}$ in. | $1\frac{5}{8}$ in. |

With regard to the sizes of rings, their diameter for weft yarn varies from $1\frac{1}{8}$″ in. to $1\frac{3}{8}$″ in.

The weft frame contains more spindles than the twist frame.

The difference in the weft frame is as follows: –

(1) Revolutions of spindles (less);
(2) Direction of motion of spindles (reverse);
(3) Ring diameter (smaller);
(4) Bobbin diameter (smaller);
(5) Gauge of spindles (smaller);
(6) Roller inclination (more).

Weft frames require no anti-balooning mechanism.

It is essential for good and economical spinning to have the temperature of the room about 72° to 78° Fah.

## Ballooning.

Ballooning is the bulging or flying outwards of the thread during the operation of spinning. It takes place between the thread guide and the traveller, and unless prevented from doing so, the tendency would be for the threads to touch and break each other.

The ballooning is always worst at the early part of the building of the bobbin. A certain amount of balooning is necessary and is a good thing, as a good baloon shows that there is no tendency to strain the threads by having them too tight.

By the adoption of the separators great speed is obtained with a greater production, since lighter travellers can be used with them than without them.

No traveller will give the same balloon when winding-on the small diameter, as when winding-on the large diameter of the bobbin.

## Traveller Clearer.

An indispensable adjunct secured to the ring rail is a small projection known as the traveller clearer. It is well known that when machines in a cotton mill are working, a good many fine fibres are always flying about, and in the ring room some of them would naturally fall upon the ring and would accumulate and interfere with the traveller by clogging its action. Therefore the function of traveller clearer is to catch any fibres that adhere to the traveller while it is revolving round the ring.

## Faults in Yarn.

To have good quality yarn, a good class cotton must be delivered in the form of good even roving. The draft should be medium and roller set correctly for the fibres to be used. Rollers set too open will produce uneven yarn. Rollers set too close will produce cracker yarn or yarn with parts not drawn between the rollers.

Rovings are another item in the production of a good yarn, and should not have much twist in, say sufficient to allow the roving to unwind from the bobbin in the creel without breakage. The less the twist in the roving, the better will it draw between the rollers. Hard twisted rovings cause cracker yarn.

## Soft Yarn.

Yarn which contains an insufficient amount of twist is often termed 'soft twist' in case it is warp yarn. The causes of soft yarn are as follows :—

Slack spindle bands, twist change wheel too large, empty bobbins not properly pushed down during doffing, bobbins out of balance, spindle out of balance. The negligence of oiling spindles or a poor quality of oil is more responsible for soft twist than the spindle bands, as it does not require bands to be very tight to turn a spindle if well oiled with a good oil.

## Hard Twist.

Hard twist is another fault, and can be caused by neglecting to oil top front roller or using poof oil; this fault can also be caused by dirt or waste being allowed to get round the centres or ends of the top front roller in cases where solid rollers are used. There is not the same danger of making hard twist where loose boss rollers are used.

## Thick and Double Yarn.

The causes are as follows :—

An end broken in front of the rollers and attached to an adjacent end instead of passing round one of the clearers. Two ends of roving being combined in case of spinning from single roving. Long roving piecings when creeling, the spinner allowing the broken end to be twisted too long before effecting the actual piecing.

## Thin Places.

Too much soft waste in the mixing. Insufficient twist in the roving. Too much draft at the roving frame or ring frame. Thin places at uneven distances apart are due to stretched roving. Blunt skewer points. A broken tooth in one of the roller wheels.

## Slubs.

A slub in yarn is a soft place which is much too thick, and may be only a fraction of an inch or it may extend for a few inches in length.

The causes are as follows :—

Waste held in spinners hand allowed to catch on the end when piecing up. Fly on creel top adhering to full roving bobbins and not removed before creeling. Too long an overlap when piecing-up ends at the front or when renewing rovings in the creel. Carelessly removing waste from bottom clearer.

## Cloudy Yarn.

The causes are as follows :—

Draft too small. Leather rollers not held in proper position by the cap bar nebs. Leather covered rollers rough, hollow, soft, or channelled. Uneven roving. Bad spinning. Using too much soft waste in mixings or bad blending of cotton with regard to staples. Roving stretched either at the roving frame or whilst unwinding in the ring frame creel.

## Dirty and Oil-Stained Yarn.

The causes are as follows :—

Making piecings of roving or yarn with oily or dirty fingers. Oil escaping from necks of rollers and running on to the actual parts of rollers, thus staining the roving. Full roving bobbins knocked about on the floor and under the frame.

## Crackers.

This fault in yarn is the result of carelessly starting and stopping the ring frame. Mixing cottons which are too widely different in length of staple. Rollers set too close. Travellers too light. Poor leather rollers.

## Ends Breaking Down.

The causes are as follows :—

Draft change wheel of unsuitable size. Twist change wheel too large or not correctly meshed. Cotton weaker than usual. Not enough twist in roving. Travellers too heavy. Excessive seed of ring rails. Top and bottom rollers not kept clean enough. Blunt-pointed roving skewers. Clearers not picked often enough. Bobbins not gripping the spindles properly.

## Waste Cotton Yarns.

The waste produced at the various cleaning and other processes in Cotton–Spinning mills, along with the waste from subsequent stages of manufacturing yarn into cloth, is utilized in several ways. In an ordinary cotton spinning mill it is quite a general practice for certain kinds of waste, such as roving or bobbin waste, and roller clearer waste, to be mixed in along with new cotton at the required juncture, passed through the usual processes, and spun into weft yarn. These yarns are not waste yarns. Proper waste yarns are readily recognised by being dirty, weak, uneven, and composed of short--staple cotton.

Waste cotton yarns are used for many purposes, the most important being either for warp or weft, or both, of certain classes of fabrics such as flanelettes, waste plain sheets, chaddars, blankets, dusters, and towels.

SPEED.

| Diam. of Spindle Warfe. | Diam. of Tin Roller. | Actual Revs. of Tin Roller per minute. | Actual Revs. of Spindle per minute. | Remarks. |
|---|---|---|---|---|
| 7/8″ | 10″ | 894 | 9500 | 7% deduction has been made to allow for the diam. of spindle band, in making the calculation in this table |
| 7/8″ | 10″ | 847 | 9000 | |
| 7/8″ | 10″ | 800 | 8500 | |
| 7/8″ | 10″ | 753 | 8000 | |
| 7/8″ | 10″ | 706 | 7500 | |
| 7/8″ | 10″ | 659 | 7000 | |
| 7/8″ | 10″ | 612 | 6500 | |

## Electric Drive.

Apart from the rated power factor and efficiency the individual drive motors must have some margin in power for changing the speed of the spindles when required, which in the average lowers the power factor still more. Moreover the cost of individual motors, cables and starting equipments add abnormally to the capital expenditure, so that from a commercial point of view the individual drive is not tempting at all although the advocates of individual drive agree that there is much variation of speed and inherent losses by long lengths of belting and shafting. But the proper selection of belt as regards its width, thickness and number of plies and material would eliminate the above trouble. The ring frames should be divided in as many lines as possible. Half of each line should be driven by a 100 B. H. P. pipe ventilated type of motor having roller type of line shaft bearings and driving 22 ring frames of an average of 454 spindles each at 8500 average revs. All together 5–100 B. H. P. motors for 110 ring frames machinery.

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**Table of Weights**—

24 Grains = 1 Dwt. (Troy)
18 Dwts, $5\frac{1}{2}$ Grains or 437.5 Grains = 1 oz. (Avoir)
16 Ozs. or 7000 Grains = 1 Lb.

---

| | | | | | | |
|---|---|---|---|---|---|---|
| 54 Inches | = 1 thread or circumference of wrap reel. | | | | | |
| 4320 „ | = 80 threads | or | 1 Lea or Skein. | | | |
| 30240 „ | = 560 „ | | 7 | „ | „ | 1 Hank or 840 Yards. |

---

The number of Hanks in 1 Lb. is the count of cotton yarn.

A bundle of cotton yarn is as many hanks as make 10 Lbs in weight.

The number by which sewing cotton threads are sold represent three threads of the count twisted together—that is, No. 60's standard thread has 3 strands of No. 60's yarn in it.

In a six-cord thread each of the three strands is made up of two threads twisted together.

Six threads of No. 120's make six cord 12's.

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SPINNING CALCULATIONS.

Draft :—

| | | |
|---|---|---|
| Crown wheel | = | 110 |
| Back roller wheel | = | 60 |
| Change Pinion | = | 52 |
| Front roller wheel | = | 20 |

$$\frac{110 \times 60}{52 \times 20} \times 6.34$$

## Constant for Draft:—

| | |
|---|---|
| Crown wheel | = 110 |
| Back roller wheel | = 60 |
| Front roller wheel | = 20 |

$$\frac{110 \times 60}{20} = 330$$

## Draft Constant :—

$$\frac{\text{Crown wheel} \times \text{Back roller wheel} \times \text{front roller diameter}}{\text{Front roller pinion} \times \text{Back roller diameter.}}$$

## Draft wheel:—

Draft constant $\div$ actual draft required.

To find the draft when two rovings of a different hank are being doubled together.

| | |
|---|---|
| *Example* ;—Hank roving | = 4 |
| Hank roving | = 2 |
| Counts of yarn desired | = 20s |

*Rule* ;—Multiply the two rovings together and divide by their sums to ascertain what hank the two rovings doubled together will equal. Then the counts of yarn desired divided by the hank roving will give the draft.

$4 \times 2 = 8$
$4 \times 2 = 6$
$8 \div 6 = 1.33$ Hank Roving.
$20 \div 1.33 = 15.03$ draft.

## To find the resulting Hank :—

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

Two hanks one 11 and the other 12, will give

$$\frac{11 \times 12}{11 + 12} = \frac{132}{23} = 5.74 \text{ hank.}$$

### Speed of Spindles :—

| | |
|---|---|
| Rev. of Main Shaft | = 250 |
| Drum on ,, ,, | = 33 |
| Pulley on Frame | = 14 |
| Dia. of tin roller | = 10 |
| Dia. of Spindle wharfe | = $\frac{7}{8}''$ |

$$\frac{250 \times 33 \times 10}{14 \times .875} = 6734$$

### To find the Speed of the Spindle.

*Example* :—Revolution of tin roller = 1080
Diameter of tin roller = 10
Diameter of wharf. = $\frac{7}{8}''$ or .875.

*Rule* :—Multiply the revolutions per minute of the tin roller by its diameter and divide the result by the diameter of the wharf.

$$\frac{1080 \times 10}{.875} = 12343 \text{ Revs. per min.}$$

Deduct 5 per cent for band Slippage. 5 % on 12343 = 617
12343—617 = 11726 Revs. per min.

### Constant for Speed of Spindles:—

| | |
|---|---|
| Rev. of main Shaft | = 250 |
| Drum on ,, ,, | = 33 |
| Dia. of tin roller | = 10 |
| ,, ,, Spindle wharf | = $\frac{7}{8}$ |

Add to the dia. of roller and wharfe 1/16″ allowing for the dia. of band.

$$\frac{250 \times 33 \times (10 + 1/16)}{\frac{7}{8} \times 1/16} = 8924$$

Constant ÷ Dia. of pulley = Speed of Spindles.

Speed of Tin Roller :—

| | |
|---|---|
| Rev. of main Shaft | = 250 |
| Drum on main Shaft | = 33 |
| Pulley on frame | = 14 |

$$\frac{250 \times 33}{14} = 589.$$

**Speed of Front Roller:—**

| | |
|---|---|
| Rev. of main Shaft | = 250 |
| Drum on main Shaft | = 33 |
| Pulley on frame | = 14 |
| Tin roller wheel | = 30 |
| Twist carrier | = 100 |
| Twist wheel | = 44 |
| Wheel on end of front roller | = 75 |

$$\frac{250 \times 33 \times 30 \times 44}{100 \times 75 \times 14} = 103$$

**Constant for Speed of Front Roller :—**

| | |
|---|---|
| Rev. of main shaft | = 250 |
| Drum on main Shaft | = 33 |
| Tin Roller wheel | = 30 |
| Twist carrier | = 100 |
| Wheel on end of front roller | = 75 |
| Pulley on frame | = 14 |

$$\frac{250 \times 33 \times 30}{100 \times 75 \times 14} = 2.53$$

Constant $\times$ Twist wheel = Speed of front roller.

**Twist per inch :—**

| | |
|---|---|
| Speed of Spindle | = 6700 |
| ,, ,, front roller | = 103 |
| Circumference of front roller | = 2.75 |

$6700 \div (103 \times 2.75) = 23$ Twist per inch.

**Twist per inch :—**

| | |
|---|---|
| Speed of spindles | = 6700 |
| Delivery in inches | = 282.96 |

$6700 \div 282.96 = 23$ twist per inch.

**To Find the number of Turns Per Inch :—**

Divide the member of turns of the spindle for 1 turn of the front roller by the circumference of the front roller in inches.

Example :—If the number of turns of the spindle to one of the front roller is 3.29 and the diameter of the front roller is $1\frac{1}{4}''$ what is the number of turns per inch being inserted.

$$\frac{3.29}{1.25 \times 3.1416} = .84$$

**Twist per inch from Gearing :—**

$$\frac{\text{Twist wheel carrier} \times \text{front roller wheel} \times \text{diameter of tin roller}}{\text{Tin roller wheel} \times \text{Twist change wheel} \times \text{dia. of Spindle wharfe} \times \text{cir. of front roller.}}$$

**Delivery in Inches :—**

| | | |
|---|---|---|
| Speed of front roller | = | 103 |
| Circumference of front roller | = | 2.75 |

$103 \times 2.75 = 282.96$ inches.

or

Speed of front roller × Dia. of front roller × 3.1416.

**Rev. of Spindle for one of Front Roller :—**

| | | |
|---|---|---|
| Twist carrier | = | 100 |
| Wheel on end of front roller | = | 75 |
| Dia. of tin roller | = | 10 |
| Change pinion | = | 44 |
| Wheel on tin roller | = | 30 |
| Dia. of Spindle wharfe | = | $\frac{7}{8}''$ |
| Dia. of front roller | = | $\frac{7}{8}''$ |

$$\frac{100 \times 75 \times 10 \times 7 \times 8}{44 \times 30 \times 7 \times 8} = 56.80$$

**Constant for Twists :—**

| | | |
|---|---|---|
| Wheel on end of front roller | = | 75 |
| Twist carrier | = | 100 |
| Dia. of tin roller | = | 10 |
| Tin roller wheel | = | 30 |
| Dia. of Spindle wharve | = | $\frac{7}{8}''$ |
| Circumference of front roller | = | 2.75 |

$$\frac{75 \times 100 \times 10}{30 \times .875 \times 2.75} = 1039$$

Constant ÷ twist wheel = twist per inch.

**Actual Draft:—**

Hank roving = 3.75
Counts running = 24

$24 \div 3.75 = 6.40$ Draft.

or

Draft constant÷Draft wheel
add 4 to 16 per cent for milling up.

To find what draft a certain draft wheel will produce when the draft wheel in use and the draft that is produced is known.

*Example ;*—Draft wheel in use = 35T
Draft being produced = 8
Draft wheel is desired to be used = 40T

*Rule ;*—Multiply the draft wheel in use by the draft being produced, and divide this product by the draft wheel to be used.

$$\frac{35 \times 8}{40} = 7 \text{ Draft}$$

**Twist wheel :—**

Speed of front roller = 103
Rev. of tin roller = 589
Tin roller wheel = 30
Carrier = 100
Wheel on end of front roller = 75

$$\frac{75 \times 100 \times 103}{30 \times 589} = 43 \text{ Twist wheel.}$$

or

$$\frac{\text{Sq. root of counts Spinning} \times \text{Twist wheel in use.}}{\text{Sq. root of counts to be spun.}}$$

To find the twist multiplier used for given turns per inch and counts of yarn.

*Example ;*—Counts of yarn = 40s
Turns per inch = 28

*Rule ;*—Divide the turns per inch that is being put in the yarn by the square root of the number of yarn being spun.

$\sqrt{40\text{'s}} = 6.32$
$28 \div 6.32 = 4.43$ Multiplier (const. number)

To find the twist, or turns per inch to put in any counts of yarn.

*Example* ;—Counts of yarn = 16s
Twist Multiplier = 3.5

*Rule* ;—Extract the square root of the counts of yarn and multiply the result by the twist multiplier

$$\sqrt{16} = 4$$

$$4 \times 3.5 = 14.0 \text{ Turns per inch.}$$

## Change Pinion—

| | |
|---|---|
| Front roller wheel | = 20 |
| Twist carrier | = 100 |
| Back roller | = 60 |
| Draft | = 6.40 |

$$\frac{100 \times 60}{20 \times 6.40} = 47 \text{ change pinion.}$$

Change pinion when changing from one hank roving to another and when the counts are the same.

| | |
|---|---|
| Counts to be spun | = 24 |
| Hank roving | = 4.5 |
| Front roller wheel | = 20 |
| Crown wheel | = 110 |
| Back roller wheel | = 60 |

$$\frac{110 \times 60 \times 4.5}{24 \times 20} = \frac{247.5}{4} = 61 \text{ practically.}$$

## To find back Roller Wheel for Draft required.

| | |
|---|---|
| Crown wheel | = 110 |
| Front roller wheel | = 20 |
| Change pinion | = 33 |
| Draft required | = 10 |

$$\frac{33 \times 20 \times 10}{110} = 60 \text{ Back roller wheel.}$$

To find twist wheel when changing from one count to another.

**Sq. root of present count × present twist wheel ÷ sq. root of intended count.**

**Shaper Wheel—**

Sq. root of intended count × present shaper wheel ÷ sq. root of present count.

**Diameter of Yarn—**

Yards in hank ÷ counts of yarn and then find the sq. root of the result.

**Find Change Pinion for Draft required—**

| | |
|---|---|
| Crown wheel | =110 |
| Front roller | = 20 |
| Back roller | = 60 |
| Draft required | = 10 |

$$\frac{110 \times 60}{20 \times 10} = 33$$

1 tooth of pinion wheel = 2 teeth of back roller in making a change.

**Production—**

| | |
|---|---|
| Delivery in inches per min. | =282.96 |
| No. of spindles on frame | =464 |
| Minutes in 10 hours | =600 |
| Counts spinning | = 24 |
| No. of yards in a hank | =840 |
| No. of inches in a yard | = 36 |

$$\frac{282.96 \times 464 \times 600}{840 \times 36 \times 24} = 108 \text{ lbs. per day per frame.}$$

## Loss to be allowed for Doffing and Breakages.

| Counts. | Cotton | Percentages |
|---|---|---|
| 10s to 20s | Indian | 10 |
| 14s to 16s | American | 9 |
| 26s to 24s | ,, | 8 |
| 28s to 32s | ,, | 7 |
| 36s to 40s | ,, | 6 |
| 50s to 80s | Egyptian | 5 |

**Length of time a Bobbin will last on Creel—**

| | |
|---|---|
| Weight of bobbin | = 8 oz. |
| Hank | = 3.75 |
| Draft | = 6.40 |
| Constant | =1890 |
| Rev. of front roller | = 103 |
| Circumference of front roller | = 2.75 |

$$\frac{3 \times 3.75 \times 6.40 \times 1890}{103 \times 2.75} = 1281 \text{ min. or 21 hrs. and 21 min.}$$

**To find Efficiency—**

| | |
|---|---|
| Delivery in inches | =278.5 |
| Ozs. in 1 lb. | = 16 |
| Minutes in 10 hrs. | =600 |
| Yards in a hank | =840 |
| Inches in a yard | = 36 |
| Actual counts being spun | = 24 |

$$\frac{278.3 \times 16 \times 600}{480 \times 36 \times 24} = 3.68 \text{ ozs. per spindle} = 100\%.$$

**To find actual Efficiency of total Spindles—**

| | |
|---|---|
| Total production obtained of 16 frames | = 1593 lbs. |
| 1593 lbs. ×16 (ozs. to a lb.) | =25448 ozs. |
| 464 spindles to a frame (464 ×16 frames) | =7424 spindles |
| 25448÷7424 | = 3.44 ozs. per spindle |
| Actual production | = 3.44 ozs. |
| 100% ,, | = 3.74 ,, |

$$\frac{3.44 \times 100}{3.74} = 91.9\% \text{ actual efficiency.}$$

Constant for 100% Efficiency—

$$\frac{\text{Total min.} \times \text{ozs. to 1 lb.}}{840 \times \text{inches in a yard}} = \frac{610 \times 16}{840 \times 36} = .3227$$

Constant ×delivery in inches÷counts running =100% efficiency.

.3227 ×278.5 =89.87195

89.87195÷24 (counts)=3.74 (100%) ozs. per spindle.

## To Find Draft Wheel when Changing Counts of yarn..

$$\frac{\text{Draft wheel in use} \times \text{counts being spun}}{\text{counts required.}} = \text{New draft wheel.}$$

## To find the Hank Roving to produce a given count of yarn.

| | | |
|---|---|---|
| *Example* :—Count of yarn desired | = | 40 |
| Draft desired | = | 8 |

*Rule* ;—Divide the number of yarn desired by the draft desired.

40÷8 = 5 Hank Roving.

To find the hanks per day per spindle, from speed of front roller.

| | | |
|---|---|---|
| *Example* ;—Circumference of front roller | = | 3.1416 |
| Rev. per minute | = | 160 |
| Minutes in one hour | = | 60 |
| Hours per day | = | 10 |

*Rule* ;—Multiply the circumference of front roller by the revolutions per minute, and by the minutes in one hour, and by the hours per day, and divide the product thus obtained, by 840 ×36.

$$\frac{3.1416 \times 160 \times 60 \times 10}{840 \times 36} = 9.97 \text{ hanks.}$$

The hanks divided by the counts of yarn will show pounds per spindle. Then the pounds multiplied by the number of days run per week or per month, will show the total pounds per week or per month, per Spindle at 100 per cent efficiency. Allowances for stoppages to doff, clean frames, etc. may be made as follows :—

Twist 8s to 14s = about 14% Twist 30s to 40s = about 10%.
,, 15s to 30s = ,, 11% Twist 40s to 50s = ,, 9%.

The allowance for weft will have to be greater in comparison with Twist yarn.

The allowances will depend on the quality of cotton, condition of machinery and class of labour. .

**To Find Draft wheel when Changing Hank Roving only.**

$$\frac{\text{Draft wheel in use} \times \text{New hank roving}}{\text{Hank roving in use.}} = \text{draft wheel for new roving.}$$

**To find Draft wheel when changing Counts of yarn and Hank Roving.**

$$\frac{\text{Counts being spun} \times \text{draft wheel in use} \times \text{new hank roving}}{\text{counts required} \times \text{hank roving in use.}} = \text{new draft wheel.}$$

**To find Draft wheel when front roller pinion and back roller wheel are changed.**

$$\frac{\text{Front roller pinion in use} \times \text{draft wheel in use} \times \text{new back roller wheel}}{\text{Back roller wheel in use} \times \text{new front roller pinion}} = \text{New draft wheel.}$$

**To find Builder wheel.**

$$\frac{\text{Sq. root of counts Spinning} \times \text{Builder wheel in use}}{\text{Sq. root of counts to be spun.}} = \text{New Builder wheel}$$

In some cases the speed of the ring rail must be altered in relation to the front-roller speed, and to effect this change the speed of the heart cam bevel is altered. This is generally done by changing the front roller carrier worm and the worm wheel.

A change in the spindle speed necessitates the driving drum or frame—end pulleys being altered on belt—driven frames, while if a different hank roving or length of staple is used the rollers would require resetting and probably a change made in the type of middle top roller.

**To get weigth of 20s conversion.**

Multiply the gross production of each count by the nominal count and divide by 20s.

### To get Average per spindle (gross).

Reduce the gross production to ounces and divide by the Spindle working.

### To get Average per spindle 20s (converted).

Reduce the converted 20s weight to ounces and divide by working Spindle.

### To find the average count.

Multiply the total weight of production by 20s and divide by the total gross weight.

### To find the average count of yarn when different counts are being spun.

*Example* ;—5000 pounds of 10s
3000 pounds of 20s
6000 ,, ,, 30s
2000 ,, ,, 40s

*Rule* ;—Multiply the pounds produced of each count by the count of yarn or by itself. Add the result obtained, and divide it by the total pounds spun.

$$\begin{array}{rcr} 5000 \times 10 & = & 50000 \\ 3000 \times 20 & = & 60000 \\ 6000 \times 30 & = & 180000 \\ 2000 \times 40 & = & 80000 \\ \hline 16000 & & 370000 \\ \hline \end{array}$$

$$370000 \div 16000 = 23.12 \text{ Av. count.}$$

Q. If 120 yards or 1 lea of yarn weigh 31 grains what are the counts ?

A. $$\frac{120 \times 100}{12 \times 31} = 32.26 \text{ counts}$$

Or.

$$1000 \div 31 \text{ grains} = 32.26 \text{ counts.}$$

Q. If a ring frame is spinning 30's with a 40 change pinion wheel on, find wheel required to spin 40's.

A. $\dfrac{30 \times 40}{40} = 30$ wheel required.

Q. If a ring frame is spinning 30's with a 40 pinion and a 48 back roller, and it is required to change 48 for a 42 back roller wheel, find change pinion required.

A. $\dfrac{42 \times 40}{48} = 35$ wheel required.

Q. If a ring frame is spinning 32's with a 40 change pinion and 120 crown wheel and it is desired to change the 120 crown wheel for 110 crown wheel, find change pinion required.

A. $\dfrac{40 \times 110}{120} = 36.66$ wheel required.

Q. If a ring frame is spinning 32's with a 40 ratchet wheel and you are required to change it to 40's. Find ratchet wheel required.

A. Find sq. root of 32's which is $= 5.66$
" " 40's " $= 6.32$

$\dfrac{6.32 \times 40}{5.66} = 44$ wheel required.

Q. If a ring frame is spinning 32's with a 44 twist wheel, and it is required to change it to 40's

A. Find the sq. root of 32's which is $= 5.6$
" " 40's " $= 6.32$

$\dfrac{5.66 \times 44}{6.32} = 39$ wheel required.

Q. A ring frame spindle is making 900 revolutions per minute and the traveller when working on empty bobbin loses 202 revolutions per minute. Find revolutions of the traveller.

A. 900—202 =8798 Revs. of traveller.

**To find speed of spindles if speed of front roller turns per inch and diameter of front roller are given.**

*Example ;—*

| | |
|---|---|
| Speed of front roller | = 152 |
| Turns per inch | = 19.81 |
| Dia. of front roller | = $\frac{7}{8}''$ |

2.75 ×152 =418

418 ×1981 =8280 speed of spindles.

**To find the speed of front roller from the speed of spindle turns per inch and dia. of rollers.**

*Example ;—*

| | |
|---|---|
| Speed of spindles | =4524 |
| Turns per inch | = 8 |
| Circumference of front roller | = 3.1416 |
| 4524÷8 | = 565.5 |

565.5÷3.1416 = speed of front roller.

Details of Ring Twist Frame (D. & B.)

| | |
|---|---|
| Line shaft speed | 250 |
| Pulley on the shaft | 33 |
| ,, ,, Frame | 11 |
| Tin roller speed | 750 |
| Tin roller wheel | 30 |
| Dia. of tin roller | 10″ |
| ,, ,, spindle wharfe | $\frac{7}{8}''$ |
| Speed of spindle | 8,571 |
| Twist carrier | 100 |
| Large front roller end wheel | 70 |
| Small front roller wheel | 20 |
| Crown wheel | 110 |
| Back roller wheel | 60 |
| Diameter of ring | $1\frac{3}{4}''$ |
| Diameter of front roller | $\frac{7}{8}''$ |
| Space of spindles | $2\frac{3}{4}''$ |
| Diameter of middle roller | $\frac{3}{4}''$ |
| Diameter of back roller | $\frac{7}{8}''$ |
| Length of lift | $5\frac{1}{2}''$ |
| Lines of rollers | 3 |

**Particulars of Ring Frame Machinery.**

| Description. | No. | No. of Spindles. | Date. | Maker. | REMARKS. |
|---|---|---|---|---|---|
| Twist Frame .. | 14 | 500 | 1924 | D. & B. | Each. |
| ,, ,, .. | 7 | 460 | ,, | ,, | ,, |
| ,, ,, .. | 40 | 400 | ,, | ,, | ,, |
| Weft Frame .. | 40 | 464 | ,, | ,, | ,, |
| ,, ,, .. | 9 | 560 | ,, | ,, | ,, |
| | 110 | 49748 | | | |

## POWER.

About 70 ring Spindles, running at 8,500 revs. per minute, require about one horse power, excludng power for line Shaft etc.

## STORES CONSUMED.

| Description. | Quantity. No. | Quantity. Lbs. | Per. | |
|---|---|---|---|---|
| Leather Belting .. | 22′ | | M. | All sizes. |
| Tubular Banding .. | | 69 | ,, | |
| Grease Lubricator .. | | 11 | ,, | |
| Oil Velocite E. .. | | 92 | ,, | |
| ,, Carding 90 R. .. | | 187 | ,, | |
| ,, Castor .. .. | | 7 | ,, | |
| ,, Power Extra Heavy | | 9 | ,, | |
| Ring Traveller .. .. | 10 Boxes | | ,, | All sizes. |
| Rings .. .. .. | 10 | | ,, | |
| Emery Cloth .. .. | 2 | | ,, | |
| Brooms Palm .. .. | 130 | | ,, | |
| Cane Basket .. .. | 22 | | ,, | |
| Footstep (China) .. | 30 | | ,, | |
| Tube for Spindle .. | 6 | | ,, | |
| Soda Ash .. .. | | ½ | ,, | |
| Acid Acetic .. .. | | ½ | ,, | |
| Hessian Cloth .. .. | 4 Yds. | | ,, | |
| Hacksaw Blade 12″ .. | 1 | | ,, | |
| Skewers .. .. .. | 230 | | ,, | |
| Disinfectant .. .. | | 1½ | ,, | |

## HANDS EMPLOYED.

| Designation. | No. | Amount. Rs. | As. | P. | Per. | Remarks |
|---|---|---|---|---|---|---|
| Head Mistry .. .. | 1 | 50 | 0 | 0 | M. | |
| Asst. ,, .. .. .. | 1 | 35 | 0 | 0 | ,, | |
| ,, ,, .. .. | 1 | 30 | 0 | 0 | ,, | |
| ,, ,, .. .. | 1 | 29 | 0 | 0 | ,, | |
| ,, ,, .. .. | 1 | 29 | 0 | 0 | ,, | |
| ,, ,, .. .. | 1 | 26 | 0 | 0 | ,, | |
| ,, ,, .. .. | 1 | 25 | 0 | 0 | ,, | |
| Head Fitter .. .. | 1 | 80 | 0 | 0 | ,, | |
| Asst. ,, .. .. .. | 1 | 50 | 0 | 0 | ,, | |
| ,, ,, .. .. | 1 | 30 | 0 | 0 | ,, | |
| Carpenter .. .. | 1 | 35 | 0 | 0 | ,, | |
| Roller Coverer .. .. | 1 | 32 | 0 | 0 | ,, | |
| Asst. ,, .. .. | 1 | 18 | 0 | 0 | ,, | |
| ,, ,, .. .. | 1 | 15 | 0 | 0 | ,, | |
| ,, ,, .. .. | 1 | 14 | 0 | 0 | ,, | |
| Banding man and Oiler | 6 | 19 | 0 | 0 | ,, (each) | |
| Bobbin Carrier .. .. | 6 | 18 | 0 | 0 | ,, ,, | |
| ,, ,, .. .. | 13 | 15 | 0 | 0 | ,, ,, | |
| Twist Piecers .. .. | 82 | 18 | 0 | 0 | ,, ,, | |
| ,, ,, .. .. | 40 | 19 | 0 | 0 | ,, ,, | |
| Weft ,, .. .. | 18 | 21 | 0 | 0 | ,, ,, | |
| ,, ,, .. .. | 80 | 20 | 0 | 0 | ,, ,, | |
| Spare ,, .. .. | 25 | 14 | 0 | 0 | ,, ,, | |
| Doffers .. .. .. | 58 | 12 | 0 | 0 | ,, ,, | |
| Special Doffers .. .. | 8 | 12 | 12 | 0 | ,, ,, | |
| Head Doffers .. .. | 5 | 22 | 0 | 0 | ,, ,, | |
| Sweepers .. .. | 11 | 11 | 0 | 0 | ,, ,, | |
| Mochi .. .. .. | 1 | 20 | 0 | 0 | ,, ,, | |
| Spindle Oilers .. .. | 2 | 25 | 0 | 0 | ,, ,, | |
| Fitter Coolie .. .. | 2 | 15 | 0 | 0 | ,, ,, | |
| Ring Cleaner .. .. | 1 | 15 | 0 | 0 | ,, ,, | |

## DIMENSIONS OF SPINNING ROOM.

| Size of Room. | | | Doors. | | Windows. | | Skylights. | | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| L. | B. | H. | No. | Size. | No. | Size. | No. | Size. | |
| 382 | 116 | 11′-6″ | 3 | 8′ × 6′ | 42 | 8′ × 6′ | 5 | 10′-6″ × 4′ | |
| | | | 2 | $7\frac{1}{2}$′ × $4\frac{1}{2}$′ | | | | | |
| | | | 1 | 8′ × 8′ | | | | | |
| | | | 1 | 5′ × $7\frac{1}{2}$′ | | | | | |

## DIMENSION OF WASTE PLANT ROOM.

| Size of Room. | | | Doors. | | Windows. | | |
|---|---|---|---|---|---|---|---|
| L. | B. | H. | No. | Size. | No. | Size. | |
| 124′ | 70′ | 12′—6″ | 1 | 7′—6″ × 5′—6″ | 19 | 7′—0″ × 5′—3″ | |

## DIRECTION OF TWIST IN YARNS.

As the direction of twist is important in many fabrics, it is desirable that in the analysis of every sample there should appear a record of the direction of twist in each set of threads. Take the thread to be examined between the finger and thumb of each hand, first turn from you with the right hand, if the twist runs out then the yarn has been spun T. way; if however, the twist comes out by turning towards you with the right hand, then the yarn has been Spun Weft way.

## YARN TESTING FOR COUNTS Etc.

The following physical properties of the yarn are very importan t and both the spinners and manufacturers should consider them in dealing with yarn.

(1) Counts (2) Percentage of moisture (3) Length of yarn of on bobbin, cop or in hank (4) Elasticity (5) Strength (6) Evenness (7) Twist per inch (8) colour. When cotton yarn is removed from the spindle it will be found to be very dry and lighter unless there is humidification arrangement in the spinning department.

The first operation, for testing yarn for counts, is to reel a certain length of yarn on a machine known as a "wrap reel". The wrap reel is also used to find the length of yarn in a hank, and to wrap yarns from bobbins or cops into leas or hanks for testing their strength.

The circumference of a reel is $1\frac{1}{2}$ yard. So 80 turns gives 120 yards of yarn, or one lea. When yarn is reeled it is removed tested on a testing machine for strength and then weighed on a pair of scales and the counts obtained thus :—

*Example* ;—120 yards weigh 40 grains.

$\therefore 1000 \div 40 = 25$s counts.

The factors that affect the elasticity and the strength of the yarn are as follows :—(1) Length of fibre (2) Twist in the fibre (3) fineness of fibre (4) whether or not it contains any natural wax (5) The hygroscopic and temperature conditions during production (6) The counts of the yarn (7) The twist in the yarn (8) The moisture the thread contains during testing.

Both the strength and stretch or elasticity of the yarn is ascertained at the same time and in one operation on a type of machine known as lea tester.

Certain yarn testing machines are made for working by hand and others by power, but the latter one is recommended as the results of tests, with a constant speed, are more even on the latter, and the averages more accurate than those obtained from a machine worked by hand at varying speeds. In comparing strength tests it is very essential that the speed of traverse of lower hook is alike in each case, the standard speed being 12″ per minute. Also the condition of the yarn on bobbins or in cops must be taken into account, tests of yarn taken from conditioned cops or bobbins show a greater breaking strain than those which have been for a while in testing room. Variations will result even between cops or bobbins taken from the lower or upper portion of the same skip.

## TEST FOR IMPORTED YARN.

After spinning, cotton yarn is 'conditioned,' *i.e.*, treated with a fine spray of water, or steamed in a room made for the purpose to give it the moisture necessary for imparting pliability—perfectly dry cotton being brittle. As cotton has hygroscopic properties which enable it to absorb up to 8 per cent of moisture (on the average) from the atmosphere, cotton yarn which contains that amount of moisture is called 'natural cotton'. Anything in excess is illegitimate.

Some spinners add calcium chloride or magnesium chloride or both, sometimes with, sometimes without, the addition of zinc chloride, thereby increasing the hygroscopic property of the yarn—which enables water to be sold as cotton.

Yarn should be tested, therefore, for the presence of 'chlorides' by steeping it in warm distilled water for some time and testing the liquor with silver nitrate solution. A white precipitate, insoluble in nitric acid and soluble in ammonia, proves the presence of chlorides.

In some cases it may be desirable, and even necessary, to add zinc chloride when conditioning, *e.g.*, in very coarse yarns which will be woven up after stocking it for some length of time to prevent mildew.

## Testing Yarn for Strength and Stretch to Breaking.

The strength anfl stretch of yarn under tension are two of its most important features, and samples of all yarns should be tested before being put into work. The results of these tests should be recorded. There are various methods and practices in use for testing and estimating the strength and stretch of the yarn. Some prefer a careful observation of the material as it passes through the winding and warping processes, it being assumed that if it stands this test successfully there will be no trouble in weaving. The principal objection to this method of testing the material is well advanced before its faults, if any can be detected.

Whilst it is very desirable that the strength of a yarn should be determined by single thread testing, and time occupied in making a sufficient number of tests is rather considerable, and this has probably retarded the more extensive use of this type of apparatus. An advantage of simgle thread testing is the great amount of variation in the yarn is disclosed as compared with that shown in lea testing.

Q. A 28s ring yarn with a mean single thread break of 8.875 ozs Find the breaking length in yards.

A. $$\frac{\text{Mean single thread in ozs} \times \text{count} \times 840}{16 \text{ ozs.}}$$

$$\frac{8.875 \times 28 \times 840}{16} = 13046 \text{ yards.}$$

*Twist Testing ;—*

The strength and appearance of yarn being so greatly affected by the amount of twist put in during Spinning or doubling, it is necessary to make systematic tests for twists.

It is very important to examine yarns more closely for faults, such as uneven places, knots, neps, etc.

The threads are drawn from one or more bobbins or cops and spread evenly upon a piece of cardboard with a dead black surface. The guider spreads the threads over this blackboard with sufficient space to enable defects to be seen. When sufficient yarn has been wound the board is removed, and another placed in the clips for the next test. The machine used for this purpose is known as machine used for testing the quality and evenness of yarn.

## GASSED YARNS.

To determine if a yarn is gassed, draw a few warp threads out of the sample and examine under a strong glass, and, if a very smooth surface is seen, the yarn has been gassed. Gassed yarns are rapidly passed through a gas flame or over a hot single plate to burn off the projecting fibres and make the thread very smooth and round. Generally used for the better types of fabrics such as poplins, voiles, etc.

**Counts of yarn, with weight in grains, and strength in lbs., of one Lea.**

| Counts. | Grains | Breaking Strength | | | | | Counts. | Grains. | Breaking Strength | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ordinary Quality. | Fair Quality. | Good Quality. | Extra Quality. | Sup. Extra Quality | | | Ordinary Quality. | Fair Quality. | Good Quality. | Extra Quality. | Sup. Extra Quality. |
| 4 | 250 | 350 | | 410 | | | 18.18 | 55.00 | | | | | |
| 5 | 200 | 280 | | 328 | | | 18.51 | 54.00 | | | | | |
| 6 | 166.66 | 240 | | 275 | | | 18.86 | 53.00 | | | | | |
| 6.94 | 144.00 | | | | | | 19 | 52.63 | | | | | |
| 7 | 142.85 | 205 | | 235 | | | 19.23 | 52.00 | | | | | |
| 7.14 | 140.00 | | | | | | 19.60 | 51.00 | | | | | |
| 7.35 | 136.00 | | | | | | 20.00 | 50.00 | 68 | 69 | 71 | 72 | 74 |
| 7.37 | 132.00 | | | | | | 20.40 | 49.00 | | | | | |
| 7.81 | 128.00 | | | | | | 20.83 | 48.00 | | | | | |
| 8 | 125.00 | 140 | | 209 | | | 21 | 47.61 | | | | | |
| 8.06 | 124.00 | | | | | | 21.05 | 47.50 | | | | | |
| 8.33 | 120.00 | | | | | | 21.27 | 47.00 | | | | | |
| 8.62 | 116.00 | | | | | | 21.50 | 46.50 | | | | | |
| 8.92 | 112.00 | | | | | | 21.73 | 46.00 | | | | | |
| 9 | 111.11 | 132 | | 180 | | | 21.97 | 45.50 | | | | | |
| 9.25 | 108.00 | | | | | | 22 | 45.45 | 61 | 63 | 64 | 66 | 67 |
| 9.61 | 104.00 | | | | | | 22.22 | 45.00 | | | | | |
| 10 | 100.00 | 115 | 120 | 125 | 130 | 135 | 22.47 | 44.50 | | | | | |
| 10.41 | 96.00 | | | | | | 22.72 | 44.00 | | | | | |
| 10.63 | 94.00 | | | | | | 22.98 | 43.50 | | | | | |
| 10.86 | 92.00 | | | | | | 23 | 43.47 | | | | | |
| 11 | 90.90 | 102 | 104 | 106 | 108 | 111 | 23.25 | 43.00 | | | | | |
| 11.11 | 90.00 | | | | | | | | | | | | |
| 11.36 | 88.00 | | | | | | 23.52 | 42.50 | | | | | |
| 11.62 | 86.00 | | | | | | 23.80 | 42.00 | | | | | |
| 11.90 | 84.00 | | | | | | 24 | 41.66 | 58 | 60 | 61 | 62 | 64 |
| 12 | 83.33 | 96 | 99 | 100 | 103 | 105 | 24.09 | 41.50 | | | | | |
| 12.19 | 82.00 | | | | | | 24.39 | 41.00 | | | | | |
| 12.50 | 80.00 | | | | | | 24.69 | 40.50 | | | | | |
| 12.82 | 78.00 | | | | | | 25 | 40.00 | | | | | |
| 13 | 76.92 | 91 | 93 | 96 | 98 | 100 | 25.31 | 39.50 | | | | | |
| 13.15 | 76.00 | | | | | | 25.64 | 39.00 | | | | | |
| 13.51 | 74.00 | | | | | | 25.97 | 38.50 | | | | | |
| 13.88 | 72.00 | | | | | | 26 | 38.46 | 54 | 56 | 57 | 58 | 59 |
| 14 | 71.42 | 89 | 91 | 93 | 95 | 97 | 26.31 | 38.00 | | | | | |
| 14.08 | 71.00 | | | | | | 26.66 | 37.50 | | | | | |
| 14.28 | 70.00 | | | | | | 27 | 37.03 | | | | | |
| 14.49 | 69.00 | | | | | | 27.02 | 37.00 | | | | | |
| 14.70 | 68.00 | | | | | | 27.39 | 36.50 | | | | | |
| 14.92 | 67.00 | | | | | | 27.77 | 36.00 | | | | | |
| 15 | 66.66 | 83 | 85 | 87 | 89 | 91 | 28 | 35.71 | 50 | 51 | 52 | 53 | 53 |
| 15.15 | 66.00 | | | | | | 28.16 | 35.50 | | | | | |
| 13.38 | 65.00 | | | | | | 28.57 | 35.00 | | | | | |
| 13.62 | 64.00 | | | | | | 28.98 | 34.50 | | | | | |
| 15.87 | 63.00 | | | | | | 29 | 34.48 | | | | | |
| 16 | 62.50 | 81 | 83 | 85 | 87 | 89 | 29.41 | 34.00 | | | | | |
| 16.12 | 62.00 | | | | | | 29.85 | 33.50 | | | | | |
| 16.39 | 61.00 | | | | | | 30 | 33.33 | 48 | 49 | 51 | 52 | 55 |
| 16.66 | 60.00 | | | | | | 30.30 | 33.00 | | | | | |
| 16.94 | 59.00 | | | | | | 30.76 | 32.50 | | | | | |
| 17 | 58.82 | 76 | 78 | 80 | 82 | 83 | 31 | 32.25 | | | | | |
| 17.24 | 58 | | | | | | 31.25 | 32.00 | | | | | |
| 17.54 | 57 | | | | | | 31.74 | 31.50 | | | | | |
| 17.85 | 56 | | | | | | 32 | 31.25 | 45 | 46 | 47 | 48 | 49 |
| 18 | 55.55 | 72 | 74 | 76 | 77 | 79 | 32.25 | 31.00 | | | | | |

**Counts of yarn, with weight in grains, and Strength in lbs., in one Lea.**- contd

| Counts. | Grains. | Breaking Strength. | | | | | Counts. | Grains. | Breaking Strength. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ordinary Quality. | Fair Quality. | Good Quality. | Extra Quality. | Sup. Extra Quality. | | | Ordinary Quality. | Fair Quality. | Good Quality. | Extra Quality. | Sup. Extra Quality. |
| 32.78 | 30.50 | | | | | | 54 | 18.51 | 30 | 31 | 32 | 33 | 34 |
| 33 | 30.30 | | | | | | 54.05 | 18.50 | | | | | |
| 33.33 | 30.00 | | | | | | 54.79 | 18.25 | | | | | |
| 33.89 | 29.50 | | | | | | 55 | 18.18 | 30 | 31 | 32 | 32 | 33 |
| 34 | 29.41 | 44 | 45 | 46 | 47 | 48 | 55.55 | 18.00 | | | | | |
| 34.48 | 29.00 | | | | | | 56 | 17.85 | 29 | 30 | 31 | 32 | 33 |
| 35 | 28.57 | | | | | | 56.33 | 17.75 | | | | | |
| 35.08 | 28.50 | | | | | | 57 | 17.54 | 29 | 30 | 31 | 32 | 33 |
| 35.71 | 28.00 | | | | | | 57.14 | 17.50 | | | | | |
| 36 | 27.77 | 42 | 43 | 44 | 45 | 46 | 57.97 | 17.25 | | | | | |
| 36.36 | 27.50 | | | | | | 58 | 17.24 | 28 | 29 | 30 | 31 | 32 |
| 37 | 27.02 | | | | | | 58.82 | 17.00 | | | | | |
| 37.03 | 27.00 | | | | | | 59 | 16.94 | 28 | 29 | 30 | 31 | 32 |
| 37.73 | 26.50 | | | | | | 59.70 | 16.75 | | | | | |
| 38 | 26.31 | 39 | 40 | 41 | 42 | 43 | 60 | 16.66 | 27 | 28 | 29 | 29 | 30 |
| 38.46 | 26.00 | | | | | | 60.60 | 16.50 | | | | | |
| 39 | 25.64 | | | | | | 61 | 16.39 | 27 | 28 | 29 | 29 | 30 |
| 39.21 | 25.50 | | | | | | 61.53 | 16.25 | | | | | |
| 40 | 25.00 | 39 | 40 | 41 | 42 | 43 | 62 | 16.12 | 27 | 28 | 29 | 29 | 30 |
| 40.81 | 24.50 | | | | | | 62.50 | 16.00 | | | | | |
| 41 | 24.39 | | | | | | 63 | 15.87 | 26 | 27 | 28 | 28 | 29 |
| 41.66 | 24.00 | | | | | | 63.49 | 15.75 | | | | | |
| 42 | 23.80 | 38 | 39 | 40 | 41 | 42 | 64 | 15.62 | 26 | 27 | 28 | 28 | 29 |
| 42.10 | 23.75 | | | | | | 64.51 | 15.50 | | | | | |
| 42.55 | 23.50 | | | | | | 65 | 15.38 | 25 | 26 | 27 | 27 | 28 |
| 43 | 23.25 | | | | | | 65.67 | 15.25 | | | | | |
| 43.01 | 23.25 | | | | | | 66 | 15.15 | 25 | 26 | 27 | 27 | 28 |
| 43.47 | 23.00 | | | | | | 66.66 | 15.00 | | | | | |
| 43.95 | 22.75 | | | | | | 67 | 14.92 | 25 | 26 | 27 | 27 | 28 |
| 44 | 22.72 | 35 | 36 | 37 | 38 | 39 | 67.79 | 14.75 | | | | | |
| 44.44 | 22.50 | | | | | | 68 | 14.70 | 25 | 26 | 27 | 27 | 28 |
| 44.94 | 22.25 | | | | | | 68.96 | 14.50 | | | | | |
| 45 | 22.22 | | | | | | 69 | 14.49 | 24 | 25 | 25 | 26 | 27 |
| 45.45 | 22.00 | | | | | | 70 | 14.28 | 24 | 25 | 25 | 26 | 27 |
| 45.97 | 21.75 | | | | | | 70.17 | 14.25 | | | | | |
| 46 | 21.73 | 33 | 34 | 35 | 36 | 37 | 71 | 14.08 | 23 | 24 | 24 | 25 | 26 |
| 46.51 | 21.50 | | | | | | 71.42 | 14.00 | | | | | |
| 47 | 21.27 | | | | | | 72 | 13.88 | 23 | 24 | 24 | 25 | 26 |
| 47.05 | 21.25 | | | | | | 72.72 | 13.75 | | | | | |
| 47.61 | 21.00 | | | | | | 73 | 13.69 | 23 | 24 | 24 | 25 | 26 |
| 48 | 20.83 | 32 | 33 | 34 | 35 | 36 | 74 | 13.51 | 22 | 23 | 24 | 24 | 25 |
| 48.19 | 20.75 | | | | | | 74.07 | 13.50 | | | | | |
| 48.78 | 20.50 | | | | | | 75 | 13.33 | 22 | 23 | 24 | 24 | 25 |
| 49 | 20.40 | | | | | | 75.47 | 13.25 | | | | | |
| 49.38 | 20.25 | | | | | | 76 | 13.15 | 22 | 22 | 23 | 23 | 24 |
| 50 | 20.00 | 32 | 33 | 33 | 34 | 35 | 76.92 | 13.00 | 22 | 22 | 23 | 23 | 24 |
| 50.63 | 19.75 | | | | | | 77 | 12.98 | 22 | 22 | 23 | 23 | 24 |
| 51 | 19.60 | 31 | 32 | 33 | 34 | 35 | 78 | 12.82 | 22 | 22 | 23 | 23 | 24 |
| 51.28 | 19.50 | | | | | | 78.43 | 12.75 | | | | | |
| 51.93 | 19.25 | | | | | | 79 | 12.65 | 22 | 22 | 23 | 23 | 24 |
| 52 | 19.23 | 31 | 32 | 33 | 34 | 35 | 80.00 | 12.50 | 22 | 22 | 23 | 23 | 24 |
| 52.63 | 19.00 | | | | | | 81 | 12.34 | | | | | |
| 53 | 18.86 | 30 | 31 | 32 | 33 | 34 | 81.63 | 12.25 | | | | | |
| 53.33 | 18.75 | | | | | | 82 | 12.19 | 20 | 21 | 21 | 22 | 23 |

## YARN TABLE (in Grains).

**Method of Using:** Weigh 1 Lea (120 yards), 2 Leas, 3 leas or 4 Leas of yarn; find the weight of same in grains under its respective column; and opposite in first column (marked Counts) will be found the correct Counts of the yarn.

| Counts No. of Hanks per lb. | 1 Lea Grains | 2 Leas Grains | 3 Leas Grains | 4 Leas Grains | Counts No. of Hanks per lb. | 1 Lea Grains | 2 Leas Grains | 3 Leas Grains | 4 Leas Grains |
|---|---|---|---|---|---|---|---|---|---|
| 5 | 200.00 | 400.00 | 600.00 | 800.00 | 16 | 62.50 | 125.00 | 187.50 | 250.00 |
| 5¼ | 190.47 | 380.95 | 571.42 | 761.90 | 16¼ | 61.53 | 123.07 | 184.61 | 246.15 |
| 5½ | 181.81 | 363.63 | 645.43 | 727.27 | 16½ | 60.60 | 121.21 | 181.81 | 242.42 |
| 5¾ | 173.91 | 347.82 | 521.73 | 695.64 | 16¾ | 59.70 | 119.40 | 179.10 | 238.80 |
| 6 | 166.66 | 333.33 | 499.99 | 666.66 | 17 | 58.82 | 117.64 | 176.46 | 235.29 |
| 6¼ | 160.00 | 320.00 | 480.00 | 640.00 | 17¼ | 57.97 | 115.94 | 173.91 | 231.88 |
| 6½ | 153.84 | 307.69 | 461.52 | 615.38 | 17½ | 57.14 | 114.28 | 171.42 | 228.57 |
| 6¾ | 148.14 | 296.29 | 444.44 | 592.59 | 17¾ | 56.33 | 112.67 | 169.01 | 225.35 |
| 7 | 142.85 | 285.71 | 428.56 | 571.42 | 18 | 55.55 | 111.11 | 166.66 | 222.22 |
| 7¼ | 137.93 | 275.86 | 413.79 | 551.72 | 18¼ | 54.73 | 109.47 | 164.21 | 218.95 |
| 7½ | 133.33 | 266.66 | 399.99 | 533.33 | 18½ | 54.05 | 108.10 | 162.15 | 216.21 |
| 7¾ | 129.03 | 258.06 | 387.09 | 516.12 | 18¾ | 53.33 | 106.66 | 159.99 | 213.33 |
| 8 | 125.00 | 250.00 | 375.00 | 500.00 | 19 | 52.63 | 105.26 | 157.89 | 210.52 |
| 8¼ | 121.21 | 242.42 | 363.63 | 484.84 | 19¼ | 51.84 | 103.68 | 155.53 | 207.37 |
| 8½ | 117.64 | 235.29 | 352.93 | 470.58 | 19½ | 51.28 | 102.56 | 153.84 | 205.12 |
| 8¾ | 114.28 | 228.57 | 342.85 | 457.14 | 19¾ | 50.62 | 101.25 | 151.88 | 202.50 |
| 9 | 111.11 | 222.22 | 333.33 | 444.44 | 20 | 50.00 | 100.00 | 150.00 | 200.00 |
| 9¼ | 108.11 | 216.21 | 324.32 | 432.43 | 20¼ | 49.38 | 98.76 | 148.14 | 197.32 |
| 9½ | 105.26 | 210.52 | 315.78 | 421.05 | 20½ | 48.78 | 97.56 | 146.34 | 195.12 |
| 9¾ | 102.56 | 205.13 | 307.69 | 410.25 | 20¾ | 48.19 | 96.38 | 144.57 | 192.76 |
| 10 | 100.00 | 200.00 | 300.00 | 400.00 | 21 | 47.61 | 95.23 | 142.85 | 190.47 |
| 10¼ | 97.56 | 195.12 | 292.68 | 390.24 | 21¼ | 47.05 | 94.11 | 141.17 | 188.23 |
| 10½ | 95.23 | 190.47 | 285.70 | 380.95 | 21½ | 46.51 | 93.02 | 139.53 | 186.04 |
| 10¾ | 93.02 | 186.04 | 279.06 | 372.09 | 21¾ | 45.97 | 91.95 | 137.93 | 183.90 |
| 11 | 90.90 | 181.81 | 272.71 | 363.63 | 22 | 45.45 | 90.90 | 136.36 | 181.81 |
| 11¼ | 88.88 | 177.77 | 266.66 | 355.55 | 22¼ | 44.94 | 89.88 | 134.82 | 179.77 |
| 11½ | 86.95 | 173.91 | 260.86 | 347.82 | 22½ | 44.44 | 88.88 | 133.33 | 177.77 |
| 11¾ | 85.10 | 170.21 | 255.31 | 340.42 | 22¾ | 43.95 | 87.91 | 131.86 | 175.82 |
| 12 | 83.33 | 166.66 | 249.99 | 333.33 | 23 | 43.47 | 86.95 | 130.42 | 173.91 |
| 12¼ | 81.63 | 163.26 | 244.89 | 326.52 | 23¼ | 43.01 | 86.02 | 129.03 | 172.04 |
| 12½ | 80.00 | 160.00 | 240.00 | 320.00 | 23½ | 42.55 | 85.10 | 127.65 | 170.20 |
| 12¾ | 78.43 | 156.86 | 235.29 | 313.72 | 23¾ | 42.10 | 84.21 | 126.31 | 168.42 |
| 13 | 76.92 | 153.84 | 230.76 | 307.68 | 24 | 41.66 | 83.33 | 124.99 | 166.66 |
| 13¼ | 75.47 | 150.94 | 226.41 | 301.88 | 24¼ | 41.23 | 82.47 | 123.71 | 164.94 |
| 13½ | 74.07 | 148.14 | 222.21 | 296.29 | 24½ | 40.81 | 81.63 | 122.45 | 163.26 |
| 13¾ | 72.72 | 145.45 | 218.18 | 290.90 | 24¾ | 40.40 | 80.80 | 121.21 | 161.61 |
| 14 | 71.42 | 142.85 | 214.27 | 285.71 | 25 | 40.00 | 80.00 | 120.00 | 160.00 |
| 14¼ | 70.17 | 140.35 | 210.52 | 280.70 | 25½ | 39.21 | 78.43 | 117.64 | 156.86 |
| 14½ | 68.96 | 137.93 | 206.89 | 275.86 | 26 | 38.46 | 76.92 | 115.38 | 153.84 |
| 14¾ | 67.79 | 135.39 | 203.38 | 271.18 | 26½ | 37.73 | 75.47 | 113.20 | 150.94 |
| 15 | 66.66 | 133.33 | 199.99 | 206.66 | 27 | 37.03 | 74.07 | 111.10 | 148.14 |
| 15¼ | 65.67 | 131.14 | 196.72 | 262.29 | 27½ | 36.36 | 72.72 | 109.08 | 145.45 |
| 15½ | 64.51 | 129.03 | 193.54 | 258.06 | 28 | 35.71 | 31.42 | 107.13 | 142.85 |
| 15¾ | 63.49 | 126.98 | 190.47 | 253.97 | 28½ | 35.08 | 70.17 | 105.26 | 140.35 |

**Yarn Table (in Grains)**—contd.

| Counts No. of Hanks per lb. | 1 Lea Grains | 2 Leas Grains | 3 Leas Grains | 4 Leas Grains | Counts No. of Hanks per lb. | 1 Lea Grains | 2 Leas Grains | 3 Leas Grains | 4 Leas Grains |
|---|---|---|---|---|---|---|---|---|---|
| 29 | 34.48 | 68.96 | 103.44 | 137.93 | 55 | 18.18 | 36.36 | 54.54 | 72.72 |
| 29½ | 33.89 | 67.79 | 101.69 | 135.59 | 56 | 17.85 | 35.71 | 53.56 | 71.42 |
| 30 | 33.33 | 66.66 | 99.99 | 133.33 | 57 | 17.54 | 35.08 | 52.62 | 70.17 |
| 30½ | 32.78 | 65.57 | 98.35 | 131.14 | 58 | 17.24 | 34.48 | 51.72 | 68.96 |
| 31 | 32.25 | 64.51 | 96.77 | 129.03 | 59 | 16.94 | 33.89 | 50.83 | 67.79 |
| 31½ | 31.74 | 63.49 | 95.23 | 126.98 | 60 | 16.66 | 33.33 | 49.99 | 66.66 |
| 32 | 31.25 | 62.50 | 93.75 | 125.00 | 61 | 16.39 | 32.78 | 49.17 | 65.57 |
| 32½ | 30.76 | 61.53 | 92.29 | 123.07 | 62 | 16.12 | 32.25 | 48.37 | 64.51 |
| 33 | 30.30 | 60.60 | 90.90 | 121.21 | 63 | 15.87 | 31.74 | 47.61 | 63.49 |
| 33½ | 29.85 | 59.70 | 89.55 | 119.40 | 64 | 15.62 | 31.25 | 46.87 | 62.50 |
| 34 | 29.41 | 58.82 | 88.53 | 117.64 | 65 | 15.38 | 30.76 | 46.14 | 61.53 |
| 34½ | 28.98 | 57.97 | 86.95 | 115.94 | 66 | 15.15 | 30.30 | 45.45 | 60.60 |
| 35 | 28.57 | 57.14 | 85.71 | 114.28 | 67 | 14.92 | 29.85 | 44.77 | 59.70 |
| 35½ | 28.16 | 56.33 | 84.50 | 112.67 | 68 | 14.70 | 29.41 | 44.11 | 58.82 |
| 36 | 27.77 | 55.55 | 83.33 | 111.11 | 69 | 14.49 | 28.98 | 43.47 | 57.97 |
| 36½ | 27.39 | 54.79 | 82.18 | 109.58 | 70 | 14.28 | 28.57 | 42.85 | 57.14 |
| 37 | 27.02 | 54.05 | 81.07 | 108.10 | 71 | 14.08 | 28.16 | 42.24 | 56.33 |
| 37½ | 26.66 | 53.33 | 79.99 | 106.66 | 72 | 13.88 | 27.77 | 41.65 | 55.55 |
| 38 | 26.31 | 52.63 | 78.94 | 105.26 | 73 | 13.69 | 27.39 | 41.08 | 54.79 |
| 38½ | 25.97 | 51.94 | 77.91 | 103.89 | 74 | 13.51 | 27.02 | 40.53 | 34.05 |
| 39 | 25.64 | 51.28 | 76.92 | 102.36 | 75 | 13.33 | 26.66 | 39.99 | 53.33 |
| 39½ | 25.31 | 50.63 | 75.94 | 101.26 | 76 | 13.15 | 26.31 | 39.46 | 32.63 |
| 40 | 25.00 | 50.00 | 75.00 | 100.00 | 77 | 12.98 | 25.97 | 38.95 | 51.94 |
| 40½ | 24.69 | 49.38 | 74.07 | 98.76 | 78 | 12.82 | 25.64 | 38.46 | 51.28 |
| 41 | 24.39 | 48.78 | 73.17 | 97.56 | 79 | 12.65 | 25.31 | 37.96 | 50.63 |
| 41½ | 24.09 | 48.19 | 72.28 | 96.38 | 80 | 12.50 | 25.00 | 37.50 | 50.00 |
| 42 | 23.80 | 47.61 | 71.41 | 95.23 | 81 | 12.34 | 24.69 | 37.03 | 49.38 |
| 42½ | 23.32 | 47.05 | 70.57 | 94.11 | 82 | 12.19 | 24.39 | 36.58 | 48.78 |
| 43 | 23.25 | 46.51 | 69.76 | 93.02 | 83 | 12.04 | 24.09 | 36.13 | 48.19 |
| 43½ | 22.98 | 45.97 | 68.95 | 91.95 | 84 | 11.90 | 23.80 | 35.70 | 47.61 |
| 44 | 22.72 | 43.45 | 68.17 | 90.90 | 85 | 11.76 | 23.52 | 35.28 | 47.05 |
| 44½ | 22.47 | 44.94 | 67.41 | 89.88 | 86 | 11.62 | 23.25 | 34.87 | 46.51 |
| 45 | 22.22 | 44.44 | 66.66 | 88.88 | 87 | 11.49 | 22.98 | 34.47 | 45.97 |
| 45½ | 21.97 | 43.95 | 65.92 | 87.91 | 88 | 11.36 | 22.72 | 34.08 | 45.45 |
| 46 | 21.73 | 43.47 | 65.10 | 86.95 | 89 | 11.23 | 22.47 | 33.70 | 44.94 |
| 46½ | 21.50 | 43.01 | 64.51 | 86.02 | 90 | 11.11 | 22.22 | 33.33 | 44.44 |
| 47 | 21.27 | 42.55 | 63.82 | 85.10 | 91 | 10.98 | 21.97 | 32.95 | 43.95 |
| 47½ | 21.05 | 42.10 | 63.15 | 84.21 | 92 | 10.86 | 21.73 | 32.59 | 43.47 |
| 48 | 20.83 | 41.66 | 62.49 | 83.33 | 93 | 10.75 | 21.50 | 32.25 | 43.01 |
| 48½ | 20.61 | 41.23 | 61.84 | 82.47 | 94 | 10.63 | 21.27 | 31.90 | 42.55 |
| 49 | 20.40 | 40.81 | 61.21 | 81.63 | 95 | 10.52 | 21.05 | 31.57 | 42.10 |
| 49½ | 20.20 | 40.40 | 60.60 | 80.80 | 96 | 10.41 | 20.83 | 31.24 | 41.66 |
| 50 | 20.00 | 40.00 | 60.00 | 80.00 | 97 | 10.30 | 20.61 | 30.91 | 41.23 |
| 50½ | 19.80 | 39.60 | 59.40 | 79.20 | 98 | 10.20 | 20.40 | 30.60 | 40.81 |
| 51 | 19.60 | 39.21 | 58.81 | 78.43 | 99 | 10.10 | 20.00 | 30.30 | 44.40 |
| 52 | 19.23 | 38.46 | 57.69 | 76.92 | 100 | 10.00 | 20.00 | 30.00 | 40.00 |
| 53 | 18.86 | 37.73 | 56.59 | 75.47 | | | | | |
| 54 | 18.51 | 37.03 | 55.54 | 74.07 | | | | | |

## TABLE FOR YARN NUMBERING.

| No. of Count. | Weight in Grains. | No. of Count. | Weight in Grains. | No. of Count. | Weight in Grains. | No. of Count. | Weight in Grains. | No. of Count. | Weight in Grains. | No. of Count. | Weight in Grains. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 1400 | 24 | 291.7 | 43 | 162.8 | 62 | 112.9 | 81 | 86.4 | 100 | 70 |
| 6 | 1166.6 | 25 | 280 | 44 | 159.1 | 63 | 111.1 | 82 | 83.4 | 105 | 66.7 |
| 7 | 1000 | 26 | 269.2 | 45 | 155.6 | 64 | 109.4 | 83 | 84.3 | 110 | 63.6 |
| 8 | 875 | 27 | 259.3 | 46 | 152.2 | 65 | 107.7 | 84 | 83.3 | 115 | 60.9 |
| 9 | 777.8 | 28 | 350 | 47 | 148.9 | 66 | 106.1 | 85 | 82.4 | 120 | 58.3 |
| 10 | 700 | 29 | 241.4 | 48 | 145.8 | 67 | 104.5 | 86 | 81.4 | 125 | 56 |
| 11 | 636.4 | 30 | 233.3 | 49 | 142.9 | 68 | 102.9 | 87 | 80.4 | 130 | 53.8 |
| 12 | 583.3 | 31 | 225.8 | 50 | 140 | 69 | 101.4 | 88 | 79.6 | 135 | 51.8 |
| 13 | 538.5 | 32 | 218.8 | 51 | 137.3 | 70 | 100 | 89 | 78.6 | 140 | 50 |
| 14 | 500 | 33 | 212.1 | 52 | 134.6 | 71 | 98.6 | 90 | 77.8 | 145 | 48.3 |
| 15 | 466.7 | 34 | 205.9 | 53 | 132.1 | 72 | 97.2 | 91 | 76.9 | 150 | 46.7 |
| 16 | 437.5 | 35 | 200 | 54 | 129.6 | 73 | 95.9 | 92 | 76.1 | 155 | 45.2 |
| 17 | 411.8 | 36 | 194.4 | 55 | 127.3 | 74 | 94.6 | 93 | 75.3 | 160 | 43.8 |
| 18 | 388.9 | 37 | 189.2 | 56 | 125 | 75 | 93.3 | 94 | 74.5 | 165 | 42.4 |
| 19 | 368.4 | 38 | 184.2 | 37 | 122.8 | 76 | 92.1 | 95 | 73.7 | 176 | 41.2 |
| 20 | 350 | 39 | 179.5 | 58 | 120.7 | 77 | 90.9 | 96 | 72.9 | 175 | 40 |
| 21 | 333.3 | 40 | 175 | 59 | 118.6 | 78 | 89.7 | 97 | 72.2 | 180 | 38.9 |
| 22 | 318.2 | 41 | 170.7 | 60 | 116.7 | 79 | 88.6 | 98 | 71.4 | 190 | 36.8 |
| 23 | 304.3 | 42 | 166.7 | 61 | 114.8 | 80 | 87.5 | 99 | 70.7 | 200 | 35 |

To find Cotton Counts—Reel 840 yards. =one hank. Weight this, and against its weight of grains in the table will be found its number or count.

To find Linen Counts—Reel 300 yards. =one lea. Weigh it, and against its weight of grains in the table will be found its number or count.

To find Worsted Counts—Reel 500 yards =one skein. Weighit, and aga inst its weight of grains in the table will be found its number or count.

7000 ÷ Counts =Weight or Vice Versa.

**Strength of one Lea in lbs. of various counts of yarn according to length of Staple**

**INDIAN AND CHINESE COTTON.**

| Counts of yarn. | Length of Staple or Fibres. | | | | |
|---|---|---|---|---|---|
| | 7/8″ | 1″ | 1 1/8″ | 1 1/4″ | 1 3/8″ |
| 10 | 145.5 | 186.5 | 218.5 | 254 | - |
| 12 | 116 | 153.5 | 181.5 | 210 | 248 |
| 14 | 100 | 130 | 154 | 178 | 205 |
| 16 | 90 | 111.5 | 133 | 155 | 176.5 |
| 18 | 78 | 97.5 | 116.5 | 137 | 156 |
| 20 | 68 | 85.5 | 103.5 | 122.5 | 140.5 |
| 22 | 59.5 | 76 | 92 | 109 | 123.5 |
| 24 | 53 | 69 | 83 | 98.5 | 111.5 |
| 26 | 47.5 | 62.5 | 76 | 89 | 102 |
| 28 | 43.5 | 57.5 | 70 | 81.5 | 93 |
| 30 | 40 | 52.5 | 64.5 | 75 | 86 |
| 32 | 35.5 | 48 | 60 | 69 | 80 |
| 34 | 33.5 | 44.5 | 55.5 | 64 | 75 |
| 36 | 30.5 | 41 | 51 | 60 | 70 |
| 38 | 28 | 38.5 | 47.5 | 56 | 66 |
| 40 | 25.5 | 35.5 | 44 | 52.5 | 62 |
| 42 | 23.5 | 33 | 41 | 49 | 58.5 |
| 44 | 22 | 30.5 | 38.5 | 46 | 55 |
| 46 | 20 | 28.5 | 36 | 44 | 52 |
| 48 | 18.5 | 27 | 34 | 41.5 | 48.5 |
| 50 | 17 | 25 | 32 | 39 | 46.5 |
| 52 | 16 | 23.5 | 30 | 37 | 44.5 |
| 54 | 15 | 22 | 28.5 | 35 | 42.5 |
| 56 | 13.5 | 20.5 | 26.5 | 33.5 | 40.5 |
| 58 | 12.5 | 19 | 25 | 31.5 | 38.5 |
| 60 | 11.5 | 17.5 | 23.5 | 30 | 36.5 |

**Strength of one Lea in lbs. of various counts of yarn according to length of Staple.**

## AMERICAN AND EGYPTIAN COTTON.

| Counts of yarn. | Length of Staple | | | | | Counts of yarn. | Length of Staple. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1⅛ | 1¼ | 1⅜ | 1½ | 1⅝ | | 1⅛ | 1¼ | 1¾ | 1½ | 1⅝ |
| 20 | 113 | 132.5 | 151.5 | 170 | 189 | 70 | 20 | 26 | 31 | 36.5 | 41.5 |
| 22 | 100 | 119 | 136.5 | 152.5 | 173 | 72 | 19 | 24.5 | 30 | 35 | 40 |
| 24 | 90 | 108.5 | 125 | 139.5 | 157 | 74 | 18 | 23.5 | 28.5 | 33.5 | 38.5 |
| 26 | 83 | 98.5 | 114 | 128 | 143.5 | 76 | 17 | 22.5 | 27.5 | 32 | 37.5 |
| 28 | 76.5 | 90 | 105 | 117.5 | 133 | 78 | 16.5 | 21.5 | 26.5 | 31 | 36 |
| 30 | 70.5 | 82.5 | 96 | 108 | 121.5 | 80 | 15.5 | 20.5 | 25.5 | 30 | 34.5 |
| 32 | 64.5 | 76.5 | 89 | 100 | 112 | 82 | 15 | 19.5 | 24.5 | 28.5 | 33 |
| 34 | 60 | 71 | 82.5 | 94 | 105 | 84 | 14 | 18.5 | 23 | 27.5 | 31.5 |
| 36 | 56 | 66.5 | 77.5 | 88 | 99 | 86 | 13 | 17.5 | 22 | 26.5 | 30.5 |
| 38 | 52 | 61.5 | 72.5 | 82 | 92.5 | 88 | 12.5 | 17 | 21 | 25.5 | 29.5 |
| 40 | 48 | 57.5 | 68 | 77.5 | 87 | 90 | 12 | 16 | 20 | 25 | 28.5 |
| 42 | 45 | 54 | 64 | 73 | 82 | 92 | 11 | 15.5 | 19.5 | 24 | 27.5 |
| 44 | 42 | 51 | 60 | 68.5 | 77.5 | 94 | 10.5 | 15 | 18.5 | 23 | 27 |
| 46 | 39.5 | 48 | 57 | 65 | 73.5 | 96 | 9.5 | 14 | 17.5 | 22 | 26 |
| 48 | 37.5 | 45.5 | 53.5 | 61.5 | 69 | 98 | 9 | 13.5 | 17 | 21 | 25.5 |
| 50 | 35 | 43 | 51 | 58.5 | 65.5 | 100 | 8.5 | 12.5 | 16.5 | 20 | 24.5 |
| 52 | 33 | 40.5 | 48 | 55.5 | 62 | 102 | 8 | 12 | 15.5 | 19.5 | 23.5 |
| 54 | 31 | 38.5 | 46 | 52.5 | 59 | 104 | 7.5 | 11.5 | 15 | 19 | 22.5 |
| 56 | 29.5 | 36.5 | 43.5 | 50.5 | 56.5 | 106 | 7 | 11 | 14.5 | 18 | 22 |
| 58 | 28 | 34.5 | 41 | 47.5 | 53.5 | 108 | 7 | 10.5 | 14 | 17.5 | 21.5 |
| 60 | 26.5 | 32.5 | 39.5 | 45.5 | 51 | 110 | 6.5 | 10 | 13.5 | 17 | 20.5 |
| 62 | 25 | 31 | 37.5 | 43.5 | 49 | 112 | 6 | 9.5 | 12.5 | 16.5 | 19.5 |
| 64 | 24 | 29.5 | 35.5 | 41.5 | 47 | 114 | 5.5 | 9 | 12 | 16 | 19 |
| 66 | 22.5 | 28 | 34 | 39.5 | 45 | 116 | 5.5 | 8.5 | 11.5 | 15.5 | 18.5 |
| 68 | 21.5 | 27 | 32.5 | 38.5 | 43.5 | 118 | 5 | 8 | 11 | 15 | 17.5 |

**Particulars of Test etc. of Silk yarn of Various Countries.**

| Description | International Denier. | Metric Denier. | Strength. | Elongation | Stretch in Metres. |
|---|---|---|---|---|---|
| **Tussar Silk.** Japan | 120/160 | 64 | 279.60 | 15.26 | 17894 |
| ,, | 120/160 | 64 | 237.80 | 11.60 | 15219 |
| ,, | 135/160 | 61 | 299.25 | 17.90 | 18254 |
| ,, | 140/180 | 56 | 338.30 | 17.75 | 18945 |
| ,, | 220/250 | 38 | 549.70 | 17.67 | 20889 |
| ,, | 230/270 | 36 | 668.70 | 18.62 | 24073 |
| ,, | 280/320 | 30 | 655.80 | 20.10 | 19674 |
| ,, | 240/280 | 35 | 529.50 | 18.42 | 18533 |
| **Spun Silk.** Japan | .... | 100 | 251.10 | 5.95 | 21510 |
| ,, | .... | 100 | 121.30 | 5.12 | 12130 |
| ,, | .... | 100 | 180.60 | 5.40 | 18060 |
| ,, | .... | 120 | 163.30 | 5.76 | 19596 |
| ,, | .... | 140 | 136.10 | 6.57 | 19054 |
| ,, | .... | 160 | 127.70 | 6.45 | 20432 |
| ,, | .... | 2/80 | 719.00 | 9.16 | 28760 |
| ,, | .... | 2/80 | 592.50 | 6.50 | 23700 |
| ,, | .... | 2/100 | 481.20 | 8.48 | 24060 |
| ,, | .... | 2/120 | 326.20 | 7.43 | 19582 |
| ,, | .... | 2/140 | 297.90 | 6.28 | 20853 |
| ,, | .... | 2/160 | 295.95 | 6.60 | 23675 |
| ,, | .... | 2/200 | 259.55 | 6.48 | 25955 |
| ,, | .... | 2/200 | 288.70 | 7.10 | 28870 |
| ,, | .... | 2/100 | 366.50 | 15.22 | 18325 |
| ,, | .... | 2/115 | 230.15 | 9.70 | 13119 |
| **Rayon.** Japan | 120 | 75 | 188 | 7.64 | 14100 |
| ,, | 120 | 75 | 186 | 11.00 | 13950 |
| ,, | 180 | 50 | 226 | 18.10 | 11300 |
| ,, | 180 | 50 | 267 | 18.30 | 12850 |

**Particulars of Test etc. of Silk Yarn of Various Countries.**—continued.

| Description | International Denier. | Metric Denier. | Strength. | Elongation. | Stretch in Metres. |
|---|---|---|---|---|---|
| **Raw Silk.** | | | | | |
| Hungary | 12/13 | 720 | 36.25 | 11.75 | 26100 |
| Turkey | 15/15 | 643 | 49.55 | 15.80 | 31861 |
| Italy | 13/15 | 613 | 50.30 | 6.79 | 32343 |
| ,, | 14/16 | 600 | 44.53 | 12.21 | 26718 |
| ,, | 19/21 | 450 | 81.78 | 13.35 | 36801 |
| Turkey | 18/20 | 474 | 58.60 | 10.00 | 27776 |
| ,, | 22/24 | 301 | 57.00 | 9.50 | 22287 |
| ,, | 16/18 | 529 | 65.43 | 13.39 | 34612 |
| ,, | 14/16 | 600 | 60.80 | 11.86 | 30480 |
| **Doubling.** | | | | | |
| Italy | 17/19 | 500 | 58.95 | 14.50 | 29475 |
| Silesia | 18/22 | 450 | 118.20 | 13.60 | 53190 |
| Italy (Extra) | 19/21 | 450 | 86.03 | 14.16 | 38714 |
| Japan | 20/24 | 409 | 62.60 | 9.25 | 25603 |
| Italy (Milano) | 23/25 | 375 | 80.65 | 12.43 | 30244 |
| China | 24/28 | 346 | 70.80 | 7.60 | 24497 |
| Italy (Milano) | 24/28 | 346 | 112.53 | 15.30 | 38935 |
| Do. (Extra) | 24/28 | 346 | 90.20 | 15.79 | 31209 |
| Japan | 28/30 | 310 | 101.00 | 12.70 | 31310 |
| ,, | 32/36 | 265 | 105.40 | 8.78 | 27931 |
| Italy | 34/38 | 250 | 118.50 | 15.42 | 29625 |
| China | 43/48 | 198 | 193.10 | 12.08 | 38234 |
| Japan | 46/50 | 188 | 165.37 | 11.55 | 31090 |
| **Double Yarn (Twisted):** | | | | | |
| Italy (Extra) | 16/18 | 529 | 69.00 | 16.35 | 36501 |
| ,, ,, | 18/20 | 474 | 80.60 | 12.17 | 38204 |
| ,, ,, | 20/21 | 439 | 73.75 | 14.08 | 32376 |
| ,, ,, | 20/22 | 429 | 83.72 | 14.62 | 35916 |
| ,, ,, | 26/30 | 321 | 119.40 | 16.69 | 38224 |
| China | 38/42 | 225 | 119.35 | 12.27 | 26857 |

## COUNTS EQUIVALENTS.

| Denier. | Cotton. | Worsted. | Woollen. | Linen and Jute. | Inter-National. | Denier. | Cotton. | Worsted. | Woollen. | Linen and Jute. | Inter-National. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **5315** | **7972** | **17439** | **14882** | **9000** | 33 | 161.06 | 241.58 | 528.45 | 450.97 | 272.73 |
| 2 | 2657.5 | 3986.00 | 8719.50 | 7441 | 4500 | 34 | 156.3 | 234.47 | 512.91 | 437.71 | 264.41 |
| 3 | 1771.7 | 2657.33 | 5813.00 | 4960.67 | 3000 | 35 | 151.85 | 227.77 | 498.26 | 423.49 | 257.14 |
| 4 | 1328.75 | 1993.00 | 4359.75 | 3720.50 | 2250 | 36 | 147.63 | 221.44 | 484.42 | 413.39 | 250.00 |
| 5 | 1063.0 | 1594.40 | 3487.80 | 2956.40 | 1800 | 37 | 143.65 | 215.46 | 471.32 | 402.22 | 243.24 |
| 6 | 885.83 | 1328.67 | 2906.50 | 2480.33 | 1500 | 38 | 139.87 | 209.97 | 456.29 | 391.63 | 236.84 |
| 7 | 759.28 | 1138.86 | 2491.29 | 2126.00 | 1285.71 | 39 | 136.28 | 204.41 | 447.15 | 381.59 | 230.77 |
| 8 | 664.38 | 996.50 | 2179.88 | 1860.25 | 1125.00 | 40 | 132.88 | 199.30 | 435.98 | 372.05 | 225.00 |
| 9 | 520.55 | 885.78 | 1936.56 | 1653.56 | 1000.00 | 41 | 129.64 | 194.44 | 425.34 | 362.98 | 219.51 |
| 10 | 531.5 | 797.20 | 1743.90 | 1488.20 | 900.00 | 42 | 126.55 | 189.81 | 415.21 | 354.33 | 214.29 |
| 11 | 483.18 | 724.73 | 1585.36 | 1352.91 | 818.18 | 43 | 123.60 | 185.40 | 405.56 | 346.09 | 209.30 |
| 12 | 442.9 | 664.33 | 1453.25 | 1240.17 | 750.00 | 44 | 120.79 | 181.18 | 396.34 | 338.23 | 204.55 |
| 13 | 408.8 | 613.23 | 1341.46 | 1144.77 | 692.31 | 45 | 118.11 | 177.16 | 387.53 | 330.71 | 200.00 |
| 14 | 379.6 | 569.43 | 1245.64 | 1063.00 | 642.86 | 46 | 115.54 | 173.3 | 379.11 | 323.52 | 195.65 |
| 15 | 354.3 | 531.47 | 1162.60 | 992.13 | 600.00 | 47 | 113.09 | 169.62 | 371.04 | 316.64 | 191.49 |
| 16 | 332.1 | 498.25 | 1089.94 | 930.13 | 562.50 | 48 | 110.73 | 166.08 | 363.30 | 310.04 | 187 50 |
| 17 | 312.6 | 468.94 | 1025.82 | 875.41 | 529.41 | 49 | 108.45 | 162.69 | 355.90 | 303.70 | 183.67 |
| 18 | 295.2 | 442.89 | 968.83 | 826.72 | 500.00 | 50 | 106.30 | 159.44 | 348.78 | 295.64 | 180.00 |
| 19 | 279.7 | 419.58 | 917.84 | 783.26 | 473.68 | 51 | 104.21 | 156.31 | 341.94 | 291.80 | 176.47 |
| 20 | 265.75 | 398.60 | 871.95 | 744.10 | 450.00 | 52 | 102.10 | 153.31 | 335.37 | 286.19 | 173.08 |
| 21 | 253.1 | 379.62 | 830.43 | 708.67 | 428.57 | 53 | 100.28 | 150.42 | 329.04 | 280.79 | 169.81 |
| 22 | 241.6 | 362.36 | 792.68 | 676.45 | 409.09 | 54 | 98.43 | 147.26 | 322.94 | 275.59 | 166.67 |
| 23 | 231.09 | 346.61 | 758.21 | 647.04 | 391.30 | 55 | 96.64 | 144.94 | 317.07 | 270.58 | 163.64 |
| 24 | 221.46 | 332.17 | 726.63 | 620.08 | 375.00 | 56 | 94.91 | 142.36 | 311.41 | 265.71 | 160.71 |
| 25 | 212.6 | 318.88 | 697.56 | 595.28 | 360.00 | 57 | 93.25 | 139.86 | 305.95 | 261.09 | 157.89 |
| 26 | 204.4 | 306.62 | 670.73 | 572.58 | 346.15 | 58 | 91.64 | 137.45 | 300.67 | 256.59 | 155.17 |
| 27 | 196.85 | 295.26 | 645.89 | 551.19 | 333.33 | 59 | 90.08 | 135.12 | 295.57 | 252.34 | 152.54 |
| 28 | 189.8 | 284.71 | 622.82 | 531.50 | 321.43 | 60 | 88.58 | 132.87 | 290.65 | 248.03 | 150.00 |
| 29 | 183.3 | 274.83 | 601.34 | 513.17 | 310.36 | 61 | 87.13 | 130.69 | 285.87 | 243.97 | 147.54 |
| 30 | 177.16 | 265.73 | 581.30 | 496.07 | 300.00 | 62 | 85.73 | 128.58 | 281.13 | 240.03 | 145.16 |
| 31 | 171.45 | 257.16 | 562.55 | 480.06 | 290.32 | 63 | 84.73 | 126.54 | 276.81 | 236.22 | 142.86 |
| 32 | 166.09 | 249.13 | 544.97 | 465.06 | 281.25 | 64 | 83.05 | 124.56 | 272.48 | 232.53 | 140.63 |

**COUNTS EQUIVALENTS.**—continued.

| Denier. | Cotton. | Worsted | Woollen | Linen and Jute | Inter-National | Denier. | Cotton | Worsted. | Woollen | Linen and Jute | Intter-Nationsl. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 65 | 81.77 | 122.64 | 268.29 | 227.42 | 138.46 | 97 | 54.79 | 82.19 | 179.78 | 153.42 | 92.78 |
| 66 | 80.53 | 120.79 | 264.23 | 225.48 | 136.36 | 98 | 54.23 | 81.45 | 177.95 | 151.86 | 91.84 |
| 67 | 79.33 | 118.99 | 260.28 | 222.12 | 134.33 | 99 | 53.69 | 80.32 | 176.15 | 150.32 | 90.91 |
| 68 | 78.16 | 117.24 | 256.46 | 218.85 | 132.35 | 100 | 53.15 | 79.72 | 174.39 | 148.82 | 90.00 |
| 69 | 77.03 | 115.54 | 252.74 | 215.39 | 130.43 | 110 | 48.32 | 72.47 | 158.54 | 135.30 | 81.82 |
| 70 | 75.93 | 113.89 | 249.13 | 212.60 | 128.57 | 120 | 44.29 | 66.43 | 145.33 | 124.02 | 75.00 |
| 71 | 74.86 | 112.28 | 245.62 | 209.61 | 126.76 | 130 | 40.88 | 61.32 | 134.15 | 114.48 | 69.23 |
| 72 | 73.82 | 110.72 | 242.20 | 206.69 | 125.00 | 140 | 37.96 | 56.94 | 124.56 | 106.30 | 64.29 |
| 73 | 72.81 | 109.21 | 238.89 | 203.86 | 123.29 | 150 | 35.43 | 53.01 | 116.26 | 99.21 | 60.00 |
| 74 | 71.82 | 107.73 | 235.66 | 201.11 | 121.62 | 160 | 33.22 | 49.83 | 108.99 | 93.01 | 56.25 |
| 75 | 70.87 | 106.29 | 232.52 | 198.43 | 120.00 | 170 | 31.26 | 46.00 | 102.58 | 87.54 | 52.94 |
| 76 | 69.93 | 104.89 | 229.46 | 195.82 | 118.42 | 180 | 29.53 | 44.20 | 96.88 | 82.67 | 50.00 |
| 77 | 69.03 | 103.53 | 226.48 | 193.27 | 116.88 | 190 | 27.97 | 41.96 | 91.78 | 78.33 | 47.37 |
| 78 | 68.14 | 102.21 | 223.58 | 190.79 | 115.38 | 200 | 26.58 | 39.86 | 84.20 | 74.41 | 45.00 |
| 79 | 67.28 | 100.91 | 220.75 | 188.38 | 113.92 | | | | | | |
| 80 | 66.44 | 99.65 | 217.99 | 186.03 | 112.50 | | | | | | |
| 81 | 65.62 | 98.42 | 215.30 | 183.72 | 111.11 | | | | | | |
| 82 | 64.82 | 97.22 | 212.67 | 181.49 | 109.76 | | | | | | |
| 83 | 64.04 | 96.05 | 210.11 | 179.30 | 108.44 | | | | | | |
| 84 | 63.27 | 94.90 | 207.61 | 177.16 | 107.14 | | | | | | |
| 85 | 62.53 | 93.79 | 205.10 | 175.82 | 105.88 | | | | | | |
| 86 | 61.80 | 92.71 | 202.78 | 173.05 | 104.65 | | | | | | |
| 87 | 61.09 | 91.63 | 200.44 | 171.06 | 103.45 | | | | | | |
| 88 | 60.40 | 90.59 | 198.70 | 169.11 | 102.27 | | | | | | |
| 89 | 59.72 | 89.57 | 195.94 | 167.21 | 101.12 | | | | | | |
| 90 | 59.06 | 88.58 | 193.77 | 165.30 | 100.00 | | | | | | |
| 91 | 58.41 | 87.60 | 191.64 | 163.54 | 98.90 | | | | | | |
| 92 | 57.77 | 86.65 | 189.55 | 161.76 | 97.84 | | | | | | |
| 93 | 57.15 | 85.72 | 188.59 | 160.02 | 96.77 | | | | | | |
| 94 | 56.54 | 84.81 | 185.52 | 158.32 | 95.78 | | | | | | |
| 95 | 55.95 | 83.92 | 183.57 | 156.65 | 94.74 | | | | | | |
| 96 | 55.36 | 83.04 | 181.66 | 155.02 | 93.75 | | | | | | |

## SPINNING PRODUCTION

**Per Hour at 100% Efficiency.**

| Counts | Spindle Speed | Twist per Inch | Revs of Front Roller | | Delivery in Inches | | Production in ounces | |
|---|---|---|---|---|---|---|---|---|
| | | | 7/8" | 1" | 7/8" | 1" | 7/8" | 1" |
| 4s | 4520 | 8.00 | 203 | 180 | 558.25 | 565.20 | 4.42 | 4.48 |
| 5s | 5000 | 8.94 | 203 | 178 | 558.25 | 558.92 | 3.54 | 3.55 |
| | 5200 | 10.00 | 193 | 165 | 530.70 | 518.10 | 3.37 | 3.28 |
| | 6000 | 8.94 | 244 | 213 | 671.00 | 668.82 | 4.26 | 4.24 |
| | 6200 | 9.50 | 236 | 204 | 649.00 | 640.56 | 4.12 | 4.06 |
| | 6800 | 10.62 | 232 | 200 | 638.00 | 628.00 | 4.05 | 3.98 |
| 6s | 5200 | 10.00 | 193 | 165 | 530.75 | 518.10 | 2.10 | 2.74 |
| | 5500 | 9.79 | 204 | 179 | 561.00 | 562.06 | 2.96 | 2.97 |
| | 6000 | 9.80 | 223 | 200 | 613.25 | 628.00 | 3.24 | 3.32 |
| | 7300 | 11.64 | 228 | 196 | 627.00 | 615.44 | 3.31 | 3.25 |
| 7s | 5500 | 10.58 | 189 | 165 | 519.75 | 518.10 | 2.35 | 2.34 |
| | 6000 | 10.58 | 206 | 180 | 566.50 | 565.20 | 2.56 | 2.56 |
| | 6500 | 10.58 | 223 | 195 | 613.25 | 612.30 | 2.78 | 2.77 |
| 7.9s | 6850 | 12.63 | 197 | 172 | 541.75 | 540.41 | 2.17 | 2.17 |
| 8s | 5800 | 11.32 | 186 | 163 | 511.50 | 511.82 | 2.02 | 2.02 |
| | 6400 | 11.31 | 205 | 180 | 563.75 | 565.20 | 2.23 | 2.24 |
| | 6750 | 12.07 | 202 | 178 | 555.50 | 558.92 | 2.20 | 2.21 |
| | 7000 | 12.07 | 211 | 184 | 580.25 | 577.76 | 2.30 | 2.28 |
| | 8100 | 13.44 | 219 | 188 | 602.25 | 590.32 | 2.39 | 2.34 |
| 9.8s | 6900 | 12.63 | 197 | 172 | 531.75 | 540.41 | 1.74 | 1.74 |
| 9.8s | 7700 | 14.29 | 191 | 167 | 525.25 | 524.85 | 1.70 | 1.70 |
| 9s | 8400 | 14.25 | 211 | 184 | 580.25 | 577.76 | 2.04 | 2.03 |
| 10s | 6000 | 12.60 | 173 | 151 | 475.75 | 474.14 | 1.50 | 1.50 |
| | 6000 | 15.00 | 148 | 127 | 407.00 | 398.78 | 1.29 | 1.26 |
| | 6750 | 12.64 | 194 | 170 | 533.50 | 533.80 | 1.69 | 1.69 |
| | 6800 | 12.01 | 206 | 180 | 566.50 | 565.20 | 1.80 | 1.79 |
| | 6800 | 12.01 | 206 | 180 | 566.50 | 565.50 | 1.80 | 1.79 |

**SPINNING PRODUCTION.**—contd.

**Per Hour at 100% Efficiency.**

| Counts. | Spindle Speed. | Twist per Inch. | Revs of Front Roller | | Delivery in Inches | | Production in ounces. | |
|---|---|---|---|---|---|---|---|---|
| | | | 7/8" | 1" | 7/8" | 1" | 7/8" | 1" |
| 10s | 6825 | 14.00 | 178 | 155 | 489.50 | 486.70 | 1.55 | 1.54 |
| | 7150 | 12.64 | 205 | 180 | 563.75 | 565.20 | 1.79 | 1.79 |
| | 7500 | 12.64 | 215 | 188 | 591.25 | 590.32 | 1.87 | 1.87 |
| | 7750 | 14.29 | 197 | 172 | 541.75 | 540.03 | 1.71 | 1.71 |
| | 8000 | 14.29 | 203 | 178 | 558.25 | 558.92 | 1.77 | 1.77 |
| | 8600 | 15.02 | 208 | 180 | 572.00 | 565.20 | 1.81 | 1.79 |
| 11s | 6000 | 13.90 | 157 | 138 | 431.75 | 433.32 | 1.24 | 1.25 |
| | 6381 | 16.43 | 141 | 123 | 387.75 | 386.22 | 1.12 | 1.11 |
| | 6825 | 14.00 | 178 | 155 | 489.5 | 486.7 | 1.41 | 1.40 |
| | 7000 | 13.90 | 183 | 160 | 503.25 | 502.40 | 1.45 | 1.44 |
| | 7500 | 13.85 | 196 | 172 | 539.00 | 540.00 | 1.55 | 1.55 |
| | 7800 | 18.00 | 154 | 138 | 423.5 | 4332.32 | 1.22 | 1.25 |
| | 8300 | 13.85 | 218 | 191 | 599.5 | 599.7 | 1.73 | 1.73 |
| | 9000 | 16.45 | 199 | 172 | 547.25 | 540.08 | 1.58 | 1.56 |
| 12s | 6600 | 14.68 | 164 | 143 | 451.00 | 449.42 | 1.19 | 1.19 |
| | 7000 | 13.90 | 183 | 160 | 503.25 | 502.40 | 1.33 | 1.32 |
| | 7500 | 13.85 | 196 | 172 | 539.00 | 540.08 | 1.42 | 1.42 |
| | 7800 | 18.00 | 154 | 138 | 423.5 | 433.32 | 1.11 | 1.14 |
| | 8000 | 13.90 | 209 | 183 | 574.75 | 574.62 | 1.52 | 1.51 |
| | 8800 | 15.75 | 203 | 176 | 558.25 | 552.6 | 1.47 | 1.46 |
| 13s | 5600 | 11.00 | 185 | 162 | 508.75 | 508.68 | 1.24 | 1.24 |
| 13.8s | 7750 | 14.98 | 192 | 168 | 528.00 | 528.00 | 1.21 | 1.21 |
| 13s | 9000 | 16.45 | 199 | 172 | 547.25 | 540.08 | 1.44 | 1.42 |
| 14s | 6000 | 14.96 | 145 | 127 | 398.75 | 398.78 | 0.90 | 0.90 |
| | 6872 | 18.97 | 132 | 115 | 363.00 | 361.10 | 0.82 | 0.82 |
| | 7200 | 15.00 | 174 | 153 | 478.50 | 480.42 | 1.08 | 1.08 |

**SPINNING PRODUCTION** (contd )
**Per Hour at 100% Efficiency.**

| Counts | Spindle Speed | Twist per Inch | Revs. of Front Roller 7/8" | Revs. of Front Roller 1" | Delivery in Inches 7/8" | Delivery in Inches 1" | Production in ounces 7/8" | Production in ounces 1" |
|---|---|---|---|---|---|---|---|---|
| 14s | 7700 | 14.21 | 197 | 172 | 541.75 | 540.08 | 1.2 | 1.22 |
| | 8000 | 14.96 | 195 | 170 | 536.25 | 533.80 | 1 | 1.21 |
| | 8400 | 14.98 | 202 | 176 | 555 50 | 533.14 | 1.25 | 1.25 |
| 14.4s | 8750 | 16.85 | 190 | 166 | 522.50 | 521.71 | 1.15 | 1.15 |
| | 8800 | 14.96 | 214 | 187 | 588.50 | 587.18 | 1.33 | 1.33 |
| | 9000 | 17.77 | 184 | 164 | 506.00 | 514.96 | 1.14 | 1.16 |
| | 10400 | 16.98 | 222 | 195 | 610.50 | 512 30 | 1 38 | 1.38 |
| 15s | 7800 | 16.00 | 178 | 155 | 489.50 | 486.70 | 1 03 | 1.03 |
| 15.6s | 8000 | 15.97 | 182 | 159 | 500.50 | 499.71 | 1.02 | 1.02 |
| 15.7s | 8550 | 15.97 | 190 | 166 | 522.50 | 521.71 | 1.05 | 1.05 |
| 15.7 | 9000 | 15.97 | 194 | 170 | 533.50 | 534.28 | 1.07 | 1.07 |
| 15.9 | 9600 | 18.10 | 192 | 168 | 528.00 | 528.00 | 1.05 | 1.05 |
| 16s | 6000 | 16.00 | 140 | 119 | 385.00 | 373.66 | .76 | .74 |
| | 7000 | 16.10 | 158 | 138 | 434.50 | 433.32 | .86 | .85 |
| | 7500 | 16.00 | 170 | 149 | 467.50 | 467.86 | .92 | .92 |
| | 8000 | 16.00 | 189 | 159 | 519.75 | 699.26 | 1.03 | .99 |
| | 8500 | 16.00 | 193 | 169 | 530.75 | 530.66 | 1.05 | 1.05 |
| | 8571 | 17.00 | 186 | 148 | 511.50 | 464.72 | 1.01 | 0.92 |
| | 8800 | 18.10 | 172 | 150 | 473.00 | 471.42 | 0.89 | 0.89 |
| | 9000 | 16.00 | 204 | 179 | 561.00 | 562.06 | 1.11 | 1.11 |
| | 9400 | 19.00 | 188 | 156 | 517.00 | 489.84 | 1.02 | 0.97 |
| 17s | 7440 | 18.97 | 142 | 125 | 390.50 | 392.50 | 0.73 | 0.73 |
| | 7800 | 17.00 | 168 | 146 | 462.00 | 458.44 | 0.86 | 0.85 |
| | 9400 | 19.58 | 174 | 153 | 478.50 | 480.42 | 0.89 | 0.89 |
| | 9600 | 19.58 | 178 | 152 | 489.50 | 477.28 | 0.91 | 0.89 |
| 18s | 6000 | 17.00 | 128 | 112 | 352.00 | 351.68 | 0.62 | 0.62 |
| | 6500 | 16.96 | 141 | 124 | 387.75 | 389.36 | 0.68 | 0.68 |
| | 7000 | 17.00 | 150 | 131 | 412.50 | 411.34 | 0.72 | 0.72 |

**SPINNING PRODUCTION**—(contd.)
**Per Hour at 100% Efficiency.**

| Counts. | Spindle Speed. | Twist per Inch. | Revs. of Front Roller | | Delivery in Inches | | Production in ounces. | |
|---|---|---|---|---|---|---|---|---|
| | | | 7/8" | 1" | 7/8" | 1" | 7/8" | 1" |
| 18s | 7500 | 16.96 | 160 | 141 | 440.00 | 442.74 | 0.77 | 0.78 |
| | 8000 | 17.00 | 171 | 149 | 470.25 | 467.86 | 0.83 | 0 82 |
| | 8500 | 16.97 | 182 | 159 | 500.50 | 499.26 | 0.83 | 0.88 |
| | 9000 | 17.00 | 192 | 168 | 528.00 | 527.48 | 0.93 | 0.93 |
| | 9680 | 20.83 | 163 | 147 | 448.25 | 461.58 | 0.79 | 0.81 |
| | 10400 | 20.26 | 187 | 164 | 514.25 | 514.96 | 0.90 | 0.90 |
| 19.4s | 7700 | 17.98 | 157 | 137 | 431.75 | 430.57 | 0.70 | 0.70 |
| 19.9s | 8100 | 17.98 | 164 | 143 | 551.00 | 449.42 | 0.89 | 0.89 |
| 19.5s | 8900 | 17.98 | 183 | 160 | 503.25 | 502.85 | 0.82 | 0.82 |
| 19.8s | 9200 | 17.98 | 187 | 163 | 514.25 | 512.28 | 0.84 | 0.84 |
| | 9650 | 17.98 | 198 | 173 | 544.50 | 543 70 | 0.87 | 0.87 |
| 19.9 | 9800 | 17.98 | 196 | 171 | 539 00 | 537.42 | 0.85 | 0.85 |
| | 10700 | 20.23 | 188 | 164 | 517.00 | 515.42 | 0.82 | 0.82 |
| 20s | 6000 | 17.90 | 122 | 103 | 335.50 | 323.42 | 0.53 | 0.51 |
| | 7500 | 16.85 | 162 | 142 | 445.50 | 445.88 | 0.70 | 0.70 |
| | 8000 | 17.90 | 163 | 142 | 448.25 | 445.88 | 0.70 | 0.70 |
| | 8340 | 16.85 | 180 | 157 | 495.00 | 492.98 | 0.78 | 0.78 |
| | 8600 | 20.88 | 149 | 131 | 409.75 | 411.34 | 0.65 | 0.65 |
| | 8800 | 23.60 | 135 | 118 | 371.25 | 370.52 | 0.58 | 0.58 |
| | 9000 | 17.90 | 183 | 160 | 503.25 | 502.40 | 0.79 | 0.79 |
| | 9400 | 17.98 | 190 | 166 | 522.50 | 521.71 | 0.83 | 0.83 |
| | 9600 | 19.26 | 186 | 162 | 511.50 | 509.14 | 0.81 | 0.80 |
| | 10200 | 17.98 | 210 | 183 | 577.50 | 575.14 | 0.92 | 0.91 |
| 20.6s | 10200 | 19.26 | 192 | 168 | 528.00 | 528.00 | 0.81 | 0.81 |
| 21s | 9300 | 18.15 | 186 | 163 | 511.50 | 511.82 | 0.77 | 0.77 |
| | 9400 | 21.77 | 157 | 138 | 431.75 | 433.32 | 0.65 | 0.65 |
| | 9650 | 17.98 | 195 | 171 | 536.25 | 536.94 | 0.81 | 0.81 |
| 22s | 7000 | 18.80 | 131 | 119 | 360.25 | 373.66 | 0.52 | 0.53 |

**SPINNING PRODUCTION.**— (contd )
**Per Hour at 100% Efficiency.**

| Counts | Spindle Speed | Twist per Inch. | Revs. of Front Roller | | Delivery in Inches | | Production in ounces. | |
|---|---|---|---|---|---|---|---|---|
| | | | 7/8" | 1" | 7/8" | 1" | 7/8" | 1" |
| 22s | 8000 | 18.80 | 155 | 135 | 426.25 | 423.90 | 0.61 | 0.61 |
| | 8500 | 18.76 | 165 | 144 | 453.75 | 452.16 | 0.65 | 0.65 |
| | 8750 | 22.98 | 138 | 121 | 379.50 | 379.94 | 0.55 | 0.55 |
| | 9000 | 18.80 | 174 | 152 | 478.50 | 477.28 | 0.69 | 0.68 |
| | 9500 | 22.28 | 155 | 136 | 426.25 | 427.04 | 0.61 | 0.61 |
| | 9800 | 24.98 | 142 | 125 | 390.50 | 392.50 | 0.56 | 0.56 |
| | 10000 | 18.80 | 193 | 169 | 530.75 | 530.66 | 0.76 | 0.76 |
| | 10400 | 20.88 | 182 | 159 | 500.50 | 499.26 | 0.72 | 0.72 |
| | 10400 | 22.98 | 165 | 144 | 453.75 | 452.16 | 0.65 | 0.65 |
| 23s | 8550 | 19.69 | 158 | 138 | 434.50 | 433.32 | 0.59 | 0.59 |
| | 9500 | 22.78 | 151 | 132 | 415.25 | 414.48 | 0.57 | 0.57 |
| 23.5s | 9700 | 19.73 | 178 | 155 | 489.00 | 487.14 | 0.66 | 0.66 |
| 24s | 7000 | 19.60 | 126 | 113 | 346.50 | 354.82 | 0.45 | 0.46 |
| | 8000 | 19.60 | 150 | 130 | 412.50 | 408.20 | 0.54 | 0.54 |
| | 8500 | 19.59 | 156 | 137 | 429.00 | 430.18 | 0.56 | 0.56 |
| | 9000 | 18.61 | 175 | 153 | 481.25 | 480.42 | 0.63 | 0.63 |
| | 9600 | 23.27 | 150 | 131 | 412.50 | 411.34 | 0.54 | 0.54 |
| 24.5s | 9750 | 19.73 | 183 | 160 | 503.25 | 502.85 | 0 65 | 0.65 |
| 24s | 10000 | 19.60 | 185 | 162 | 508.75 | 508.65 | 0.67 | 0.67 |
| 24.4s | 10500 | 20.74 | 186 | 162 | 511.50 | 509.14 | 0.66 | 0.66 |
| 25s | 9600 | 23.75 | 147 | 128 | 404.25 | 401.92 | 0.53 | 0.53 |
| | 9650 | 19.73 | 178 | 156 | 489.50 | 489.84 | 0.62 | 0.62 |
| 26s | 7000 | 20.40 | 125 | 108 | 343.75 | 339.12 | 0.42 | 0.41 |
| | 8000 | 20.40 | 142 | 125 | 390.50 | 392.50 | 0.47 | 0.48 |
| | 8500 | 20.39 | 151 | 133 | 415.25 | 417.62 | 0.50 | 0.51 |
| | 8900 | 22.80 | 140 | 123 | 385.00 | 386.22 | 0.47 | 0.47 |
| | 9000 | 20.40 | 160 | 140 | 440.00 | 439.60 | 0.53 | 0–53 |
| | 9500 | 20.39 | 169 | 148 | 464.75 | 464.72 | 0.56 | 0.56 |

**SPINNING PRODUCTION** -(contd.)
**Per Hour at 100% Efficiency.**

| Counts. | Spindle Speed. | Twist per Inch. | Revs. of Front. Roller. | | Delivery in Inches | | Production in ounces. | |
|---|---|---|---|---|---|---|---|---|
| | | | 7/8" | 1" | 7/8" | 1" | 7/8" | 1" |
| 26s | 9700 | 24.22 | 146 | 128 | 401.50 | 401.92 | 0.49 | 0.49 |
| | 10000 | 20.46 | 177 | 155 | 486.75 | 486.70 | 0.59 | 0.59 |
| 27s | 9700 | 24.62 | 143 | 126 | 393.25 | 395.64 | 0.46 | 0.46 |
| 28s | 7000 | 21.20 | 120 | 105 | 330.00 | 329.70 | 0.37 | 0.37 |
| | 7500 | 21.16 | 129 | 112 | 354.75 | 351.68 | 0.40 | 0.39 |
| | 8000 | 21.20 | 139 | 120 | 382.25 | 387.80 | 0.43 | 0.42 |
| | 8500 | 21.16 | 146 | 128 | 401.50 | 401.92 | 0.45 | 0.45 |
| | 9000 | 20.10 | 161 | 141 | 442.75 | 142.74 | 0.50 | 0.50 |
| | 9500 | 22.20 | 155 | 136 | 246.25 | 427.04 | 0.48 | 0.48 |
| | 9800 | 26.98 | 132 | 115 | 363 00 | 361.10 | 0.41 | 0.40 |
| | 10000 | 24.98 | 145 | 127 | 398.75 | 398.78 | 0.45 | 0.45 |
| 29s | 9800 | 25.58 | 139 | 124 | 382.25 | 389.36 | 0.41 | 0.42 |
| | 10400 | 22.7 | 168 | 147 | 462.00 | 462.00 | 0.50 | 0.50 |
| 30s | 7000 | 22.00 | 116 | 101 | 319.00 | 317.14 | 0.33 | 0.33 |
| | 8000 | 21.90 | 133 | 116 | 365.75 | 364.24 | 0.38 | 0.38 |
| | 8500 | 19.75 | 156 | 137 | 429.00 | 430.18 | 0.45 | 0.45 |
| | 9000 | 21.90 | 149 | 131 | 409.75 | 411.34 | 0.43 | 0.43 |
| | 9800 | 26.02 | 137 | 120 | 376.75 | 376.08 | 0.39 | 0.39 |
| | 10000 | 22.00 | 165 | 144 | 453.75 | 396.00 | 0.48 | 0.41 |
| 31s | 9900 | 26.45 | 136 | 120 | 374.00 | 376.08 | 0.38 | 0.38 |
| 32s | 7000 | 22.60 | 112 | 98 | 308.00 | 307.72 | 0.30 | 0.30 |
| | 8000 | 22.60 | 128 | 112 | 352.00 | 351.68 | 0.34 | 0.34 |
| | 8500 | 20.40 | 151 | 132 | 415.25 | 414.48 | 0.41 | 0.41 |
| | 0000 | 22.60 | 145 | 127 | 398.75 | 398.78 | 0.39 | 0.39 |
| | 9680 | 24.84 | 140 | 124 | 385.00 | 389.36 | 0.38 | 0.38 |
| | 10000 | 26.87 | 135 | 118 | 371.25 | 370.52 | 0.36 | 0.36 |
| 33s | 10200 | 27.29 | 136 | 118 | 374.00 | 370.52 | 0.36 | 0.35 |
| 34s | 7000 | 23.30 | 109 | 95 | 299.75 | 298.30 | 0.28 | 0.27 |

**SPINNING PRODUCTION.**—(Contd.)
**Per Hour at 100% Efficiency.**

| Counts. | Spindle Speed. | Twist per Inch. | Revs. of Front Roller | | Delivery in Inches | | Production in ounces. | |
|---|---|---|---|---|---|---|---|---|
| | | | 7/8″ | 1″ | 7/8″ | 1″ | 7/8″ | 1″ |
| 34s | 8000 | 23.30 | 124 | 109 | 341.00 | 342.26 | 0.31 | 0.31 |
| | 8500 | 21.02 | 147 | 128 | 404.25 | 401.92 | 0.37 | 0.37 |
| | 9000 | 23.30 | 140 | 123 | 385.00 | 386.22 | 0.36 | 0.36 |
| | 9500 | 23.32 | 148 | 130 | 407.00 | 408.20 | 0.38 | 0.38 |
| | 10000 | 23.30 | 156 | 136 | 429.00 | 427.04 | 0.40 | 0.39 |
| 35s | 10200 | 28.10 | 132 | 116 | 363.00 | 364.34 | 0.32 | 0.33 |
| 36s | 7000 | 24.00 | 106 | 93 | 291.50 | 292.02 | 0.25 | 0.25 |
| | 8000 | 24.00 | 121 | 106 | 332.7 | 332.84 | 0.29 | 0.29 |
| | 8500 | 21.64 | 142 | 125 | 390.50 | 392.50 | 0.34 | 0.34 |
| | 9000 | 24.00 | 136 | 120 | 374.00 | 376.80 | 0.33 | 0.33 |
| | 9500 | 24.00 | 144 | 126 | 396.00 | 395.64 | 0.34 | 0.34 |
| | 10000 | 24.00 | 151 | 133 | 415.25 | 417.62 | 0.36 | 0.36 |
| | 10200 | 28.17 | 131 | 114 | 360.25 | 357.96 | 0.31 | 0.31 |
| 37s | 10100 | 28.24 | 130 | 113 | 357.50 | 354.82 | 0.30 | 0.30 |
| 38s | 7000 | 24.70 | 103 | 90 | 283.25 | 282.60 | 0.23 | 0.23 |
| | 8000 | 24.70 | 118 | 103 | 324.50 | 323.62 | 0.27 | 0.27 |
| | 8500 | 22.23 | 138 | 124 | 379.50 | 389.36 | 0.31 | 0.32 |
| | 9000 | 24.70 | 132 | 116 | 363.00 | 364.24 | 0.30 | 0.30 |
| | 9500 | 24.65 | 140 | 123 | 385.00 | 386.22 | 0.32 | 0.32 |
| | 10000 | 28.38 | 128 | 112 | 352.00 | 351.68 | 0.28 | 0.28 |
| 39s | 10000 | 28.38 | 128 | 112 | 352.00 | 351.68 | 0.28 | 0.28 |
| 40s | 7000 | 25.30 | 100 | 88 | 275.00 | 276.32 | 0.21 | 0.21 |
| | 8000 | 25.30 | 114 | 100 | 313.50 | 314.00 | 0.24 | 0.24 |
| | 8500 | 22.81 | 135 | 118 | 371.25 | 370.52 | 0.29 | 0.29 |
| | 85.71 | 20.72 | 150 | 131 | 412.50 | 411.34 | 0.32 | 0.32 |
| | 9000 | 25.30 | 130 | 113 | 357.50 | 354.82 | 0.28 | 0.28 |
| | 9500 | 25.29 | 136 | 120 | 374.00 | 376.80 | 0.29 | 0.29 |
| | 10000 | 28.46 | 128 | 112 | 352.00 | 351.68 | 0.27 | 0.27 |

**SPINNING PRODUCTION.**—(continued)
**Per Hour at 100% Efficiency.**

| Counts | Spindle Speed | Twist per Inch. | Revs of Front Roller. | | Delivery in Inches. | | Production in ounces. | |
|---|---|---|---|---|---|---|---|---|
| | | | $\frac{7}{8}''$ | 1″ | $\frac{7}{8}''$ | 1″ | $\frac{7}{8}''$ | 1″ |
| 40s | 11000 | 27.30 | 146 | 128 | 401.50 | 401.92 | 0.31 | 0.31 |
| 41s | 10000 | 28.50 | 127 | 111 | 349.26 | 348.54 | 0.27 | 0.27 |
| 42s | 8000 | 26.50 | 110 | 96 | 302.50 | 301.44 | 0.22 | 0.22 |
| | 8500 | 23.37 | 132 | 115 | 363.00 | 316.25 | 0.27 | 0.24 |
| | 9000 | 26.50 | 123 | 108 | 338.25 | 339.12 | 025. | 0.25 |
| | 10000 | 28.81 | 126 | 110 | 346.50 | 345.50 | 0.26 | 0.26 |
| 43s | 10000 | 29.18 | 124 | 109 | 341.00 | 342.26 | 0.25 | 0.25 |
| 44s | 7500 | 26.53 | 102 | 90 | 280.60 | 282.60 | 0.20 | 0.20 |
| | 8500 | 23.92 | 129 | 113 | 354.75 | 354.82 | 0.25 | 0.25 |
| | 9500 | 26.53 | 131 | 114 | 360.25 | 357.96 | 0.25 | 0.25 |
| | 10000 | 27.10 | 133 | 117 | 365.75 | 367.38 | 0.26 | 0.26 |
| 45s | 9500 | 25.12 | 137 | 120 | 376.75 | 376.80 | 0.26 | 0.26 |
| | 10000 | 30.19 | 120 | 105 | 33.00 | 329.70 | 0.23 | 0.23 |
| 46s | 8000 | 27.80 | 104 | 91 | 286.00 | 285.74 | 0.19 | 0.19 |
| | 8500 | 24.45 | 126 | 110 | 346.50 | 345.40 | 0.23 | 0.23 |
| | 10000 | 30.51 | 120 | 104 | 330.00 | 326.56 | 0.22 | 0.22 |
| 47s | 10000 | 30.85 | 118 | 103 | 324.50 | 323.42 | 0.21 | 0.21 |
| 48s | 7500 | 27.71 | 98 | 86 | 269.50 | 270.04 | 0.17 | 0.17 |
| | 8500 | 24.96 | 124 | 108 | 341.00 | 339.12 | 0.22 | 0.22 |
| | 9500 | 27.71 | 124 | 109 | 341.00 | 342.26 | 0.22 | 0.22 |
| | 10000 | 28.40 | 128 | 112 | 352.00 | 351.68 | 0.23 | 0.23 |
| - | 10000 | 31.18 | 117 | 102 | 321.75 | 320.28 | 0.21 | 0.21 |
| 49s | 10000 | 31.50 | 115 | 101 | 316.25 | 317.14 | 0.20 | 0.20 |
| 50s | 7000 | 28.28 | 90 | 78 | 247.50 | 244.92 | 0.15 | 0.15 |
| | 8000 | 29.00 | 100 | 88 | 275.00 | 276.32 | 0.17 | 0.17 |
| | 8500 | 25.50 | 121 | 106 | 332.75 | 332.84 | 0.21 | 0.21 |
| | 9000 | 28.28 | 115 | 101 | 316.25 | 317.14 | 0.20 | 0.20 |
| | 9500 | 25.49 | 135 | 118 | 371.25 | 370.52 | 0.22 | 0.22 |

**SPINNING PRODUCTION**—(cont.)
**Per Hour at 100% Efficiency.**

| Counts | Spindle Speed | Twist per Inch | Revs. of Front Roller | | Delivery in Inches | | Production in ounces | |
|---|---|---|---|---|---|---|---|---|
| | | | $\frac{7}{8}''$ | 1″ | $\frac{7}{8}''$ | 1″ | $\frac{7}{8}''$ | 1″ |
| 50s | 10000 | 29.00 | 125 | 109 | 343.75 | 342.26 | 0.21 | 0.21 |
| 50.5s | 10400 | 28.16 | 138 | 120 | 378.50 | 377.14 | 0.24 | 0.23 |
| 52s | 8500 | 26.00 | 119 | 104 | 327.25 | 326.56 | 0.19 | 0.19 |
| 54s | 8500 | 26.50 | 117 | 102 | 321.75 | 320.28 | 0.18 | 0.18 |
| 55s | 9000 | 27.78 | 118 | 103 | 324.50 | 323.42 | 0.18 | 0.18 |
| | 9500 | 26.71 | 120 | 113 | 354.75 | 354.82 | 0.20 | 0.20 |
| | 10000 | 33.37 | 109 | 95 | 299.75 | 298.30 | 0.17 | 0.17 |
| 56s | 8500 | 27.46 | 112 | 98 | 308.00 | 307.72 | 0.17 | 0.17 |
| 60s | 8400 | 33.00 | 92 | 81 | 253.00 | 254.34 | 0.13 | 0.13 |
| | 9000 | 29.02 | 112 | 98 | 308.00 | 307.72 | 0.16 | 0.16 |
| | 9400 | 27.92 | 122 | 107 | 335.50 | 335.98 | 0.17 | 0.17 |
| | 10000 | 34.86 | 104 | 91 | 286.00 | 285.74 | 0.15 | 0.15 |
| | 10940 | 28.26 | 127 | 112 | 349.25 | 351.68 | 0.38 | 0.38 |
| 65s | 10000 | 36.28 | 100 | 88 | 275.00 | 276.32 | 0.14 | 0.14 |
| 70s | 8500 | 31.35 | 98 | 86 | 269.50 | 270.04 | 0.12 | 0.12 |
| | 9200 | 30.16 | 111 | 97 | 305.25 | 304.58 | 0.13 | 0.13 |
| | 10000 | 37.65 | 97 | 84 | 266.75 | 263.76 | 0.12 | 0.12 |
| 75s | 9800 | 38.97 | 91 | 80 | 250.25 | 251.20 | 0.10 | 0.10 |
| 80s | 8500 | 32.54 | 95 | 83 | 261.25 | 260.62 | 0.10 | 0.10 |
| | 9000 | 32.25 | 102 | 90 | 280.50 | 282.60 | 0.11 | 0.11 |
| | 9600 | 39.08 | 90 | 78 | 247.50 | 244.92 | 0.09 | 0.09 |
| 85s | 9400 | 39.18 | 87 | 76 | 239.25 | 238.64 | 0.08 | 0.08 |
| 90s | 8000 | 35.55 | 80 | 71 | 220.00 | 222.94 | 0.07 | 0.07 |
| | 9400 | 40.32 | 85 | 74 | 233.75 | 232.36 | 0.08 | 0.08 |
| 95s | 9400 | 41.22 | 83 | 72 | 228.25 | 226.08 | 0.07 | 0.07 |
| 100s | 9400 | 42.50 | 80 | 70 | 220.00 | 219.80 | 0.06 | 0.06 |

## YARN TABLE OF TWISTS PER INCH, AND SQUARE ROOT OF COUNTS.

"INDIAN AND AMERICAN COTTON."

### TWIST MULTIPLES FOR RING—SPUN YARNS.

The turns per inch in ring—spun yarns are governed by the class of cotton, the speed of the frame, the use of the yarn, the counts, etc. The square root of the counts multiplied by one of the following twist multipliers will serve as a guide to determine the turns of twist per inch.

### FORNULA FOR TURNS PER INCH.

Ring Twist = $\sqrt{\text{counts}} \times 4.00$, ordinary.
,, ,, = $\sqrt{\text{counts}} \times 4.25$, ,,
,, ,, = $\sqrt{\text{counts}} \times 3.75$, Soft.
,, Weft = $\sqrt{\text{counts}} \times 3.25$, ,,
,, ,, = $\sqrt{\text{counts}} \times 3.50$ Medium.

### EGYPTIAN COTTON.

Ring Twist = $\sqrt{\text{counts}} \times 3.606$
,, Weft = $\sqrt{\text{counts}} \times 3.50$
,, ,, = $\sqrt{\text{counts}} \times 3.25$
,, ,, = $\sqrt{\text{counts}} \times 3.188$

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Ring Frame Twist = Sq. root of counts × 5.5 to 9 (crepe Twist)
,, ,, ,, = 4.7 (Extra hard twist
,, ,, ,, = 4.5 ( Hard twist ).
,, ,, ,, = 8 (crepe Hard twisted)

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*Twist Constant for ;—*

Hosiery yarn = $\sqrt{\text{counts}} \times 2.5$.

Strength is affected, or after you reach about $\sqrt{\text{counts}} \times 4.5$ with American cotton the yarn is weakened through over twisting, so that where the extra hard twist is put in it is necessary to use better cotton than for ordinary twists.

**Yarn Table of Twists per Inch, and Square Root of Counts.**

| Counts. | Sq. Root of Counts. | Indian and American Cotton. Ring Weft. | Indian and American Cotton. Ring Twist. | Egyptian Cotton Ring Twist. |
|---|---|---|---|---|
| 1 | 1.000 | 3.25 | 4.00 | .... |
| 2 | 1.414 | 4.60 | 5.65 | .... |
| 3 | 1.732 | 5.62 | 6.92 | .... |
| 4 | 2.000 | 6.50 | 8.00 | .... |
| 5 | 2.326 | 7.26 | 8.94 | .... |
| 6 | 2.449 | 7.96 | 9.79 | .... |
| 7 | 2.645 | 8.59 | 10.58 | .... |
| 8 | 2.828 | 9.19 | 11.31 | .... |
| 9 | 3.000 | 9.75 | 12.00 | .... |
| 10 | 3.162 | 10.27 | 12.64 | 11.44 |
| 11 | 3.316 | 10.77 | 13.26 | 11.95 |
| 12 | 3.464 | 11.25 | 13.85 | 12.47 |
| 13 | 3.605 | 11.71 | 14.22 | 13.00 |
| 14 | 3.741 | 12.16 | 14.96 | 13.46 |
| 15 | 3.872 | 12.48 | 15.49 | 13.98 |
| 16 | 4.000 | 13.00 | 16.00 | 14.40 |
| 17 | 4.123 | 13.40 | 16.49 | 14.86 |
| 18 | 4.242 | 13.78 | 16.97 | 15.27 |
| 19 | 4.358 | 14.16 | 17.43 | 15.71 |
| 20 | 4.472 | 14.53 | 17.88 | 16.09 |
| 22 | 4.690 | 15.25 | 18.76 | 16.88 |
| 24 | 4.898 | 15.92 | 19.59 | 17.63 |
| 26 | 5.099 | 16.57 | 20.39 | 18.35 |
| 28 | 5.291 | 17.19 | 21.16 | 19.64 |
| 30 | 5.477 | 17.80 | 21.90 | 19.75 |
| 32 | 5.656 | 18.38 | 22.62 | 20.40 |
| 34 | 5.830 | 18.95 | 23.32 | 21.02 |
| 36 | 6.000 | 19.50 | 24.00 | 21.64 |
| 38 | 6.164 | 20.03 | 24.65 | 22.23 |
| 40 | 6.324 | 20.55 | 25.29 | 22.81 |
| 42 | 6.480 | 21.06 | 25.92 | 23.37 |
| 44 | 6.633 | 21.55 | 26.53 | 23.92 |
| 46 | 6.782 | 22.04 | 27.12 | 24.45 |
| 48 | 6.928 | 22.51 | 27.71 | 24.98 |
| 50 | 7.071 | 21.98 | 28.28 | 25.50 |
| 52 | 7.211 | .... | .... | 26.00 |
| 54 | 7.348 | .... | .... | 26.50 |
| 56 | 7.483 | .... | .... | 26.98 |
| 58 | 7.615 | .... | .... | 27.46 |
| 60 | 7.745 | .... | .... | 27.93 |
| 62 | 7.874 | .... | .... | 28.39 |
| 64 | 8.000 | .... | .... | 28.85 |
| 66 | 8.124 | .... | .... | 29.29 |
| 68 | 8.246 | .... | .... | 29.73 |
| 70 | 8.366 | .... | .... | 30.17 |
| 72 | 8.485 | .... | .... | 30.60 |
| 74 | 8.602 | .... | .... | 31.02 |
| 76 | 8.717 | .... | .... | 31.44 |
| 78 | 8.831 | .... | .... | 31.85 |
| 80 | 8.944 | .... | .... | 32.25 |

## SPEED OF FRONT ROLLER AND DELIVERY IN INCHES.

| Speed of Front Roller. | Delivery in Inches. Dia. of Rollers. | | Speed of Front Roller. | Delivery in Inches. Dia. of Rollers. | | Speed of Front Roller. | Delivery in Inches. Dia. of Rollers. | |
|---|---|---|---|---|---|---|---|---|
| | 7/8" | 1" | | 7/8" | 1" | | 7/8" | 1" |
| 70 | 192.50 | 219.80 | 103 | 283.25 | 323.42 | 136 | 374.00 | 427.04 |
| 71 | 195.25 | 222.94 | 104 | 286.00 | 326.56 | 137 | 376.75 | 430.18 |
| 72 | 198.00 | 226.08 | 105 | 288.75 | 329.70 | 138 | 379.50 | 433.32 |
| 73 | 200.75 | 229.22 | 106 | 291.50 | 332.84 | 139 | 382.25 | 436.46 |
| 74 | 203 50 | 232.36 | 107 | 294.25 | 335.98 | 140 | 385.00 | 439.60 |
| 75 | 206.25 | 235.50 | 108 | 297.00 | 339.12 | 141 | 387.85 | 442.74 |
| 76 | 209.00 | 238.64 | 109 | 299.75 | 342.26 | 142 | 390.50 | 445.88 |
| 77 | 211.75 | 241.78 | 110 | 302.50 | 345.40 | 143 | 393.25 | 449.02 |
| 78 | 214.50 | 244.92 | 111 | 305.25 | 348.54 | 144 | 396.00 | 452.16 |
| 79 | 217.25 | 248.06 | 112 | 308.00 | 351.68 | 145 | 398.75 | 445.30 |
| 80 | 220.00 | 251.20 | 113 | 310.75 | 354.82 | 146 | 401.50 | 458.44 |
| 81 | 222.75 | 254.34 | 114 | 313.50 | 357.96 | 147 | 404.25 | 461.58 |
| 82 | 225.50 | 257.48 | 115 | 316.25 | 361.10 | 148 | 407.00 | 464.72 |
| 83 | 228.25 | 260.62 | 116 | 319.00 | 364.24 | 149 | 409.75 | 467.86 |
| 84 | 231.00 | 263.76 | 117 | 321.75 | 367.38 | 150 | 412.50 | 471.00 |
| 85 | 233.75 | 266.90 | 118 | 324.50 | 370.52 | 151 | 415.25 | 474.14 |
| 86 | 236.50 | 270.04 | 119 | 327.25 | 373.66 | 152 | 418.00 | 477.28 |
| 87 | 239.25 | 273.18 | 120 | 330.00 | 376.80 | 153 | 420.75 | 480.42 |
| 88 | 242.00 | 276.32 | 121 | 332.75 | 379.94 | 154 | 423.50 | 483.56 |
| 89 | 244.75 | 279.46 | 122 | 335.50 | 383.08 | 155 | 426.25 | 486.76 |
| 90 | 247.50 | 282.60 | 123 | 338.25 | 386.22 | 156 | 429.00 | 489.84 |
| 91 | 250.25 | 285.74 | 124 | 341.00 | 389.36 | 157 | 431.75 | 492.98 |
| 92 | 253.00 | 288.88 | 125 | 343.75 | 392.50 | 158 | 434.50 | 496.12 |
| 93 | 255.75 | 292.02 | 126 | 346.50 | 395.64 | 159 | 437.25 | 499.26 |
| 94 | 258.50 | 295.16 | 127 | 349.25 | 398.78 | 160 | 440.00 | 502.40 |
| 95 | 261.25 | 298.30 | 128 | 352.00 | 401.92 | 161 | 442.75 | 505.54 |
| 96 | 264.00 | 301.44 | 129 | 354.75 | 405.06 | 162 | 445.50 | 508.68 |
| 97 | 266.75 | 304.58 | 130 | 357.50 | 408.20 | 163 | 448.25 | 511.82 |
| 98 | 269.50 | 307.72 | 131 | 260.25 | 411.34 | 164 | 451.00 | 514.96 |
| 99 | 272.25 | 310.86 | 132 | 363.00 | 414.48 | 165 | 453.75 | 518.10 |
| 100 | 275.00 | 314.00 | 133 | 365.75 | 417.62 | 166 | 456.50 | 521.24 |
| 101 | 277.75 | 317.14 | 134 | 368.50 | 420.76 | 167 | 459.25 | 524.38 |
| 102 | 280.50 | 320.28 | 135 | 371.25 | 423.90 | 168 | 462.00 | 527.48 |

**Speed of Front Roller and Delivery in Inches**—contd.

| Speed of Front Roller. | Delivery in Inches. Dia. of Rollers. | | Speed of Front Roller. | Delivery in Inches.' Dia. of Rollers. | | Speed. of Front Roller. | Delivery in Inches. Dia. of Rollers. | |
|---|---|---|---|---|---|---|---|---|
| | ⅞" | 1" | | ⅞" | 1" | | ⅞" | 1" |
| 169 | 464.75 | 530.66 | 203 | 558.25 | 637.42 | 254 | 698.50 | 798.56 |
| 170 | 467.50 | 533.80 | 204 | 561.00 | 640.56 | 256 | 704.00 | 804.84 |
| 171 | 470.25 | 536.94 | 205 | 563.75 | 643.70 | 258 | 709.50 | 811.12 |
| 172 | 473.00 | 540.08 | 206 | 566.50 | 646.84 | 260 | 715.00 | 817.40 |
| 173 | 475.75 | 543.22 | 208 | 572.00 | 653.12 | 262 | 720.50 | 823.68 |
| 174 | 478.50 | 546.36 | 209 | 574.75 | 656.26 | 264 | 726.00 | 829.96 |
| 175 | 481.25 | 549.50 | 210 | 577.53 | 659.40 | 266 | 731.50 | 836.24 |
| 176 | 484.00 | 552 64 | 211 | 580.25 | 662.54 | 268 | 737.00 | 842.52 |
| 177 | 486.75 | 555.78 | 212 | 583.00 | 665.68 | 270 | 742.50 | 848.80 |
| 178 | 489.50 | 558.92 | 213 | 585.75 | 668.82 | 272 | 748.00 | 855.08 |
| 179 | 492.25 | 562.06 | 214 | 588.50 | 671.96 | 274 | 753.50 | 861.36 |
| 180 | 495.00 | 565.20 | 215 | 591.25 | 675.10 | 276 | 759.00 | 867.64 |
| 181 | 497.75 | 568.34 | 216 | 594.00 | 678.24 | 278 | 764.50 | 873.92 |
| 182 | 500.50 | 371.48 | 218 | 599.50 | 684.52 | 280 | 770.00 | 880.20 |
| 183 | 503.25 | 574.62 | 219 | 602.25 | 687.66 | 282 | 775.50 | 886.48 |
| 184 | 506.00 | 577.76 | 220 | 605.00 | 690.80 | 284 | 781.00 | 892.76 |
| 185 | 508.75 | 580.90 | 222 | 610.50 | 697.08 | 286 | 786.50 | 899.04 |
| 186 | 511.50 | 584.04 | 223 | 613.25 | 701.22 | 288 | 792.00 | 905.32 |
| 187 | 514.25 | 587.18 | 224 | 616.00 | 704.36 | 290 | 797.50 | 911.00 |
| 188 | 517.00 | 590.32 | 226 | 621.50 | 710.64 | 292 | 803.00 | 917.88 |
| 189 | 519.75 | 593.46 | 228 | 627.00 | 716.92 | 294 | 808.50 | 924.16 |
| 190 | 522.50 | 596.60 | 230 | 632.50 | 723.20 | 296 | 814.00 | 930.44 |
| 191 | 525.25 | 599.74 | 232 | 638.00 | 729.48 | 299 | 819.50 | 936.72 |
| 192 | 528.00 | 602.88 | 234 | 643.50 | 735.76 | 300 | 825.00 | 943.00 |
| 193 | 530.75 | 606.02 | 236 | 649.00 | 742.04 | | | |
| 194 | 533.50 | 609.16 | 238 | 654.50 | 748.32 | | | |
| 195 | 536.25 | 612.30 | 240 | 660.00 | 754.60 | | | |
| 196 | 539.00 | 615.44 | 242 | 665.50 | 760.88 | | | |
| 196 | 539.00 | 615.14 | 242 | 665.50 | | | | |
| 197 | 541.75 | 618.58 | 244 | 671.00 | 767.16 | | | |
| 198 | 544.50 | 621.72 | 246 | 676.50 | 773.44 | | | |
| 199 | 547.25 | 624.86 | 248 | 682.00 | 779.72 | | | |
| 200 | 550.50 | 628.00 | 250 | 687.50 | 786.00 | | | |
| 202 | 555.50 | 634.28 | 252 | 693.00 | 792.28 | | | |

## CONSTANT FOR FINDING SPINNING PRODUCTION.
**Per Hour at 100% Efficiency.**

Const.—Counts=Production in ozs. per Spindle per hour. D=Delivery in inches. C=Constant.

| D. | C. | D. | C. | D. | C. | D. | C. | D. | C. | D. | C. | D. | C. | D. | C. | D. | C. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 180 | 5.71 | 212 | 6.73 | 244 | 7.74 | 276 | 8.76 | 308 | 9.77 | 340 | 10.79 | 372 | 11.80 | 404 | 12.82 | 436 | 13.84 |
| 181 | 5.74 | 213 | 6.76 | 245 | 7.77 | 277 | 8.79 | 309 | 9.80 | 341 | 10.82 | 373 | 11.84 | 405 | 12.85 | 437 | 13.87 |
| 182 | 5.77 | 214 | 6.79 | 246 | 7.80 | 278 | 8.82 | 310 | 9.84 | 342 | 10.85 | 374 | 11.87 | 406 | 12.88 | 438 | 13.90 |
| 183 | 5.80 | 215 | 6.82 | 247 | 7.84 | 279 | 8.85 | 311 | 9.87 | 343 | 10.88 | 375 | 11.90 | 407 | 12.92 | 439 | 13.93 |
| 184 | 5.84 | 216 | 6.85 | 248 | 7.87 | 280 | 8.88 | 312 | 9.90 | 344 | 10.92 | 376 | 11.93 | 408 | 12.95 | 440 | 13.96 |
| 185 | 5.87 | 217 | 6.88 | 249 | 7.90 | 281 | 8.92 | 313 | 9.93 | 345 | 10.95 | 377 | 11.96 | 409 | 12.98 | 441 | 14.00 |
| 186 | 5.90 | 218 | 6.92 | 250 | 7.93 | 282 | 8.95 | 314 | 9.96 | 346 | 10.98 | 378 | 12.00 | 410 | 13.01 | 442 | 14.03 |
| 187 | 5.93 | 219 | 6.95 | 251 | 7.96 | 283 | 8.98 | 315 | 10.00 | 347 | 11.01 | 379 | 12.03 | 411 | 13.04 | 443 | 14.06 |
| 188 | 5.96 | 220 | 6.98 | 252 | 8.00 | 284 | 9.01 | 316 | 10.03 | 348 | 11.04 | 380 | 12.06 | 412 | 13.07 | 444 | 14.09 |
| 189 | 6.00 | 221 | 7.01 | 253 | 8.03 | 285 | 9.04 | 317 | 10.06 | 349 | 11.07 | 381 | 12.09 | 413 | 13.11 | 445 | 14.12 |
| 190 | 6.03 | 222 | 7.04 | 254 | 8.06 | 286 | 9.07 | 318 | 10.09 | 350 | 11.11 | 382 | 12.12 | 414 | 13.14 | 446 | 14.15 |
| 191 | 6.06 | 223 | 7.07 | 255 | 8.09 | 287 | 9.11 | 319 | 10.12 | 351 | 11.14 | 383 | 12.15 | 415 | 13.17 | 447 | 14.19 |
| 192 | 6.09 | 224 | 7.11 | 256 | 8.12 | 288 | 9.14 | 320 | 10.15 | 352 | 11.17 | 384 | 12.19 | 416 | 13.20 | 448 | 14.22 |
| 193 | 6.12 | 225 | 7.15 | 257 | 8.15 | 289 | 9.17 | 321 | 10.19 | 353 | 11.20 | 385 | 12.22 | 417 | 13.23 | 449 | 14.25 |
| 194 | 6.15 | 226 | 7.17 | 258 | 8.19 | 290 | 9.20 | 322 | 10.22 | 354 | 11.23 | 386 | 12.25 | 418 | 13.26 | 450 | 14.28 |
| 195 | 6.19 | 227 | 7.20 | 259 | 8.22 | 291 | 9.23 | 323 | 10.25 | 355 | 11.26 | 387 | 12.28 | 419 | 13.30 | 451 | 14.31 |
| 196 | 6.22 | 228 | 7.23 | 260 | 8.25 | 292 | 9.26 | 324 | 10.28 | 356 | 11.30 | 388 | 12.31 | 420 | 13.33 | 452 | 14.34 |
| 197 | 6.25 | 229 | 7.26 | 261 | 8.28 | 293 | 9.30 | 325 | 10.31 | 357 | 11.33 | 389 | 12.34 | 421 | 13.36 | 453 | 14.38 |
| 198 | 6.28 | 230 | 7.30 | 262 | 8.31 | 294 | 9.33 | 326 | 10.34 | 358 | 11.36 | 390 | 12.38 | 422 | 13.39 | 454 | 14.41 |
| 199 | 6.31 | 231 | 7.33 | 263 | 8.34 | 295 | 9.36 | 327 | 10.38 | 359 | 11.39 | 391 | 12.41 | 423 | 13.42 | 455 | 14.44 |
| 200 | 6.34 | 232 | 7.36 | 264 | 8.38 | 296 | 9.39 | 328 | 10.41 | 360 | 11.42 | 392 | 12.44 | 424 | 13.46 | 456 | 14.47 |
| 201 | 6.38 | 233 | 7.39 | 265 | 8.41 | 297 | 9.42 | 329 | 10.44 | 361 | 11.46 | 393 | 12.47 | 425 | 13.49 | 457 | 14.50 |
| 202 | 6.41 | 234 | 7.42 | 266 | 8.44 | 298 | 9.46 | 330 | 10.47 | 362 | 11.49 | 394 | 12.50 | 426 | 13.52 | 458 | 14.54 |
| 203 | 6.44 | 235 | 7.46 | 267 | 8.47 | 299 | 9.49 | 331 | 10.50 | 363 | 11.52 | 395 | 12.53 | 427 | 13.55 | 459 | 14.57 |
| 204 | 6.47 | 236 | 7.49 | 268 | 8.50 | 300 | 9.52 | 332 | 10.53 | 364 | 11.55 | 396 | 12.57 | 428 | 13.58 | 460 | 14.61 |
| 205 | 6.50 | 237 | 7.52 | 269 | 8.53 | 301 | 9.55 | 333 | 10.57 | 365 | 11.58 | 397 | 12.60 | 429 | 13.61 | 461 | 14.63 |
| 206 | 6.53 | 238 | 7.55 | 270 | 8.57 | 302 | 9.58 | 334 | 10.60 | 366 | 11.61 | 398 | 12.63 | 430 | 13.65 | 462 | 14.66 |
| 207 | 6.57 | 239 | 7.58 | 271 | 8.60 | 303 | 9.61 | 335 | 10.63 | 367 | 11.65 | 399 | 12.66 | 431 | 13.68 | 463 | 14.69 |
| 208 | 6.60 | 240 | 7.61 | 272 | 8.63 | 304 | 9.65 | 336 | 10.66 | 368 | 11.68 | 400 | 12.69 | 432 | 13.71 | 464 | 14.73 |
| 209 | 6.63 | 241 | 7.65 | 273 | 8.66 | 305 | 9.68 | 337 | 10.70 | 369 | 11.71 | 401 | 12.73 | 433 | 13.74 | 465 | 14.76 |
| 210 | 6.66 | 242 | 7.68 | 274 | 8.69 | 306 | 9.71 | 338 | 10.73 | 370 | 11.74 | 402 | 12.76 | 434 | 13.77 | 466 | 14.79 |
| 211 | 6.69 | 243 | 7.71 | 275 | 8.73 | 307 | 9.74 | 339 | 10.76 | 371 | 11.77 | 403 | 12.79 | 435 | 13.80 | 467 | 14.82 |

**Constant for Finding Spinning Production**– *Contd.*
**Per Hour at 100% Efficiency.**

Const.—Counts=Production in ozs. per Spindle per hour. D=Delivery in inches. C=Constant.

| D. | C. | D. | C. | D. | C. | D. | C. | D. | C. | D. | C. | D. | C. | D. | C. | D. | C. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 468 | 14.85 | 500 | 15.87 | 532 | 16.88 | 564 | 17.90 | 596 | 18.92 | 628 | 19.93 | 660 | 20.95 | 692 | 21.96 | 724 | 22.98 |
| 469 | 14.88 | 501 | 15.90 | 533 | 16.92 | 565 | 17.93 | 597 | 18.95 | 629 | 19.96 | 661 | 20.98 | 693 | 21.99 | 725 | 23.01 |
| 470 | 14.92 | 502 | 15.93 | 534 | 16 95 | 566 | 17.96 | 598 | 18.98 | 630 | 19.99 | 662 | 21.01 | 694 | 22.03 | 726 | 23.04 |
| 471 | 14.95 | 503 | 15.96 | 535 | 16.98 | 567 | 17.99 | 599 | 19.01 | 631 | 20.03 | 663 | 21.04 | 695 | 22.06 | 727 | 23.07 |
| 472 | 14.98 | 504 | 15.99 | 536 | 17.01 | 568 | 18.03 | 600 | 19.04 | 632 | 20.06 | 664 | 21.07 | 696 | 22.09 | 728 | 23.11 |
| 473 | 15.01 | 505 | 16.03 | 537 | 17.04 | 569 | 18.06 | 601 | 19.07 | 633 | 20.09 | 665 | 21.11 | 697 | 22.12 | 729 | 23.14 |
| 474 | 15.04 | 506 | 16.06 | 538 | 17.07 | 570 | 18.09 | 602 | 19.11 | 634 | 20.12 | 666 | 21.14 | 698 | 22.15 | 730 | 23.17 |
| 475 | 15.07 | 507 | 16.09 | 539 | 17.11 | 571 | 18.12 | 603 | 19.14 | 635 | 20.15 | 667 | 21.17 | 699 | 22.19 | 731 | 23.20 |
| 476 | 15.11 | 508 | 16.12 | 540 | 17.14 | 572 | 18.15 | 604 | 19.17 | 636 | 20.19 | 668 | 21.20 | 700 | 22.22 | 732 | 23.23 |
| 477 | 15.14 | 509 | 16.15 | 541 | 17.17 | 573 | 18.19 | 605 | 19.20 | 637 | 20.22 | 669 | 21.23 | 701 | 22.25 | 733 | 23.26 |
| 478 | 15.17 | 510 | 16.19 | 542 | 17.20 | 574 | 18.22 | 606 | 19.23 | 638 | 20.25 | 670 | 21.26 | 702 | 22.28 | 734 | 23.30 |
| 479 | 15.20 | 511 | 16.22 | 543 | 17.23 | 575 | 18.25 | 607 | 19.26 | 639 | 20.28 | 671 | 21.30 | 703 | 22.31 | 735 | 23.33 |
| 480 | 15.23 | 512 | 16.25 | 544 | 17.27 | 576 | 11.28 | 608 | 19.30 | 640 | 23.31 | 672 | 21.33 | 704 | 22.34 | 736 | 23.36 |
| 481 | 15.26 | 513 | 16.28 | 545 | 17.30 | 577 | 18.31 | 609 | 19.33 | 641 | 20.34 | 673 | 21.36 | 705 | 22.38 | 737 | 23.39 |
| 482 | 15.30 | 514 | 16.31 | 546 | 17.33 | 578 | 18.34 | 610 | 19.36 | 642 | 20.38 | 674 | 21.39 | 706 | 22.41 | 738 | 23.42 |
| 483 | 15.33 | 515 | 16.34 | 547 | 17.36 | 579 | 18.38 | 611 | 19.39 | 643 | 20.41 | 675 | 21.42 | 707 | 22.44 | 739 | 23.46 |
| 484 | 15.36 | 516 | 16.38 | 548 | 17.39 | 580 | 18.41 | 612 | 19.42 | 644 | 20.44 | 676 | 21.46 | 708 | 22.47 | 740 | 23.49 |
| 485 | 15.39 | 517 | 16.41 | 549 | 17.42 | 581 | 18.44 | 613 | 19.46 | 645 | 20.47 | 677 | 21.49 | 709 | 22.50 | 741 | 23.52 |
| 486 | 15.42 | 518 | 16.44 | 550 | 17.46 | 582 | 18.47 | 614 | 19.49 | 646 | 20.50 | 678 | 21.52 | 710 | 22.53 | 742 | 23.55 |
| 487 | 15.46 | 519 | 16.47 | 551 | 17.49 | 583 | 18.50 | 615 | 19.52 | 647 | 20.53 | 679 | 21.55 | 711 | 22.57 | 743 | 23.58 |
| 488 | 15.49 | 520 | 16.50 | 552 | 17.52 | 584 | 18.53 | 616 | 19.55 | 648 | 20.57 | 680 | 21.58 | 712 | 22.60 | 744 | 23.61 |
| 489 | 15.52 | 521 | 16.53 | 553 | 17.55 | 585 | 18.57 | 617 | 19.58 | 649 | 20.60 | 681 | 21.61 | 713 | 22.63 | 745 | 23.65 |
| 490 | 15.55 | 522 | 16.57 | 554 | 17.58 | 586 | 18.60 | 618 | 19.61 | 650 | 20.63 | 682 | 21.65 | 714 | 22.66 | 746 | 23.68 |
| 491 | 15.58 | 523 | 16.60 | 555 | 17.61 | 587 | 18.63 | 619 | 19.65 | 651 | 20.66 | 683 | 21.68 | 715 | 22.69 | 747 | 23.71 |
| 492 | 15.61 | 524 | 16.63 | 556 | 17.65 | 588 | 18.66 | 620 | 19.68 | 652 | 20.69 | 684 | 21.71 | 716 | 22.73 | 748 | 23.74 |
| 493 | 15.65 | 525 | 16.66 | 557 | 17.68 | 589 | 18.69 | 621 | 19.71 | 653 | 20.73 | 685 | 21.74 | 717 | 22.76 | 749 | 23.77 |
| 494 | 15.68 | 526 | 16.69 | 558 | 17.71 | 590 | 18.73 | 622 | 19.74 | 654 | 20.76 | 686 | 21.77 | 718 | 22.79 | 750 | 23.80 |
| 495 | 15.71 | 527 | 16.73 | 559 | 17.74 | 591 | 18.76 | 623 | 19.77 | 655 | 20.79 | 687 | 21.80 | 719 | 22.82 | 751 | 23.84 |
| 496 | 15.74 | 528 | 16.76 | 560 | 17.77 | 592 | 18.79 | 624 | 19.80 | 656 | 20.82 | 688 | 21.84 | 720 | 22.85 | 752 | 23.87 |
| 497 | 15.77 | 529 | 16.79 | 561 | 17.80 | 593 | 18.82 | 625 | 19.84 | 657 | 20.85 | 689 | 21.87 | 721 | 22.88 | 753 | 23.90 |
| 498 | 15.80 | 530 | 16.82 | 562 | 17.84 | 594 | 18.85 | 626 | 19.87 | 658 | 20.88 | 690 | 21.90 | 722 | 22.92 | 754 | 23.93 |
| 499 | 15.84 | 531 | 16.85 | 563 | 17.87 | 595 | 18.88 | 627 | 19.90 | 659 | 20.92 | 691 | 21.93 | 723 | 22.95 | 755 | 23.96 |

**Constant for Finding Spinning Production**—*contd.*
**Per Hour at 100% Efficiency**

Const.÷Counts=Production in ozs. per Spindle per hour. D=Delivery in inches. C=Constant.

| D. | C. | D. | C. | D. | C. | D. | C. | D. | C. | D. | C. | D. | C. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 756 | 23.99 | 788 | 25.01 | 820 | 26.03 | 852 | 27.04 | 884 | 28.06 | 916 | 29.07 | 948 | 30.09 |
| 757 | 24.03 | 789 | 25.04 | 821 | 26.06 | 853 | 27.07 | 885 | 28.09 | 917 | 29.11 | 949 | 30.12 |
| 758 | 24.06 | 790 | 25.07 | 822 | 26.09 | 854 | 27.11 | 886 | 28.12 | 918 | 29.14 | 950 | 30.15 |
| 759 | 24.09 | 791 | 25.11 | 823 | 26.12 | 855 | 27.14 | 887 | 28.15 | 919 | 29.17 | | |
| 760 | 24.12 | 792 | 25.14 | 824 | 26.15 | 856 | 27.17 | 888 | 28.19 | 920 | 29.20 | | |
| 761 | 24.15 | 793 | 25.17 | 825 | 26.19 | 857 | 27.20 | 889 | 28.22 | 921 | 29.23 | | |
| 762 | 24.19 | 794 | 25.20 | 826 | 26.22 | 858 | 27.23 | 890 | 28.25 | 922 | 29.26 | | |
| 763 | 24.22 | 795 | 25.23 | 827 | 26.25 | 859 | 27.26 | 891 | 28.28 | 923 | 29.30 | | |
| 764 | 24.25 | 796 | 25.26 | 828 | 26.28 | 860 | 27.30 | 892 | 28.31 | 924 | 29.33 | | |
| 765 | 24.28 | 797 | 25.30 | 829 | 26.31 | 861 | 27.33 | 893 | 28.34 | 925 | 29.36 | | |
| 766 | 24.31 | 798 | 25.33 | 830 | 26.34 | 862 | 27.36 | 894 | 28.38 | 926 | 29.39 | | |
| 767 | 24.34 | 799 | 25.36 | 831 | 26.38 | 863 | 27.39 | 895 | 28.41 | 927 | 29.42 | | |
| 768 | 24.38 | 800 | 25.39 | 832 | 26.41 | 864 | 27.42 | 896 | 28.44 | 928 | 29.46 | | |
| 769 | 24.41 | 801 | 25.42 | 833 | 26.44 | 865 | 27.46 | 897 | 28.47 | 929 | 29.49 | | |
| 770 | 24.44 | 802 | 25.46 | 834 | 26.47 | 866 | 27.49 | 898 | 28.50 | 930 | 29.52 | | |
| 771 | 24.47 | 803 | 25.49 | 835 | 26.50 | 867 | 27.52 | 899 | 28.53 | 931 | 29.55 | | |
| 772 | 24.59 | 804 | 25.52 | 836 | 26.53 | 868 | 27.55 | 900 | 28.57 | 932 | 29.58 | | |
| 773 | 24.53 | 805 | 25.55 | 837 | 26.57 | 869 | 27.58 | 901 | 28.60 | 933 | 29.61 | | |
| 774 | 24.57 | 806 | 25.58 | 838 | 26.60 | 870 | 27.61 | 902 | 28.63 | 934 | 29.65 | | |
| 775 | 24.60 | 807 | 25.61 | 839 | 26.63 | 871 | 27.65 | 903 | 28.66 | 935 | 29.68 | | |
| 776 | 24.63 | 808 | 25.65 | 840 | 26.66 | 872 | 27.68 | 904 | 28.69 | 936 | 29.71 | | |
| 777 | 24.66 | 809 | 25.68 | 841 | 26.69 | 873 | 27.71 | 905 | 28.73 | 937 | 29.74 | | |
| 778 | 24.69 | 810 | 25.71 | 842 | 26.73 | 874 | 27.74 | 906 | 28.76 | 938 | 29.77 | | |
| 779 | 24.73 | 811 | 25.74 | 843 | 26.76 | 875 | 27.77 | 907 | 28.79 | 939 | 29.80 | | |
| 780 | 24.76 | 812 | 25.77 | 844 | 26.79 | 876 | 27.80 | 908 | 28.82 | 940 | 29.84 | | |
| 781 | 24.79 | 813 | 25.80 | 845 | 26.82 | 877 | 27.84 | 909 | 28.85 | 941 | 29.87 | | |
| 782 | 24.82 | 814 | 25.84 | 846 | 26.85 | 878 | 27.87 | 910 | 28.88 | 942 | 29.90 | | |
| 783 | 24.85 | 815 | 25.87 | 847 | 26.88 | 879 | 27.90 | 911 | 28.92 | 943 | 29.93 | | |
| 784 | 24.88 | 816 | 25.90 | 848 | 26.92 | 880 | 27.93 | 912 | 28.95 | 944 | 29.96 | | |
| 785 | 24.92 | 817 | 25.93 | 849 | 26.95 | 881 | 27.96 | 913 | 28.98 | 945 | 29.99 | | |
| 786 | 24.95 | 818 | 25.96 | 850 | 26.98 | 882 | 27.99 | 914 | 29.01 | 946 | 30.03 | | |
| 787 | 24.98 | 819 | 25.99 | 851 | 27.01 | 883 | 28.03 | 915 | 29.04 | 947 | 30.06 | | |

*Example* :—

Delivery in inches = 283
Constant = 8.98
Counts = 24

$$\frac{8.98}{24} = .374 \text{ Production in ozs. per hour}$$

$.374 \times 9$ hours per day
$= 3.366$ ozs. per Spindle per day.

## OILING OF RING SPINNING FRAMES.

The steps of the front top and bottom rollers must be oiled every two days and those of the middle and back rollers, as also the tin roller bearings, once a week. The fly should be wiped off the necks of the top rollers every day; the fluted rollers ought to be thoroughly cleaned at least every six to eight weeks. The thread guides must be periodically examined, and if necessary set concentric to the spindles and the rings.

See that no thread guides have become bent of position, and also that they have not had a nick worn in them. See that the bobbin in 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 subjected to an irregular movement.

The under—clearers are to be stripped six to eight times a day and the top–clearers twice. Top clearers should be stripped daily, but for loose short staple or other conditions two or three times daily is not too much.

Self-contained spindles should be cleaned (after pumping out the old oil) every 800 hours, and freshly oiled. If the spindles have multiple screw oil cups, it is not necessary to pump out the old oil. Otherwise the spindles are to be cleaned and freshly oiled as in the case of self-contained spindles. The multiple screw cup should be tightened up with a set key when replaced. In the case where the spindles have large oil cups, it is only necessary to oil every 750 hours.

The flutted rollers must be taken out four times a year and the flutes thoroughly cleaned. Care should be taken to rest the rollers on bearers during the scouring, to prevent straining them. The roller steps must be well cleaned and freshly oiled on this occassion. Wipe down the ring rail often, and thoroughly clean the rings once a week.

All gearings must be oiled or greased from time to time.

The front top rollers are to be re-varnished once a week. The top roller leathers must be periodically examined and either re-covered or ground up again.

## PRINCIPAL PARTS REQUIRING LUBRICATION.

| | |
|---|---|
| All Gearing.. | Hand oiled. |
| Stud and links | ,, ,, |
| Rocker finger bowls | ,, ,, |
| Spindles | ,, ,, |
| Traverse motion | ,, ,, |
| All gearings and worn threads | Greased. |
| Rocker shaft pivots | ,, |
| Gearing end in roller shaft bearings | Hand oiled and greased. |
| Bottom rollers (front, middle and back) | ,, ,, ,, ,, |
| Top rollers (front, midle and back) | ,, ,, ,, ,, |
| Middle tin rollers shaft bearings | Ring oiled. |
| Out end tin roller shaft bearings | ,, ,, |
| Buffet end tin roller shaft bearings | ,, ,, |
| Tin roller shaft bearings when ball bearings are applied | Grease packed. |

---

## SPINNING PARTICULARS.

### 4's Reeling.

100% *Waste (Sweeps, etc.)*

| | |
|---|---|
| Speed of main line shaft | 280 |
| Drum on main line shaft | 21″ |
| Pulley on frame end | 13″ |
| No. of spindles | 400 |
| Speed of spindles | 4800 |
| Dia. of ring | $1\frac{1}{4}$′ |
| Ring travellers | No. 14 |
| Test | 280 |
| Draft | 4.00 |
| Front roller speed | 193 |
| Turns per inch | 9 |
| Production 9 hours | 642 lbs. |
| Ozs. per spindle | 25.18 |
| Hank roving | 1 |

### 6's Reeling.

*75% Bengal and 25% Soft Waste.*

| | |
|---|---|
| Speed of main line shaft .. .. .. .. | 280 |
| Drum on main line shaft .. .. .. .. | 21″ |
| Pulley on frame end .. .. .. .. .. | 12″ |
| No. of spindles .. .. .. .. .. .. | 400 |
| Speed of spindles .. .. .. .. .. .. | 5200 |
| Dia. of ring .. .. .. .. .. .. | $1\frac{3}{4}$″ |
| Ring travellers .. .. .. .. .. .. | No. 12. |
| Test .. .. .. .. .. .. .. | 160 |
| Draft .. .. .. .. .. .. .. | 6.00 |
| Front roller speed.. .. .. .. .. .. | 193 |
| Turns per inch .. .. .. .. .. .. | 10 |
| Production 9 hours .. .. .. .. .. | 504 lbs. |
| Ozs. per spindle .. .. .. .. .. .. | 20.16 |
| Hank roving .. .. .. .. .. .. | 1.00 |

### 10's Reeling.

*75% Khandesh and 25% Bengal.*

| | |
|---|---|
| Speed of main line shaft .. .. .. .. | 280 |
| Drum on main line shaft .. .. .. .. | 36″ |
| Pulley on frame end .. .. .. .. .. | 16″ |
| No. of spindles .. .. .. .. .. .. | 400 |
| Speed of spindles .. .. .. .. .. .. | 6825 |
| Dia. of ring .. .. .. .. .. .. | $1\frac{3}{4}$″ |
| Ring travellers .. .. .. .. .. .. | No. 6 |
| Test .. .. .. .. .. .. .. | 89 |
| Draft .. .. .. .. .. .. .. | 6.25 |
| Front roller speed.. .. .. .. .. .. | 178 |
| Turns per inch .. .. .. .. .. .. | 14 |
| Production 10 hours .. .. .. .. .. | 289 lbs. |
| Ozs. per spindle .. .. .. .. .. .. | $11\frac{1}{2}$ |
| Hank roving .. .. .. .. .. .. | 1.6 |

### 10's Weft.

*75% Broach and 25% Soft Waste.*

| | |
|---|---|
| Speed of main line shaft .. .. .. .. | 280 |
| Drum on main line shaft .. .. .. .. | 36″ |
| Pulley on frame end .. .. .. .. .. | 16″ |
| No. of spindles .. .. .. .. .. .. | 400 |

| | |
|---|---|
| Speed of spindles | 6825 |
| Dia. of ring | $1\frac{3}{4}''$ |
| Ring travellers | No. 5 |
| Test | 101 |
| Draft | 5.56 |
| Front roller speed | 222 |
| Turns per inch | 11 |
| Production 10 hours | 403 lbs. |
| Ozs. per spindle | 16.1 |
| Hank roving | 1.8 |

12's Warp.

*75% Western and 25% Waste.*

| | |
|---|---|
| Speed of main line shaft | 280 |
| Drum on main line shaft | 36″ |
| Pulley on frame end | 16″ |
| No. of spindles | 400 |
| Speed of spindles | 6825 |
| Dia. of ring | $1\frac{3}{4}''$ |
| Ring travellers | No. 5 |
| Test | 140 lbs. |
| Draft | 6.67 |
| Front roller speed | 178 |
| Turns per inch | 14 |
| Production 10 hours | 318 lbs. |
| Ozs. per spindle | 12.7 |
| Hank roving | 1.8 |

14's Warp.

*10% Western Cotton.*

| | |
|---|---|
| Speed of main line shaft | 280 |
| Drum on main line shaft | 36″ |
| Pulley on frame end | 14″ |
| No. of spindles | 400 |
| Speed of spindles | 7800 |
| Dia. of ring | $1\frac{3}{4}''$ |
| Ring travellers | No. 8 |
| Test | 120 |
| Draft | 6.22 |
| Front roller speed | 186 |

| | |
|---|---|
| Turns per inch | 15 |
| Production 10 hours | 216 lbs. |
| Ozs. per spindle | 8.6 |
| Hank roving | 2.25 |

### 16's Warp.

#### 100% *Western Cotton.*

| | |
|---|---|
| Speed of main line shaft | 280 |
| Drum on main line shaft | 36″ |
| Pulley on frame end | 14″ |
| No. of spindles | 400 |
| Speed of spindles | 7800 |
| Dia. of ring | $1\frac{3}{4}$″ |
| Ring travellers | No. 2 |
| Test | 98 lbs. |
| Draft | 6.40 |
| Front roller speed | 170 |
| Turns per inch | 17 |
| Production 10 hours | 238 lbs. |
| Ozs. per spindle | 9.5 |
| Hank roving | 2.5 |

### 20's Weft.

#### 100% *Cocanada Cotton.*

| | |
|---|---|
| Speed of main line shaft | 280 |
| Drum on main line shaft | 36″ |
| Pulley on frame end | 14″ |
| No. of spindles | 400 |
| Speed of spindles | 7800 |
| Dia. of ring | $1\frac{1}{4}$″ |
| Ring travellers | No. 4/0 |
| Test | 69 |
| Draft | 5.71 |
| Front roller speed | 150 |
| Turns per inch | 19 |
| Production 10 hours | 120 lbs. |
| Ozs. per spindle | 4.8 |
| Hank Roving | 3.5 |

22's Warp.

100% *Western Cotton.*

| | |
|---|---|
| Speed of main line shaft .. .. .. .. | 280 |
| Drum on main line shaft .. .. .. .. | 36″ |
| Pulley on frame end .. .. .. .. .. | 13″ |
| No. of spindles .. .. .. .. .. .. | 400 |
| Speed of spindles .. .. .. .. .. .. | 8400 |
| Dia. of ring .. .. .. .. .. .. | $1\frac{3}{4}$″ |
| Ring travellers .. .. .. .. .. .. | No. 3/0 |
| Test .. .. .. .. .. .. .. | 72 lbs. |
| Draft .. .. .. .. .. .. .. | 5.50 |
| Front roller speed.. .. .. .. .. .. | 131 |
| Turns per inch .. .. .. .. .. .. | 23 |
| Production 10 hours .. .. .. .. .. | 101 lbs. |
| Ozs. per spindle .. .. .. .. .. .. | 4.04 |
| Hank roving .. .. .. .. .. .. | 4.0 |

24's Weft.

100% *Broach.*

| | |
|---|---|
| Speed of main line shaft .. .. .. .. | 280 |
| Drum on main line shaft .. .. .. .. | 36″ |
| Pulley on frame end .. .. .. .. .. | 14″ |
| No. of spindles .. .. .. .. .. | 400 |
| Speed of spindles .. .. .. .. .. .. | 7800 |
| Dia. of ring .. .. .. .. .. .. | $1\frac{1}{4}$″ |
| Ring travellers .. .. .. .. .. .. | No. 7/0 |
| Test .. .. .. .. .. .. .. | 41 |
| Draft .. .. .. .. .. .. .. | 6.00 |
| Front roller speed.. .. .. .. .. .. | 146 |
| Turns per inch .. .. .. .. .. .. | 19 |
| Production 10 hours .. .. .. .. .. | 120 lbs. |
| Ozs. per spindle .. .. .. .. .. .. | 4.8 |
| Hank roving .. .. .. .. .. .. | 4.0 |

30's Twist.

100% *Sind American.*

| | |
|---|---|
| Speed of main line shaft .. .. .. .. | 250 |
| Drum on main line shaft .. .. .. .. | 38″ |
| Pulley on frame end .. .. .. .. .. | 11″ |
| No. of spindles .. .. .. .. .. .. | 400 |
| Speed of spindles .. .. .. .. .. .. | 8571 |

| | |
|---|---|
| Dia. of ring | $1\frac{3}{4}''$ |
| Ring travellers | No. 4/0 |
| Test | 84 lbs. |
| Draft | 5.74 |
| Front roller speed | 125.2 |
| Turns per inch | 24.87 |
| Production 10 hours | 76 lbs. |
| Ozs. per spindle | 3.04 |
| Hank roving | 5 |

### 36's Twist.

### 100% *Sind American.*

| | |
|---|---|
| Speed of main line shaft | 250 |
| Drum on main line shaft | 33″ |
| Pulley on frame end | 11″ |
| No. of spindle | 400 |
| Speed of spindles | 8571 |
| Dia. of ring | $1\frac{1}{4}''$ |
| Ring travellers | No. 5/0 |
| Test | 61 lbs. |
| Draft | 6.97 |
| Front roller speed | 112.5 |
| Turns per inch | 27.7 |
| Production 10 hours | 62 lbs. |
| Ozs. per spindle | 2.48 |
| Hank roving | 5 |

### 30's Weft.

### 100% *Surat.*

| | |
|---|---|
| Speed of main line shaft | 280 |
| Drum on main line shaft | 36″ |
| Pulley on frame end | 13″ |
| No. of spindles | 400 |
| Speed of spindles | 8400 |
| Dia. of ring | $1\frac{1}{4}''$ |
| Ring travellers | No. 12/0 |
| Test | 37 |
| Draft | 6.00 |
| Front roller speed | 131 |
| Turns per inch | 28 |

| | |
|---|---|
| Production 10 hours | 88 lbs. |
| Ozs. per spindle | 3.5 |
| Hank roving | 5.0 |

### 40's Reeling.

100% *Ankleshwar.*

| | |
|---|---|
| Speed of main line shaft | 280 |
| Drum on main line shaft | 36″ |
| Pulley on frame end | 12″ |
| No. of spindles | 400 |
| Speed of spindles | 9200 |
| Dia. of ring | 1½″ |
| Ring travellers | No. 12/0 |
| Test | 30 |
| Draft | 6.66 |
| Front roller speed | 118 |
| Turns per inch | 30 |
| Production 10 hours | 68 lbs. |
| Ozs. per spindle | 2.7 |
| Hank roving | 8 |

### 40's Warp.

95% *Uganda and* 5% *Soft Waste.*

| | |
|---|---|
| Speed of main line shaft | 250 |
| Drum on main line shaft | 38″ |
| Pulley on frame end | 11″ |
| No. of spindles | 400 |
| Speed of spindles | 8571 |
| Dia. of ring | 1¾″ |
| Ring travellers | No. 8/0 |
| Test | 49 |
| Draft | 6.98 |
| Front roller speed | 181.7 |
| Turns per inch | 20.72 |
| Production 10 hours | 72 lbs. |
| Ozs. per spindle | 3.28 |
| Hank roving | 5.5 |

### 50's Warp.

95% Uganda and 5% Soft Waste.

| | |
|---|---|
| Speed of main line shaft .. .. .. .. | 250 |
| Drum on main line shaft .. .. .. .. | 33 |
| Pulley on frame end .. .. .. .. .. | 11 |
| No. of spindles .. .. .. .. .. .. | 400 |
| Speed of spindles .. .. .. .. .. .. | 8571 |
| Dia. of ring .. .. .. .. .. .. | $1\frac{3}{4}''$ |
| Ring travellers .. .. .. .. .. .. | No. 6/0 |
| Test .. .. .. .. .. .. .. | 33 lbs. |
| Draft .. .. .. .. .. .. .. | 6.98 |
| Front roller speed .. .. .. .. .. .. | 102.8 |
| Turns per inch .. .. .. .. .. .. | 26.56 |
| Production 10 hours .. .. .. .. .. | 32 lbs. |
| Ozs. per spindles .. .. .. .. .. .. | 1.30 |
| Hank roving .. .. .. .. .. .. | 6 |

### 50's Weft.

*Uganda* 95% *Soft Waste* 5%

| | |
|---|---|
| Speed of main line shaft .. .. .. .. | 250 |
| Drum on main line shaft .. .. .. .. | 33″ |
| Pulley on frame end .. .. .. .. .. | 12″ |
| No. of spindles .. .. .. .. .. .. | 464 |
| Speed of spindles .. .. .. .. .. .. | 7857 |
| Dia. of ring .. .. .. .. .. .. | $1\frac{1}{4}''$ |
| Ring travellers .. .. .. .. .. .. | No. 8/0 |
| Test .. .. .. .. .. .. .. | 32 |
| Draft .. .. .. .. .. .. .. | 6.97 |
| Front roller speed .. .. .. .. .. .. | 104.5 |
| Turns per inch .. .. .. .. .. .. | 27.66 |
| Production 10 hours .. .. .. .. .. | 52 lbs. |
| Ozs. per spindle .. .. .. .. .. .. | 1.79 |
| Hank roving .. .. .. .. .. .. | 7 |

### 60's Weft.

100% *Uganda.*

| | |
|---|---|
| Speed of main line shaft .. .. .. .. | 250 |
| Drum on main line shaft .. .. .. .. | 33″ |
| Pulley on frame end .. .. .. .. .. | 12″ |
| No. of spindle .. .. .. .. .. .. | 464 |
| speed of spindles .. .. .. .. .. .. | 7857 |

| | |
|---|---|
| Dia. of ring .. .. .. .. .. .. | $1\frac{1}{4}''$ |
| Ring travellers .. .. .. .. .. .. | No. 14/0 |
| Test .. .. .. .. .. .. .. | 27 lbs. |
| Draft .. .. .. .. .. = .. | 8.33 |
| Front roller speed.. .. .. .. .. .. | 77 |
| Turns per inch .. .. .. .. .. .. | 37.11 |
| Production 10 hours .. .. .. .. .. | 31 lbs. |
| Ozs. per spindle .. .. .. .. .. .. | 1.07 |
| Hank roving .. .. .. .. .. .. | 7 |

60's Combed Warp.

100% Uganda.

| | |
|---|---|
| Speed of main line shaft .. .. .. .. | 250 |
| Drum on main line shaft .. .. .. .. | 33″ |
| Pulley on frame end .. .. .. .. .. | 12″ |
| No. of spindles .. .. .. .. .. .. | 400 |
| Speed of spindles .. .. .. .. .. .. | 7857 |
| Dia. of ring .. .. .. .. .. .. | $1\frac{1}{2}''$ |
| Ring travellers .. .. .. .. .. .. | No. 23/0 |
| Test .. .. .. .. .. .. .. | 22 lbs. |
| Draft .. .. .. .. .. .. .. | 7.5 |
| Front roller speed.. .. .. .. .. .. | 86.7 |
| Turns per inch .. .. .. .. .. .. | 30.49 |
| Production 10 hours .. .. .. .. .. | 30 lbs. |
| Ozs. per spindle .. .. .. .. .. .. | 1.20 |
| Hank roving .. .. .. .. .. .. | 8 |

## PARTICULARS OF COMBED YARN.

Type of cotton = Marad.
Staple Length = $1\frac{1}{2}''$.
Count Spun = 70s Twist, 90s Weft.

| | Sliver Lap. | Ribbon Lap. | Comber | Draw Frame. |
|---|---|---|---|---|
| Revs. of Machine . . . . | 228 | 228 | 365 | 405 |
| Revs. of Front Roller . . | 357.9 | 298.4 | 322.9 | 376 |
| Surface Speed of Front Roller | 1406 | 1173 | 1268.6 | 1329.4 |
| Production for 9 hrs. . . . . | 950 lbs. | 838 lbs | 96.1 lbs | 832 lbs |
| Draft constant. . . . . | 36 | 280 | 2816 | 250 |
| Draft . . . . . . | 1.71 | 5.83 | 68.60 | 5.76 |
| Weight of 1 yard . . . . | 516 grs | 540 grs. | 38.4gr | 40.8grs. |
| Nips. . . . . . . | . . | . . | 93.47 | . . |
| Revs. of Fan. . . . . | . . | . . | 1037.36 | . . |
| No of Teeth Fed . . . . | . . | . . | 4T | . . |
| Waste Percentage . . . . | . . | . . | 15% | . . |
| Step Gauge . . . . . . | . . | . . | 11 | . . |
| Dia. of Front Roller . . . . | $1\frac{1}{4}''$ | $1\frac{1}{4}''$ | $1\frac{1}{4}''$ | $1\frac{1}{8}''$ |
| ,, ,, 2nd ,, . . | $1\frac{1}{4}''$ | $1\frac{1}{8}''$ | $1\frac{1}{8}''$ | $1''$ |
| ,, ,, 3rd ,, . . | $1\frac{1}{4}''$ | $1\frac{1}{4}''$ | $1\frac{1}{8}''$ | $1\frac{1}{8}''$ |
| ,, ,, 4th ,, . . | $1\frac{1}{4}''$ | $1\frac{1}{4}''$ | $1\frac{1}{8}''$ | $1\frac{1}{8}''$ |
| ,, ,, 5th ,, . . | . . | . . | $1\frac{1}{8}''$ | . . |
| Gauge between 1st and 2nd | 7/16″ | $\frac{3}{8}''$ | $\frac{3}{8}''$ | 7/16″ |
| ,, ,, 2nd ,, 3rd. . . | 11/16″ | 9/16″ | $\frac{1}{2}''$ | 9/16″ |
| ,, ,, 3rd ,, 4th. . . | 13/16″ | $\frac{3}{4}''$ | $\frac{5}{8}''$ | 11/16″ |
| ,, ,, 4th ,, 5th. . . | . . | . . | $\frac{3}{4}''$ | . . |
| Centre distance between 1st and 2nd. . . | $1\frac{11}{16}''$ | $1\frac{9}{16}''$ | $1\frac{9}{16}''$ | $1\frac{1}{2}''$ |
| ,, ,, ,, 2nd and 3rd. | $1\frac{15}{16}''$ | $1\frac{3}{4}''$ | $1\frac{3}{4}''$ | $1\frac{5}{8}''$ |
| ,, ,, ,, 3rd and 4th | $2\frac{1}{16}''$ | 2″ | $1\frac{7}{8}''$ | $1\frac{7}{8}''$ |
| ,, , ,, 4th and 5th. | . . | . . | 2″ | . . |
| Horse Power. . . . . | $\frac{1}{2}$ | 1 | 1 | $1\frac{3}{4}''$ |

## CHAPTER XX.

### INSTRUCTIONS FOR FITTERS ERECTING BLOWING ROOM MACHINERY.

The erector should inspect the machinery he has to erect, in order to see if there are any parts broken or missing, which parts must at once be reported to the works.

### Bale-Breaker and Mixing Lattices.

Before commencing erection, look the plan over very carefully and see that the position of the bale-breaker will correspond with the position of the mixing lattices, and that the driving pulleys on line shaft will be clear of hangers or couplings.

Hav ng ascertained the position of bale-breaker, erect the machine square with the line shaft, or counter shaft, from which it is to be driven, the point to be squared from, being the stripping roller.

Put on the spiked lattice, and see that all the blocks are screwed up very tight on their shafts.

The distance between the spikes of the spiked evener roller and the spikes of the spiked lattice must be determined by the production required, and the amount of opening which the cotton requires, a good average distance being 1″.

Fitters must see that the time for erection of beams is kept separate from the time spent on the erection of mising lattices, which time must be reported to the works, and also stated on the time note. Previous to fixing the lattice sides in position, measure up the distance of the beam hangers, and see that they will be clear of the fixings and planing pieces of the lattice sides. See that all blocks are screwed up very securely on the shafts. Give all working parts a good oiling before starting the machines to work.

### Hopper Bale-breaker and Pneumatic Delivery Boxes for Cotton Mixings.

Before commencing erection, look the plan over very carefully and see that the position of the bale-breaker corresponds with the position of the delivery boxes, and that the driving pulleys on line shaft will be clear of hangers and couplings.

Having ascertained the position of bale breaker, erect the machine square with the line shaft or counter shaft from which it is driven, the point to be squared from being the stripping roller.

Put on the spiked lattice, and see that all blocks are screwed up very tight on their shafts.

The distance between the spikes of the spiked evener roller and the spikes of the spiked lattice must be set so as to give just a working clearance, say about $\frac{1}{8}''$ to $\frac{1}{4}''$.

Fitters must see that the time spent for the erection of beams is kept separate from the time spent on the erection of the delivery boxes, such time must be reported to the works and also stated on the time note.

After fixing the beams and hangers, the delivery box framing is erected and pinned after squaring-up, it is then placed in position and the hangers tightened up. Then fit loosely the cage linings, valves, or top plate. Clean the cage and thoroughly blacklead the inside and outside, and also the inside of the delivery boxes, and after fitting the cage see that all cage linings are fitted closely to the cage to prevent any air leakage. The top valves must be a dead fit both when open or closed, and in the case of the last box in a system, the top plate must be a dead fit also.

The cage damper is then set to the position given on the drawing, i.e., 1″ **below level of feed plate,** and then screwed up tightly.

Great care must be taken to get the feed plate, back plate (and in the **last box,** the under-plate), a good fit, and the joints at the sides of the box must be made up with putty.

The stripping roller leather must be sand-papered to take off any rough edges, and the roller set close up to the cage, the pedals then being fitted and adjusted to clear the stripping roller by 1/16″.

The closing doors are only applied to the intermediate boxes, and not to the last box.

Care must be taken that there are no air leakages, as satisfactory working of the boxes is entirely dependent on this. All piping and mouthpieces must also be air-tight, and all joints in the piping must be made in the direction the cotton is moving, otherwise they would cause the cotton to collect and choke up the system.

Fitters must instruct the attendants to *clean out the cages and lubricate all the moving parts weekly (not forgetting the grease cups), and also to blacklead the cage monthly.*

When operating the **valves** (for changing over the mixings) *the fan must be stopped* during this operation. The grease cups on the fan bearings must be examined weekly and replenished when necessary. A hand hole with cover plate is provided near the fan outlet. this is for the purpose of examining the fan propeller, and also for clearing any foreign matter that may be adhering to the inside of the fan or to the propeller.

## For other makes of Bale-Breaker.

We find that the spikes in the evener roller are in some makes $3\frac{1}{2}''$ between each row. These require an additional row adding between to make them $1\frac{3}{4}''$ between each row. This is imperative for bale-breakers with pneumatic mixing plants, as the cotton must be well opened to enable the system to extract a maximum amount of foreign matter.

## Speeds.

Pulley on delivery box $16'' \times 2\frac{1}{2}'' \times 2\frac{1}{2}''$ .. 100 revolutions per minute.

Power per box, $\frac{1}{4}$ H.P. Dia. of fan inlet 14″.

Dia. of fan outlet 15″. Exhaust fan pulley, $6'' \times 5''$.

Exhaust fan 1750 to 2000 revs. per minute according to the distance the cotton is being conveyed and the number of delivery boxes (*see* Plan).

## Double Horizontal opener with Hopper Feeder.

Previous to commencing erection of machines, measure up the fan holes, and see that these are in correct posiion. Note the direction of the dust flues, as this determines the direction in which the fan has to revolve. The greatest care must be taken to build the machine level, and square with the line shaft. Whilst the framing is being built and placed in position all beater bars, culinder bars, cotton guide plates, div:sion plates, and all inside material must be got out and thoroughly blackleaded and polished, so that these will be ready to be applied by the time the machine is built.

Previous to placing the beater and cylinder in position, see that all pedestals are thoroughly cleaned out and free from sand and grit, and also before placing cylinder in position all cylinder bars, cotton guide plates, and division plates can be applied. Give the inside of framings a thorough blackleading all over.

Give the cages, cage rollers, feed rollers, and calender rollers a thorough cleaning with dry whitening; see that the fan boxes are well packed round with either cement or putty; see that all cylinder blades are to correct shape, a good method of bending the blades being by means of 2″ iron pipe, also the blades are to be from all rough edges. See that the beater blades and arms are smooth, and free from sharp or rough edges. Give the stripping rails a thorough good polishing on the stripping edges, and see that they are set clear of the beater and cylinder blades. See that the regulator pedals are well polished with fine emery and blacklead, and free from sharp edges.

Examine the flutes of all feed rollers, and see that they are well polished, and free from rough places.

Before putting the hopper feeder in position, put on the pedal sides, pedal roller, pedals, feed rollers, and feed lattice.

Place the hopper feeder in the position indicated by the pin holes, in top of framing of opener sides. After having levelled and packed the machine, proceed to put in the spiked lattice, care to be taken that all blocks are in correct position on the leather of the lattice, and screwed up very tight. Next put in position the spiked evener roller, and set it to within $\frac{3}{8}$″ from the spiked lattice (a good gauge for setting it being a piece of wood, 12″ $\times$ 6″ $\times$ $\frac{3}{8}$″)

Put in position all dividion plates, dust box, and dust bars, care being taken that these are well blackleaded.

Put in position the leather stripping roller, and cut the leather strips to clear the spikes of the spiked lattice.

Put in the bottom lattice, and ee that all blocks are in correct position, and screwed up tight. The feed regulator motion can now be applied. Put in the swing door with the curve towards the spiked lattice. The setting of the swing door is determined by the weight of lap per yard, though a good system is to set the door so as to keep the hopper feeder box about three-quarters full.

If a feed trunk is required, back of trunk to be set over centre of spiked roller shaft. Bottom of trunk to be set $1\frac{1}{2}''$ from top of spikes. Trunks can be made to the following dimensions, $12''$ or $14''$ deep, and full width of machine, allowance to be made for strengthening pieces round bottom of trunk.

On starting the machine to work, personally see that all working parts are well oiled and lubricated.

Put in the cotton a good quantity of powdered dry whitening, this will clean and make smooth the inside of the machine.

If the weight of lap per yard is not correct, this can be made so by means of the various change wheels which are supplied with each machine. The wheels are a wide range, and will give a weight of lap ranging from 10 ounces to 20 ounces per yard.

## Finisher Scutcher.

Before commencing erection of the machine, fitter must ascertain if the fan hole is in correct position. Put fan and fan box in to suit the direction in which the flue into exhaust the dust chamber. See that the fan blades are well screwed up before putting it in the fan box. Have all cotton guide plates, beater bars, pedals, and all inside material well blackleaded.

Square the machine from the line-shaft, the point to be squared from being the beater. See that all beater pedestals are thoroughly cleaned out and free from grit.

Having levelled the machine, put in the division plates, cotton guide plates and beater bars, and all inside material. Next apply the pedal sides, and pedal and feed rollers, first seeing that the rollers are thoroughly clean, and free from all dents, and sharp edges.

Put in the feed lattice sides, and see that all the blocks are in correct position on their shafts to suit the leathers of the lattice. See that the lattice is put in so that the piecing of the leathers will run the right way.

On commencing to apply the material to the lap end, see that the brake treadle rail is well packed all round, so that the brake will have a solid surface. See that the brake saddle is well bedded to the brake pulley.

As each shaft is put in see that it is well oiled in its bearings. Oil all calender and lap roller pedestals before these are put in position.

## Exhaust Opener (No. 1).

The remarks *re* double horizontal opener will apply to this machine, to which must be added the following further instructions :

Pay special attention to the cylinder pedestals. As the cylinder is very heavy, and runs at a very high speed, make it necessary that the cylinder necks are well bedded in their pedestals. See that the cylinder knives are of correct shape and free from all sharp edges.

In coupling up the tin pipes arrange each section of piping so that the soldered joints run with the cotton, and not against it, as otherwise it will cause the cotton to collect and choke up the pipes This rule must be followed also in coupling the sections together. For instance, number one section (next to porcupine opener) must be inserted into number one end of number two section, number two section into number two end of number three section. This course to be pursued until the mouth-piece,, immediately over the exhaust cylinder, is reached. After all pipes are connected and levelled up, have all the joints made air-tight by putty or red-lead. See that the dust boxes are air-tight, special attention being paid to the hinged doors.

Too much importance cannot be paid to the tin pipes, seeing that they are perfectly air-tight, as any loss of air current from this source will cause the cotton to lodge in the pipes, and thereby cause irregular feeding to the opener.

## Exhaust Opener (No. 2).

In addition to the instructions given above for the No. 1 model machine, special attention must be paid to the *Feed Part* of this machine.

Inside the exhaust cage is the 'air control pipe' consisting of a cylindrical tube with a slot throughout the whole of its length. This slot must be set towards the feed trunk at an angle of 15″° from the vertical axis, as this position distributes the cotton most effectively on the exhaust cage.

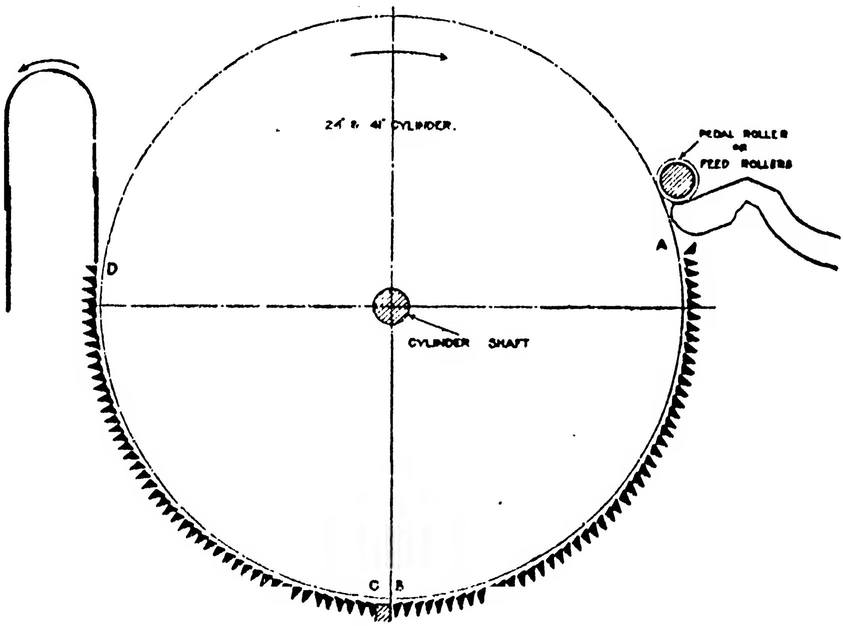
The ventilation panels in the sides of the feed trunk are to be adjusted to admit air in a sufficient quantity to allow for a free distribution of the cotton on the exhaust cage, and until the cotton passes through the cage delivery rollers in an even fleece.

The cylinder bars round the 24″ cylinder must be set in accordance with the instructions given below.

The direction of the fans must be arranged in accordance with the direction of the dust flues.

## Openers and Scutchers.

Settings and spacings of cylinder and beater bars, in openers and scutchers with the new system of bars and cotton guide plates applied.



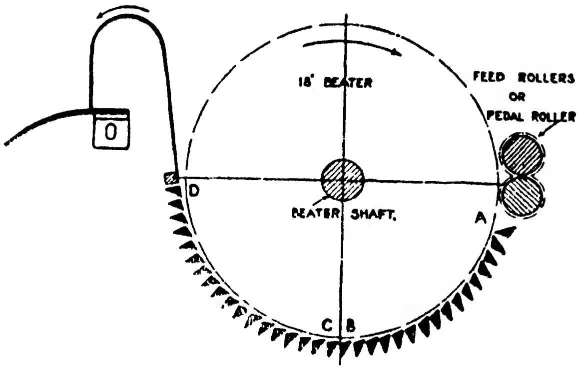

Arrangement & Setting of Cleaning Bars for 24″ & 41″ Cylinders

### Cylinder Bars.

| | | |
|---|---|---|
| A | Cylinder knives to bars | $=\frac{1}{2}''$ |
| B | ,, ,, ,, | $=\frac{3}{8}''$ |
| C | ,, ,, ,, | $=\frac{1}{2}''$ |
| D | ,, ,, ,, | $=\frac{3}{8}''$ |

Point A—The top twelve bars packed out to $\frac{3}{8}''$ space between bars.
Point D—The top six bars packed out to $\frac{3}{8}''$ space between bars.
Point C—The first six bars to be put in the reverse way.

All other bars to be $\frac{3}{16}''$ space between bars.




Arrangement & Setting of Cleaning Bars for 18″ Beater.

## Beater Bars.

A and B beater blade to bars $= \frac{3}{8}''$

C and D ,, ,, ,, $= \frac{7}{16}''$ to $\frac{1}{2}''$

Point A—The top six bars to be packed out to $\frac{3}{8}''$ space between bars.

Point D—The top four bars to be packed out to $\frac{3}{8}''$ space between bars.

All other bars to be $\frac{3}{16}''$ space between bars.

## Minimum Settings of Feed Rollers and Pedal Rollers.

| | Sea Island. | Egyptian | American and Indian |
|---|---|---|---|
| From Feed Rollers to Cylinder | $\frac{7}{16}''$ | $\frac{3}{8}''$ | $\frac{5}{16}''$ |
| ,, Pedal ,, ,, ,, | $\frac{7}{16}''$ | $\frac{3}{8}''$ | $\frac{5}{16}''$ |
| ,, Feed ,, ,, Beater | $\frac{7}{16}''$ | $\frac{3}{8}''$ | $\frac{5}{16}''$ |
| ,, Pedal ,, ,, ,, | $\frac{7}{16}''$ | $\frac{3}{8}''$ | $\frac{5}{16}''$ |

## Porcupine Opener.

Square the machine from the line shaft, the point to be squared from being the cylinder. See that all pedestals and bearings are free from grit and are thoroughly cleaned out.

Having levelled the machine, put in the cylinder bars, cotton guide plates, and all inside material. Next apply the pedal sides, and pedal and feed rollers after seeing that the rollers are thoroughly clean, free from dents and all sharp edges.

Put on the feed lattice sides, and see that all blocks are in correct position on the shafts to suit the leathers on the lattice. See that the lattice is put on so that the piecing of the leathers will run the right way.

As each shaft is put in see that it is well oiled in its bearings.

See that the mouth-piece is a good fit and air-tight.

For the setting of the cylinder bars see instructions given on page 602.

## VERTICAL CYLINDER OPENER.

Before commencing to erect the machine measure up and see that the fan hole is in correct position.

Have the cage, cage roller, fan and fan box, and pipes, grids, and all inside materials well black-leaded and polished.

Level the machine across the top of framing, and square from the mill wall or pillars. Examine all cylinder plates and see that these are of correct shape and free from sharp edges. Put in the bottom "three leg," and see that the cylinder footstep is perfectly level across every way.

Have the footsteps well cleaned out and free from all sand or grit.

If the cylinder is driven by means of a belt from the counter shaft, have the cylinder pulley set sufficiently low to allow the belt to run clear of the bottom flange of the cylinder pulley, and thus avoid any down pressure from the belt.

If the cylinder is driven by means of the improved rope driving apparatus, the cylinder pulley must be set to suit the carrier pulleys supplied with the apparatus.

Care must be taken to have the machine very well packed under the feet of the framing, as otherwise there will be considerable vibration in the machine.

## OPENERS AND SCUTCHERS.

**Good average speeds for beaters cylinders, fans, and rollers:—**

### Hopper Bale-Breakers.

| | |
|---|---|
| Leather stripping roller .. .. | 300 revolutions per minute. |
| Fan .. .. .. .. | 1000 to 1400 ,, ,, |

### Double Horizontal Opener.

| | |
|---|---|
| Cylinder .. .. .. .. | 450 to 500 revolutions per minute |
| Beater, 3 blades .. .. .. | 950 to 1050 ,, ,, |
| Beater, 2 blades .. .. .. | 1050 to 1150 ,, ,, |
| Fan .. .. .. .. | 1000 to 1400 ,, ,, |

### Exhaust Opener.

| | |
|---|---|
| Exhaust cylinder .. .. .. | 900 revolutions per minute. |
| Beater, 3 blades .. .. .. | 1000 to 1100 ,, ,, |
| Beater, 2 blades .. .. .. | 1150 to 1200 ,, ,, |
| Fan .. .. .. .. | 10 0 to 1100 ,, ,, |

### Single Scutcher.

| | |
|---|---|
| Beater 3 blades .. .. .. | 950 to 1050 revolutions per minute |
| Beater, 2 blades .. .. .. | 1050 to 1150 ,, ,, |
| Fan .. .. .. .. | 1000 to 1400 ,, ,, |

### Hopper Feeder.

| | |
|---|---|
| Leather stripping roller .. .. | 250 revolutions per minute. |
| Evener roller .. .. .. | 65 ,, ,, |

### Verticle Cylinder. Opener.

| | | |
|---|---|---|
| Cylinder .. .. | 1000 | revolutions per minute, with fan and lattice delivery. |
| Cylinder .. .. | 600 | .. .. with by-pass pipes. |
| Fan .. .. | 1000 | .. .. |

## Openers, Etc.

In setting the fan boxes and fans in all classes of blowing-room machinery, the setting will be governed by the direction of the dust flues.

When standing at the left hand side of machine, looking from feed end :—

If the dust flues run towards the delivery end of the machine, the fan and box will be placed as per sketch A 2. If the dust flues run towards back or feed part of machine, the fan and box will be placed as per sketch A1.

If the flues run at right angles to the machine or into an open dust cellar, it is advisable to place the fan and box as per sketch A2.

When fans are placed in position after erecting the machine, *see that a white arrow is painted on framing to indicate the direction in which the fans have to run.*


Sketch A.1. Sketch A.2.

**Fan Speeds.**

| | | |
|---|---|---|
| Cylinder fans | .. | 1200 to 1400 revolutions per minute. |
| Beater fans | .. | 1000 to 1200 ,, ,, |

Care must be exercised and measures taken to ensure that the fans have an unobstructed exhaust. It is essential that the dust flues or pipes are large enough. If the dust flue is cylindrical, it must not be less than 12″ dia. Flues 12″ to 14″ dia. give sufficient area.

The dust tower, which should be open at the top, must have an area considerably greater than the total area of all flues and pipes which exhaust into it.

Air must be admitted into the machine through the adjustable ventilation panels, which are of sheet iron, and will be found under the cylinder or beater bars.

On completion of erection, the fitter must have a good look round the mill to see if there is any surplus material, planks, or packing cases, which must be at once reported to the works, so that means can be taken to have them returned, removed or sold.

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## INSTRUCTIONS FOR ERECTION OF CARDING ENGINES.

The erector should inspect the machines which he has to erect in order to see if there are any broken or missing parts, which must be reported to the works at once.

All wire fillets must be put in a warm and dry place for three or four days with the paper in which they are wrapped, torn up to allow the warmth to get to the wire prior to being mounted. This is essential to obtain the best condition of the fillets. Let the flat chain soak in oil for a few days.

Also put flats, taker-in, and all combs, in a dry place to prevent any rusting.

On commencing erection see that the framings and cross rails are perfect, and black-lead all the insides of the same. Look at the calender plate to ascertain whether the card is right or left handed, fix framing and cross rails together with bolts and pins. Pack each corner foot so that the framing is level all the way round, leaving the middle foot without packings. Remove the steel ends of cylinder and tighten up all bolts on the insude. Fix in the shaft by the conical bushes as indicated by the stamped figures, placing short end of cylinder shaft on same side as the coiler.

First see that the holes in cylinder rings. the shafts. and cone bushes are perfectly clean.

Insert the short end of shaft through ring first, and on the large diameter of the shaft a mark will be found where the cone bush has been driven at the works. An indentation is cast in the cylinder ring, place the split in the cone bush exactly opposite to this indentation.

The shafts are marked on the large diameter of the body Z1 on the short ends of the shafts, and Z2 on the long ends, opposite the split in the cone bushes—place all these marks in a line and drive first one bush, and then the other up gently. See that the shafts are perfectly central with the cylinder or doffer and then drive the bushes up firmly until secured.

The cylinder and doffer are always stamped on the edge (at the short end of shaft only) with the letters and number of card, and are packed on their own shafts.

On page 602 is given a drawing illustrating the above instructions

Put cylinder, with pedestals in position, on framing, put bends in position by pins and bolts, and square up the card from the cylinder shaft to a line taken from the main driving shaft, and by adjusting the corner feet packings (raising or lowering) the same clearance will be obtained between bends and cylinder edge. *This is very necessary.* Then get four hard wood wedges and put one at each side of the middle foot which is directly under cylinder pedestal. Drive in these wedges until the packings at each corner foot are just loose. Then fit in the middle packings. drive out the wedges, thus allowing the weight to come down on the packings, which ensures that the card will run steadily and without vibration. Take off the cylinder pedestal caps and drive up finally the conical bushes by a heavy hammer taking particular care to drive up both halves of the bush together (*not* each half *separately*). Follow the same process with the doffer as regards inside bolts, and see that the cylinder and doffer are clear before revolving. Clean off all paint, etc., from the surface of the cylinder and doffer by means of emery cloth held to the surface while they are revolving, and then examine wood plugs, rectifying faulty ones. If customer desires surfaces painted this can now be done.

Mounting of Wire Fillets.

Cylinder—maintain a uniform tension throughout.

Do not exceed 330 lbs. for 2″ wide.

Doffers—do not exceed 225 lbs. for $1\frac{1}{2}$″ wide.

Roller and clearers—do not exceed 120 lbs. for 1″ wide.

In all cases for the tail ends the tension must be proportionate to their width, erring *slightly* on the excessive side. Care must be taken during mounting to see that each layer is well up against the preceding layer as this prevents any opening out of fillets in later years. During mounting have some one rubbing the wire teeth into position, also do this once before starting to mount. Put a tack in each plug on the outer edge of the cylinder, doffer, roller, or clearers.

## Grinding.

First see that the grinding rollers are in good order, running true, and that the bushes are perfect. Set the rollers to the cylinder and doffer by gauges to 10/1000″ and then set the whole in motion.

Bring them into grinding by listening carefully at each side of the card until assured that the contact is even throughout (this is termed grinding by ear). Grinding is carried on under the same conditions as usually adopted in the mills until satisfied that they are sufficiently ground. Examine the taker-in to see that all the teeth are in perfect condition, black-lead thoroughly and place in position. After having examined, cleaned, and black-leaded the casings, mote knives and feed plate, set nose of the feed plate to 7/1000″ from the feed roller. Remove the taker-in and set the undercasings, and then replace taker-in. See that all the knives and plates at the front of the card are perfectly straight (particularly the bevelled edges) before placing in position. Go over each setting and set to 15/1000″ taking the various points of flexible down together (not individually). Prior to erection of the card let the flat chain soak in oil for a few days and when putting the flats on use oil whilst screwing up, and hen proceed to finish off the card. See that everything is clear before just turning the cylinder. doffer and the taker-in by hand. After grinding, set flats down to 10/1000″ and grind the flats for at least 1½ days prior to putting cotton through. Do not use flat strips if waste cotton is to be used, for starting cards, better the stripping from the cylinder and doffer as the former is usually composed of hard buttons and does harm to the wire if fed in volume as is required to form a lap.

**In setting the various parts of the card the following settings will be found satisfactory:—**

| | Sea Island | Egyptian | American | Indian |
|---|---|---|---|---|
| Taker-in to Cylinder .. | 7/1000″ | 7/1000″ | 7/1000″ | 7/1000″ |
| Feed Plate to Taker-in .. | 7/1000″ | 7/1000″ | 7/1000″ | 7/1000″ |
| Undercasing to Cylinder (top edge) .. | 22/1000″ | 22/1000″ | 22/1000″ | 22/1000″ |
| Undercasing to Cylinder (bottom edge) .. | 34/1000″ | 34/1000″ | 34/1000″ | 34/1000″ |
| Back Knife to Cylinder (top edge) .. | 22/1000″ | 22/1000″ | 22/1000″ | 22/1000″ |
| Back Knife to Cylinder (bottom edge) .. | 22/1000″ | 22/1000″ | 22/1000″ | 22/1000″ |
| Doffer to Cylinder .. | 7/1000″ | 7/1000″ | 7/1000″ | 7/1000″ |
| Doffer Comb to Doffer .. | 12/1000″ | 12/1000″ | 12/1000″ | 12/1000″ |
| Flats to Cylinder (whilst new) .. | 10/1000″ | 10/1000″ | 10/1000″ | 10/1000″ |
| Flats to Cylinder (after six months) .. | 8/1000″ | 8/1000″ | 8/1000″ | 8/1000″ |

**Mixed cards as above with the following extras:—**

| | |
|---|---|
| Roller to Cylinder .. .. .. | 10/1000″ |
| Clearer to Cylinder .. .. .. | 22/1000″ |
| Clearer to Roller .. .. .. | 12/1000″ |
| Top Knife between Flats and Roller .. | 29/1000″ |

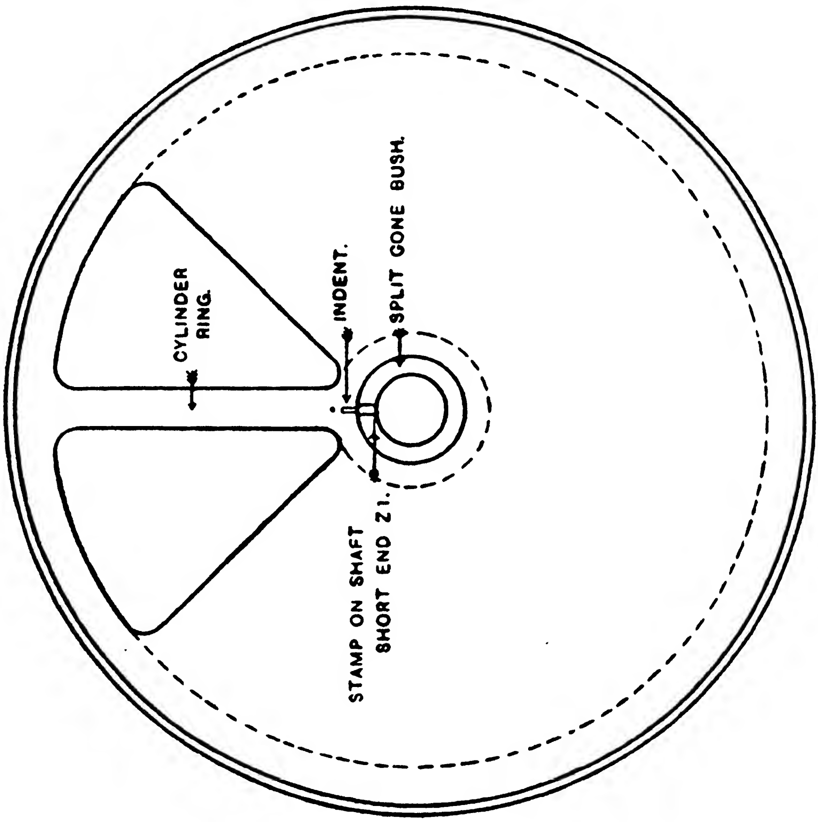
MAINTENANCE OF MIXED CARDS.

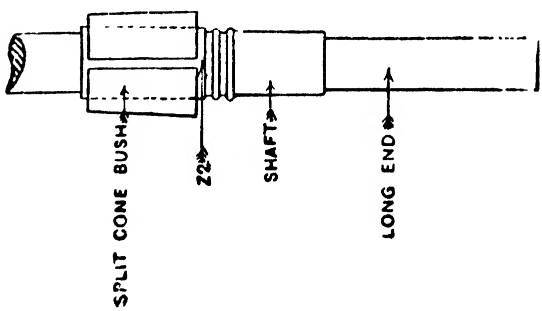
Cylinder, doffer, rollers, and clearers to be ground up, each 15 to 20 days according to class of cotton used. Flats ground up every four weeks for a full day.

Set Doffer to Cylinder each time after grinding.
Set Rollers each time after grinding.
Set Clearers each alternate time.
Set Flats every 9 weeks.

It is necessary in all cards to have taker-in and casing down at least once in a year thoroughly cleaned and re-set.

Stripping of rollers and clearers is only done when grinding is about to be done.



# INSTRUCTIONS TO FITTERS ERECTING DRAW FRAMES.

The erector should inspect the machinery be has to erect, in order to see if there are any parts broken or missing, which parts must at once be reported to the works.

The letters of machines are stamped on the frame ends with the consecutive number of machine stamped underneath these letters.

Please note when ordering material for jobbing that these letters must be given as reference. The material for each head, irrespective of number of deliveries, is also stamped. For example, a frame of 3 heads would be 1st head, A1; 2nd head, A2; and third head, A3; and also the material used for each delivery is stamped accordingly, as for instance, first delivery, A1; second celivery A2, and and so on up to the total number of deliveries per frame, but when ordering material for jobbing these letters (which may be any letter from A to Z), must not be used, as they are only for shop reference.

All top rollers must be sent to be covered, and clearers if necessary.

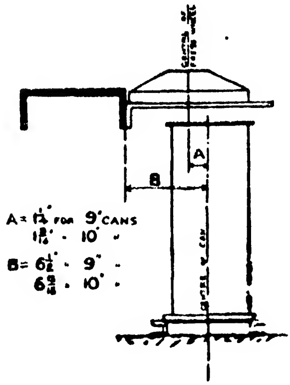
Line up the frame from the line shaft or counter shaft from which it is driven. Pack the frame sufficiently high, so as to allow a space of $1\frac{3}{4}''$ between top of sliver can and under side of coiler frame, and level beams with a spirit level. Put in bottom steel rollers, and see that they are perfectly easy, and that they also run straight in their bearings.

Mark out the position of the can bottom frames (*see* sketch next page), so that the floor can be cut by either the mason or carpenter, whilst the back portion of the frame is being erected.

See that all shafts or rollers revolve easily in their bearings, and that same are perfectly clean and thoroughly oiled during erection.

The balance of spoons can be regulated by raising or lowering the rod which supports the underside of front of spoon. The lower the rod the lighter the spoon and *vice versa.*

See that all top rollers are easy in their bearings, and have sufficient end play to ensure easy lifting and running.




The sliver funnels, are also left small in the holes, and must be reamered out to suit the weight of sliver being used on the frame. See that the front calender rollers are left easy in their position, and carefully stretched so as to run true.

Thoroughly oil all working parts, and instruct the tenter as to the various oiling places on the machine.

When each frame is finished everything must be left in perfect working order, to the satisfaction of the mill officials.

On completion of erection, the fitter must have a good look round the mill to see if there is any surplus material, planks, or packing cases, which must be at once reported to the works, so that means can be taken to have them returned, removed or sold.

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## INSTRUCTIONS TO FITTERS ERECTING FLY FRAMES.

The erector should inspect the machinery he has to erect, in order to see if there are any parts broken or missing, which parts must at once be reported to the works.

First determine the intended position of the frame, relative to plan, driving shaft, method of driving, or to other frames already in position.

The roller beam must be parallel to line shaft when driven by open or crossed belt, and at right angles to line shaft, when driven by half-twisted belt. To set the frame in position lengthways' when driven by half-twisted belt, drop a plumb line from the down face of line shaft pulley, and, with frame pulleys in position, adjust the frame so that plumb line falls $\frac{3}{8}''$ on fast pulley for outside driving and $\frac{3}{8}''$ on loose pulley for inside driving. (*See* sketches.)

Mount the first section of roller beam on frame end, and spring pieces, and place as near as possible to correct position lengthways and widthways. See that the beam rests on the two frame end supports. Mount the remaining section of roller beam and couple up.

Place the roller stands in their places, according to numbers, secure the end one's and middle ones at each coupling, in the scribed positions on the beams. Stretch a twine line in the front necks of the stands, level the frame ends in the slide and place packings of required thickness under the feet of frame ends, as may be required to make the roller beam level lengthways. A good method of testing whether the beam is level from gearing to out-end is as follows: see that the line is clear of all middle stands, take two raising screws or screw jacks, place them 3 feet apart, about the middle of the frame, adjust them to the height of the line, place a straight edge on the screws, and test with spirit level on straight edge. If not level, raise either the gearing or out-end frame end, readjust the screws to the line, try again with straight edge and spirit level, and repeat these operations until the correct level is obtained.

Line up the roller beam at each spring piece to the line on the roller stands, and level the spring pieces in the slots. Put all spring piece pins in, taking care not to drive them in too hard, and level the spring pieces sideways. Adjust frame to correct position, lengthways and sideways; hang beam weights, except at spring pieces, and line up the beam again, and lock the nuts of the raising screws.

Put in S bar, motion bar, strike shaft, and top cone drum, clean the bearings and oil well. Put in gearing bottom rail with pin in frame end bracket, and frame end level sideways on face of slide, secure to brackets on spring piece feet, and follow in like manner with remaining section. Place spring piece slides in spring pieces supported by wooden pieces 5″ long, and height slides from top of foot to roller beam by wedges placed under the wooden supports.

Adjust gearing end slide to bobbin rail, and put rail in position, and follow on with remaining section of rails. See that gearing end and off end slides are up to the frame ends, then bolt up all the spring piece slides, and see that they are perfectly free in the spring pieces the full length of slot, as sticking slides cause faulty taper of bobbins.

Line up the roller beam finally to the line on the stands, levelling the spring pieces at the same time.

In case of frames delivered without collars in the rails, the fitter should at this stage instruct the labourer to put all collars in position with washers and nuts, but not to be screwed up by the labourer. Heighten the bobbin rail from the tops of the back line of snugs to the roller beam, plumb the gearing and off end front spindles, line up the top and bottom rails to a line at top and bottom of spindles, then put in the lifting shafts, and plumb the lifting racks on side and front. Gear the train of lifting wheels from strike shaft to outside lifiting wheel as deeply as possible without sticking, and screw outside lifting shaft wheel to shaft, push lifting shaft wheel up to socket, and screw up all lifting rack wheels.

Place both strike bevels in gear with strike wheel, and screw them up, then hang balance weights, and take out wooden supports from under lifting slides, then heighten bobbin rail at each lifting rack wheel, gauging from boss of collars to let on mark on spindles, screwing up well the lifting wheels.

Whilst the gearing and motions are being fitted instuct the labourer to clean all collars and footsteps of grit and dirt.

The gearing and motions may now be put in, care being taken that all sockets and studs be well cleaned, and all working parts, studs, nuts, and bolts to be well oiled as the erection proceeds. This oiling of parts is very important, and should be carried out from the commencement of the erection. No grease to be put inside the differential motion, but it must have as much oil as it will hold. See particularly that top and bottom cone drums are easy in their bearings.

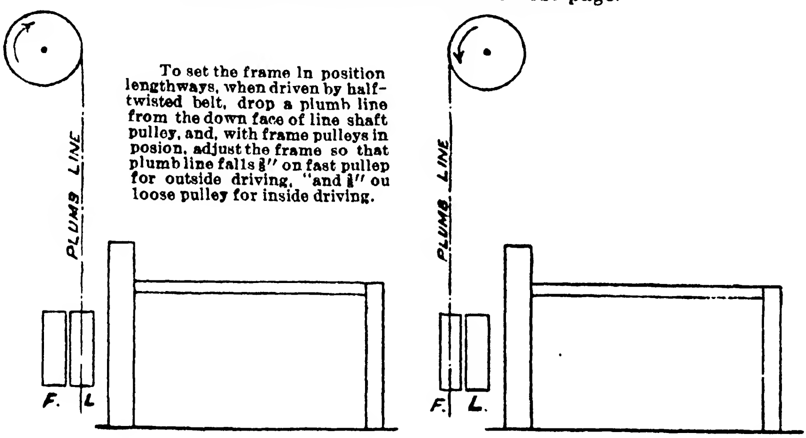
Lay out the bottom rollers in correct position according to number, and put in the two back lines, examining the rollers for being true, as each roller is coupled up. stretch the rollers if necessary as the job proceeds, line up the roller stands to a line on the front facing of the stand projection of front neck, the back and middle roller slides must be loose on the stands whilst this is being done, put in the front line of rollers, and see tnat all rollers are free in their bearings. Do not use oil or grease on the squares of the rollers, chalked squares being satisfactory.

Put in the roller traverse rods and motion and adjust same. Put front beam plates in, and remaining beam weights. Erect the creel, and see that the pot steps are cleaned out. Examine the bobbin rail for lining up to the line on the spindles. Set the collars to revolve freely in the footsteps. Couple up the bobbin and spindle shafts, and see that they are bedded to the bearings, and correctly heighted to suit the gearing of the bobbin and spindle wheels. See that the shafts are free in their bearings, place the bobbin wheels on the collars, oil well, and gear the skew gear wheels alternately so that half of the wheels have the screws on one side of the shafts and half on the other so as to ensure balancing.

Place the back line of spindles in the collars, screw up every alternate wheel at a suitable distance from spindle by means of a wooden gauge placed between the teeth of the skew gear wheel and the spindle (*for thickness of gauge see dimensions appended*). Turn shaft half a revolution, then screw up remaining wheels. Place the back spindles with the front collars, and screw up the skew gear wheels as before. Half fill the back footsteps with oil, put the back top casings and spindle washers in position, replace the front spindles in the back line, put on the spindle wheels, and gear up with skew gear wheels. Repeat this process for the front line.

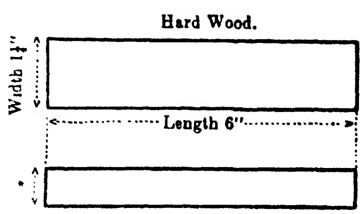
Fill the bobbin and spindle shaft bearings with grease, and cover the rails with all casing plates and boards.

Sketches as referred to on the first page.




DIMENSIONS OF GAUGES FOR SETTING SCREW GEAR WHEELS FOR SPINDLE GEARING

| Diameter of spindle. | Thickness of gauge. |
|---|---|
| $\frac{7}{8}$" | $\frac{11}{16}$" |
| $\frac{13}{16}$" | $\frac{28}{32}$" |
| $\frac{3}{4}$" | $\frac{3}{4}$" |
| $\frac{11}{16}$" | $\frac{9}{16}$" |
| $\frac{5}{8}$ | $\frac{19}{32}$" |
| $\frac{9}{16}$" | $\frac{5}{8}$" |
| $\frac{1}{2}$" | $\frac{21}{32}$" |




These dimensions are for 26's spindle wheels with $\frac{7}{8}$" × $\frac{13}{16}$ and $\frac{3}{4}$" diameter spindle, and 22's spindle wheels with $\frac{11}{16}$", $\frac{5}{8}$*, $\frac{9}{16}$, and $\frac{1}{2}$" diameter spindles.

* Thickness according to diameter of spindles and size of spindle wheels (*See table of dimensions.*)

## SETTING OF REVERSING AND BUILDING MOTIONS.

Set the bobbin rail at half lift, that is, presser in centre of bobbin; adjust cone belt to start $\frac{1}{2}''$ from line on cone drums, set tapering rack to project through bracket $\frac{1}{2}''$ at round end, drop bracket so as to gear tapering rack with wheel. Level the tapering rack by raising or lowering the tapering slide, see that the end of rack clears the tapering slide. Wind the bobbin rail by hand to its highest position, as shewn by the presser on the bobbin, and set the reversing motion catch screw, then lower the rail to bottom position of lift, and set the screw for same. Fix slide guards on off end spring pieces.

Before starting up see that all parts are well oiled, and instruct the tenter as to the chief oiling places.

Also before starting up the frame, see that the rollers are well cleaned in the flutes, and polished with whiting. See that all top rollers are free in cap nebs. Start the frame with 6 bobbins, and see that the winding is correct throughout the building of the bobbins. Wind with as little tension as possible, especially at the commencement of the bobbin.

As each frame is finished leave everything in perfect order, and to the satisfaction of the mill officials.

On completion of erection, the fitter must have a good look round the mill, to see if there is any surplus material, planks, or packing cases, which must be at once reported to the works, so that means can be taken to have them returned, removed or sold.

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## INSTRUCTIONS TO FITTERS ERECTING RING FRAMES AND DOUBLERS.

The erector should inspect the machinery he has to erect, in order to see if there are any parts broken or missing, which parts must at once be reported to the works.

First lay out the frame ends and spring pieces, level up the gearing frame end.. Drop a line from the face of the driving or guide pulley, so that its lower end overhangs $\frac{5}{8}''$ on the inside face of the fast pulley on the frame end.

Couple up all the beams, and make level on the spring pieces, put a line on the front line of the roller stands on each side of the frame, from these level the beams by lifting up the spring pieces, taking every other spring piece first, and working from both sides of the machine. Put on the gearing end spindle rail and level it up in each direction, then see if machine is in correct position, from this follow on with the others in the same manner.

Arrange the gearing and the motion, be careful to oil all the moving parts as the erection proceeds. See that the pokers are quite free in their bushes, but on no account must they be oiled, as accumulations of fly and dust take place, and cause irregular lifting. Put in the rocking shafts and couple them up to the coupling rods. After putting the ring plates in position arrange the balance weights.

Fit in the Tin rollers, and line them up very carefully, making them solid in the bearings, and easy to work. Arrange the thread-board lifting motion, and afterwards set the cap bars carefully. Put in the rollers, and see that these are well cleaned, put no oil or grease on the squares or holes. Put in traverse rods and set the guides very carefully.

When setting the ring plates, have them all one distance from the top of ring to the top of spindle rail, there must be no binding in the plates. Also see that bearings are well cleaned. Now put in the spindles, and, after winding the motion up to the centre of the lift, set the spindles to the centre of the ring. The thread guides must now be put in very tightly and directly over the centre of the spindle.

When erecting the creel see that the pot steps are well cleaned out.

When banding the spindles, first run the machine for a short time with ten on each side of the coupling of the tin roller., then put bands on the remainder of the spindles. When the frame has run for an hour or so, go over the spindles again to see if they are in the centre of the ring, also set the thread wires again. The setting of the spindles and thread wires must be done very carefully.

When setting the lift for a good bobbin, have the motion bowl in the hollow of the heart cam, and the motion wound down to the stop on the motion, the top of the ring should be $\frac{1}{2}''$ from the bottom of the bobbin. Turn the cam round so that the point is on the bowl, then sét the lug on the main block $\frac{1}{8}''$ away from the lifting chain.

On completion of erection, the fitter must have a good look round the mill, to see if there is any surplus material, planks, or packing cases, which must be at once reported to the works, so that means can be taken to have them returned.

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## INSTRUCTIONS FOR STARTING AND WORKING.

### RING SPINNING FRAMES.

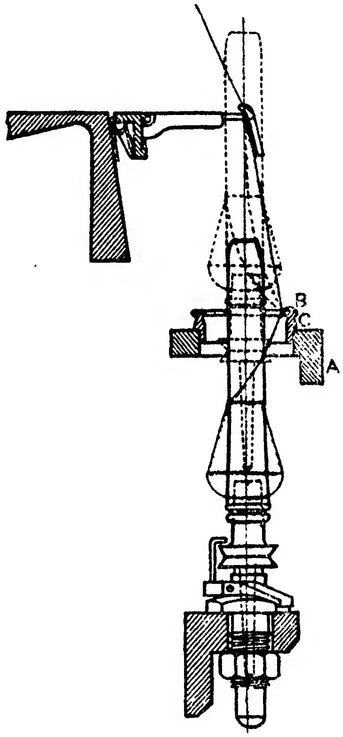
(1) Before starting the frame, oil every Spindle Base with the best Spindle oil by means of a Measuring Oiler, which should be adjusted to give a quantity of oil sufficient to fill one Base when the spindle top–part is in its place.

(2) Particular care must be taken when oiling to ensure that the spindle Top–Parts be not changed from one Base to another, as each Top-Part is assembled to its own Base. See that the Rings have all grease removed from them, particularly from the inside part directly under the flange. Before commencing to spin, after the frame has run for a few hours, it is advisable to clean the rings again with waste absolutely free from oil or grease.

(3) To doff the Bobbins, first lower the Ring Rails by carefully releasing the Stop Catch and turning down the handle in connection with the Quadrant, simultaneously moving the strap on the Loose Pulley. There will then be three or four turns of yarn wound round the bottom of the bobbin. Then wind back the Ratchet wheel on the end of the Copping Motion Lever, lift the lappets carrying the thread wires by means of the handle for that purpose, to prepare for doffing. when doffing is finished, return the Lappet Rails to their working position, raise the Ring Rails about half the height of the Bobbin by means of the handle attached to the Quadrant, holding them in that position whilst moving the strap on to the Fast Pulley. At the moment the Spindles begin to revolve, lower the Ring Rails until the Quadrant rests upon the Stop Catch. If the yarn should then 'Snarl' or 'Kink' it is because the Ring Rails were not lowered either soon enough or quickly enough.

(4) When the Spindles have run four or five days, pump all the oil out of each Spindle base and refil with fresh oil. After this second oiling, oil each spindle (without pumping out the old oil) every six weeks.

The proper time for oiling the Spindles is when the Bobbin is one–quarter filled, as shown on Sketch.




(*a*) Mark the Motion Catch Wheel with chalk on the tooth opposite the Catch. (*b*) wind the Ring Rail A to the position shown on sketch about one inch from the top of the bobbin; the traveller B on the ring C will slide on the yarn to the position shown by full red lines (*c*) Lift the Lappet Rails as when preparing for doffing (*d*) Push off below the wharves the Spindle bands or tapes, (*e*) Lift each bobbin and Spindle top-part together out of the base. Then, with the measuring oiler, pump into the base a supply of oil, and replace the top–part. The measuring oller should be adjusted to supply a predetermined quantity of oil to each base sufficient for requirements (*f*) when all spindles have been oiled, replace the spindle bands or tapes on the wharves, replace Lappet Rails in spinning position, lower the ring rails to its former place, replace the catch in the motion catch wheel where marked and start the frame. (5) To remove dirty oil from spindles provided with the "Multiple Screw" oil plug, take out and empty the plug. To re-oil, the plug should be filled with oil and inserted into its own base. (6) The rings and travellers must not be oiled. (7) Only the best tubular spindle banding or suitable tape must be used for driving the spindles. (8) It is essential for good spinning that the temperature of the room be from 72 to 78 degrees Fah. (9) It is of absolute importance that only oil of the most suitable kind be used for the spindle. (10) It is also very important that the bobbins should be of correct fit and shape.

# CHAPTER XXI.

## THE DOUBLING FRAME.

The chief purpose of the doubling frame is to twist together two or more yarns to form a cord. The peculiarity lies in the fact that the twist of doubled thread is opposite to the twist of the single thread which composes it.

All cotton yarns leave the spinning process in the form of single yarns which consist of single strands of fibres having a number of turns of twist inserted. For many purposes yarns are required to possess more tensile strength, and a greater resistance to friction, than is practically attainable in single yarns of any given relation between the length and weight, hence two or more single yarns are placed together and twisted to form another and heavier yarn, known as doubled yarn, 'double yarn', 'folded yarn', or ply yarn' Double or twisted yarns are used for purposes where a firm, tough, smooth, and round thread is required, such as heald, sewing thread, selvedge ends in the jute trade, crochet, fish net or cable, etc.

Medium twisted threads are employed in ordinary weaving for Dhoty borders, etc. The assembled and twisted single yarn or thread has three characteristics that may be varied or modified by the processes of assembling and twisting, viz., appearance, strength and elasticity. Each of these properties depends primarily upon the uniformity and fineness of the cotton fibre, and also to a large extent upon the twist inserted in the assembled fibres in the processes of spinning and additional twisting. Twist exists in an irregular degree in cotton fibres, and consists of a varying number of convolutions in one or the other direction. The degree of lustre and elasticity in the fibre will depend on the existing twist, the degree of strength will depend on the construction of the fibre, irrespective of the twist.

There are three kinds of doubling machines in use at the present time, namely, the ring doubler, which is constructed on the ring—spinning principle; the flyer doubler, which is constructed on the principle of the flyer–throstle spinning frame; and the twiner also known as the twiner–doubler, which is constructed on the mule–spinning principle.

The apparent difference between Flyer and Ring Twisting consists in the use in the former of a flyer for obtaining the necessary twist, while in the latter the twist is obtained by means of a ring and traveller. The essential differences are many.

There are two rows of spindles one on each side in the ring twisting frame, which may contain from 160 to 426 spindles. The spindle carries the bobbin attached to it; the twist is put into the yarn through the intervention of the traveller revolving on the ring; the drag or winding-on is due to the retard ation of the traveller by the ring; and the "build" or placing of the rounds on the bobbin is effected by the raising and lowering of the ring rail. All these results are produced in a manner exactly opposite to those on the flyer frame, and they have varying effects on the yarn produced.

These methods of twisting and winding constitute the reasons for the possible higher speeds and productions on this type of frame; and they are also answerable for the lower quality in the yarn produced. In the flyer frame, speed is controlled by mechanical considerations; in the ring; it is restricted only by the greatest amount of hard usage the yarn will stand.

There are two systems of doubling, one is called wet doubling and the other dry doubling. The wet doubling is so called owing to the yarn passing through a trough of water before reaching the rollers.

Dry doubling is practically on the same system with the exception of a water trough and iron rollers which are used instead of brass covered rollers. The object of wet doubling is to cause the single yarns forming the doubled yarn to lie more closely together, thereby producing a more solid, stronger, and much smoother yarn, in which the fibres that otherwise would project from the surface are laid more closely to the body of the yarn. Also, the twist that is inserted sets better, or retains its position more permanently, than is the case with dry doubled yarn. In dry doubling the yarn is received dry, then doubled without the application of moisture, and delivered in the dry state. The dry doubling system is practised when it is desired that the resulting yarn should retain as far as possible its oozy, porous, and full handling characteristics. The fyler doubling frame is generally used for dry doubling coarse counts of yarn, or when there are more folds of medium or fine yarns than the ring doubler can efficiently twist together.

The lifting cam gives the up and down motion to the rail. The speed of a doubling spindle is generally about 6000 to 8500 R. P. M., and the power required to drive 50 Spindles is one I.H.P. for Indian cottons, the diameter of the ring being $2\frac{1}{4}$ inches and the gauge of spindles $3\frac{1}{4}$ inches. The twist per inch is based on sq. root counts when doubled $\times 4.5$ the twist per inch is increased or decreased the production will of course be decreasd or increased proportionately.

The degree of twist given in a folded yarn is expressed in terms of "turns per inch" and a perfect yarn will contain the given number of turns in each individual inch. The twist will be greater in the finer portion of the yarn than in the coarser.

In the ring twisting frame the varying driving capability of the spindle—band is, however, increased very greatly in proportion to the increased speed. of the tin roller. In addition to these, however, there is the greater inequality in the twist, due to forces acting on the traveller. These are constantly varying by reason of wear of ring and traveller, position of the ring plate, etc., etc.

## REFERENCE TO GEARING OF RING DOUBLING FRAME.

A = Top Twist wheel.
B = Bottom Twist wheel.
C = Tin Roller wheel.
D = Bottom Twist carrier wheel.
E = Top Twist carrier wheel.
F = Front Roller wheel.
G = Tin Roller.
H = Spindle wharve.
J = Bottom roller.

## CALCULATIONS.

$$\text{Speed of Spindle} = \frac{\text{Revs. of G} \times \text{dia. of G}}{\text{Dia. of H.}}$$

$$\text{Speed of Front Roller} = \frac{\text{Revs. of C} \times \text{C} \times \text{B} \times \text{A}}{\text{D} \times \text{E} \times \text{F}}$$

$$\text{Revs. of Front Roller} = \frac{\text{Speed of Spindles.}}{\text{Turns per Inch} \times \text{front bottom roller} \times 3.1416}$$

$$\text{Turns of Spindle for one of Front Roller} = \frac{F \times E \times D \times G}{A \times B \times C \times H}$$

$$\text{Twist per Inch} = \frac{F \times E \times D \times G}{A \times B \times C \times H \times J \times 3.1416}$$

$$\text{Twist wheel A} = \frac{F \times E \times D \times G}{\text{Twist} \times B \times C \times H \times J \times 3.1416}$$

$$\text{Twist wheel B} = \frac{F \times E \times D \times G}{A \times \text{Twist} \times C \times H \times J \times 3.1416}$$

To find the Counts when two threads of different counts are doubled together :—

*Example* ;—If two threads, one of 30s and the other of 20s, are doubled together, what is the resulting count ?

A. Multiply the two counts and divide by their sum.

$$\frac{30 \times 20}{30 + 20} = 12\text{s resulting Counts.}$$

*Rules* :—

Hanks÷lbs = Counts.
Hanks÷Counts = lbs.
lbs × counts = Hanks.

How to find production in pounds.

$$\frac{\text{Speed of Front Roller} \times \text{Circumference} \times \text{Minutes}}{\text{Inches in Hank (30240)} \times \text{counts.}} = \text{Production in pounds.}$$

## Productions of Ring Doubling Frames.

| Counts | Speed of Spindles | Lift in Inches | Space in Inches | Dia. of Ring in Inches | Dia. of Bottom Roller in Inches | Twist per Inch | lbs. per Spindle in 10 hours | No. of Traveller for Dry Doubling | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 2/10's | 6000 | 5 or 6 | 3 | 2¼" | 2 | 10.08 | 2.10 | 12 | Shape of Traveller |
| 2/10's | 5000 | ,, | ,, | 2¾" | ,, | 8.94 | 1.99 | ,, |  |
| 2/12's | 6000 | ,, | ,, | ,, | ,, | 10.98 | 1.59 | ,, | |
| 2/16's | 6500 | ,, | ,, | ,, | ,, | 12.69 | 1.15 | 11 | |
| 2/20's | 6500 | ,, | 2¾ | 2 | ,, | 14.42 | 0.83 | 10 | |
| 2/24's | 7000 | ,, | 2¾ | 2 | ,, | 15.57 | 0.68 | 9 | |
| 2/32's | 7500 | 4½ | 2½ | 1¾ | ,, | 18.00 | 0.48 | 7 | |
| 2/36's | 7500 | ,, | ,, | ,, | ,, | 19.08 | 0.40 | 6 | |
| 2/40's | 8000 | ,, | ,, | ,, | ,, | 20.11 | 0.37 | 5 | |
| 2/50's | 8000 | ,, | ,, | ,, | 1¾ | 22.50 | 0.27 | 2 | |
| 2/60's | 8000 | ,, | 2¼ | 1½ | ,, | 24.61 | 0.20 | 1/0 | |
| 2/70's | 8000 | ,, | ,, | 1½ | ,, | 26.59 | 0.16 | 4/0 | |
| 3/10's | 5500 | 5 or 6 | 3¼ | 2½ | 2 | 8.19 | 3.54 | 12 | |
| 3/20's | 6000 | 5 or 6 | 3 | 2¼ | 2 | 11.56 | 1.42 | 27 | |
| 3/40's | 7000 | 5 | 2¾ | 2 | 2 | 16.42 | 0.60 | 14 | |
| 4/40's | 6500 | ,, | ,, | ,, | ,, | 14.22 | 0.85 | 20 | |

## CHAPTER XXII.

## REELING.

Cotton yarn, both single and doubled, is often put up in the forms of hanks and Skeins of definite length, in which marketable forms it is suitable for undergoing such processes as dyeing, bleaching, printing, polishing, mercerizing, and preparing or smoothing by calenders. A good deal of grey cotton yarn is also exported in hank form when it is more convenient and preferable to the cop and other forms. Although a large amount of weft yarn is put up in hank form, the majority of reeled yarn is intended for warp.

The reel proper is a hexagon composed of six bars of wood carried upon arms loosely mounted upon the horizontal shaft. A circuit of this hexagon is 54", the hank being generally reeled in that length, though sometimes in 72 inches.

The hanks in reeling are made up of 7 leas which are divided from one another by indicator mark or tie yarn which is generally either composed of one colour or two colours, doubled together. The usual practice is to make the hanks into bundles of 10 lbs. so that it is easy to say how many of the hanks from a reel are required for a bundle.

The chief forms in which hanks are reeled are :—

(1) cross—reeled (2) diamond or Grant reel; (3) lea—reeled, and (4) Skein—reeled.

The reel for reeling yarns from ring spinning bobbins into hanks is usually made for 40 hanks, 3½—in. gauge, driven by hand and power, and fitted with 7 lea, Crossing and 'Bridge" Doffing Motions. The bobbins are carried on split wood brushes in a vertical position. It is fitted with high speed swift, with strong tin shaft and steel swivels. The traverse rail is fitted with brushes. There is also an automatic brake motion for swift, besides the measuring and knock off arrangement.

The reeling machine may be single or double-sided and its chief feature being a collapsible swift.

**Cross Reeling**—In this style of reeling the thread receives a quick traverse of about 3 inches over the width of the hank, placing it in successive diagonal layers, and enabling broken threads to be more easily traced in the winding process. It is the cheapest style of reeling, and makes the least amount of waste.

To change from ordinary cross reeling to diamond or Grant reeling the only change necessary is to alter the ratio between swift and traverse, so that the same relative position of swift and guide is repeated more frequently.

For an example, if a 21 swift shaft wheel is substituted for a 19 so that the connecting wheels are 21 and 48 instead of 19 × 48, the ratio between the traverse and the swift is $\frac{21}{3} \times \frac{48}{3}$, or 7 to 16, instead of 19 to 48, and the exact disposition of the yarn on the swift would be repeated every 7 traverses instead of every 19 traverses.

The diagonal crossings are so open that the tie can be easily threaded in—and—out, which is a great advantage when reeling expensive yarns. There is less waste, and greater production is obtainable in winding–off.

**Straight or Lea Reeling**—Is mostly adopted in the case of yarn for export. The threads are laid side by side, and each hank is divided by ties into 7 leas of 120 yards each = 840 yards.

**Skein—Reeling**—In skein reeling the length run on before tying up is determined by the weight of skein required. This may be ¼ oz., ½ oz., or any required weight, and the length required in such a weight of skein will, as a rule, have no simple relation to lea or hank length.

TABLE.

| | |
|---|---|
| 80 Threads | =1 Lea = 120 Yds. |
| 7 Leas | =1 Hank or Lachi = 840 Yds. |
| 5 Hanks | =1 Knot or 1 Moda. |

| | | |
|---|---|---|
| 1's—15's = | 5 Leas | =1 Knot. |
| | 8 Knots | =1 Ferra. |
| 16's—40's = | 10 Leas | =1 Knot. |
| | 4 Knots | =1 Ferra. |
| 2/20's, 2/40's = | 5 Leas | =1 Knot. |
| | 4 Knots | =1 Ferra. |

The number of hanks in one pound determines the count.

As 1 hank of 1's weighs 1 lb.

∴ 1 „ „ 20.s „ $\frac{1}{20}$ lb.

∴ 20 hanks of 20's weighs 1 lb.

If a bundle of 20's yarn weighs 10 lbs. find the number of yards in it.

80 threads × 7 Leas = 560 threads.

560 ×10 hanks in a knot = 5600 threads.

5600 ×20 Knots in a bundle =112000 threads.

Now 1 thread = 54 inches.

∴ 112000 threads = 168000 Yards

i.e. a bundle of 20's yarn weighing 10 lbs. has 168000 yds. of yarn.

Power, speed and Production

Power =1 I.H.P.

Speed =125 to 150 R.P.M.

**Production** =Reeling from Ring Bobbins, cops and cheeses, 4500 to 4800 hanks per 9 hours.

Reeling from Ring Doubler Bobbins, 2700 hanks per 9 hours. One to two operatives usually attend to one swift.

Reels are stopped for a large portion of the time, from 35 to 75 per cent. of the time being occupied in doffing, piecing, and creeling. The least loss of time occurs in reeling fine yarns and making long hanks, but the coarser the yarn or the shorter the length of hank or Skein, the greater is the loss time for doffing, since the hank or Skein is completed so much more quickly in the case of coarse yarns, as there is less length on the bobbins, or in the case of reeling from small cops or bobbins. In such cases, the time occupied in replacing the supply of yarn in the creel is greater than when reeling fine yarns or reeling from warper's bobbins or cheeses. The skill or industry of the tenter also affects the allowance to be made for loss of production.

## Faults to look For.

**Piecing—up of ends**—The tenters should strictly be supervised so as to ensure that when an end breaks down or runs out it is immediately replaced and pieced up, each knot being carefully tied as small as possible without projecting ends, and not merely replaced in, or hidden under, the mass of yarn forming the hank or skein without being tied.

**Yarn Tension.**—The tension of the yarn during reeling must not be so much as to cause it to break excessively; on the other hand, the yarn should not be allowed to snarl, especially when reeling hard-twisted yarn. Hence whatever yarn—tensioning device is used should be adjusted to impose the correct tension on the yarn.

**Oiling and Cleaning.**—No dusting of the machine should be permitted to remove loose fluff, etc., when there is any yarn on the swift or in the creel. The doffing device, swift rails, and creel should be kept clean in order to prevent dirty and oil—stained hanks or skeins. The spindle bases or brass bolsters, in case the creel is equipped with revolving spindles when reeling yarn sideways from ring—doubling bobbins and flyer—doubling bobbins, should be cleaned out twice or three times a year.

## CALCULATIONS.

### To find the Revolutions of Swift per minute.

Speed of countershaft = 250 R.P.M.
Driving Pulley = 6″.
Driven pulley on the shaft of the swift = 12″.

$$\frac{250 \times 6}{12} = 125 \text{ R.P.M.}$$

### To find the length of time consumed in reeling one set.

Speed of swift = 125 R.P.M.
Swift = 54″ in circumference.
Hanks = 840

$$\frac{840 \times 36}{54 \times 125} = 4.48 \text{ minutes.}$$

### To find the production in pounds per spindle.

Speed of swift = 125 R.P.M.
Circumference of Swift = 54″
Hours per day = 9
Minutes in an hour = 60
Counts of yarn = 15s
Efficiency = 60 per cent.

$$\frac{125 \times 54 \times 60 \times 9}{36 \times 840 \times 15} = 8.035 \text{ lbs. per spindle per day.}$$

## *Details of Machinery.

| Description. | No. | Remarks. |
|---|---|---|
| Reeling Frame | 70 | 40 Hank Reel. |

## Hands Employed.

| Designation. | No. | Amount. Rs. | As. | P. | Per. | Remarks. |
|---|---|---|---|---|---|---|
| Reelers .. .. .. | 70 | Piece work | | | | |
| Mistry .. .. .. | 1 | 27 | 0 | 0 | M. | |
| Carpenter .. .. .. | 1 | 26 | 0 | 0 | ,, | |
| Sirdar (Coolies) .. .. | 1 | 19 | 0 | 0 | ,, | |
| Coolies for steaming .. | 2 | 12 | 8 | 0 | ,, | Each. |
| ,, ,, weighing yarn and delivering same to reeler | 5 | 12 | 8 | 0 | ,, | ,, |
| Coolies for weighing reeled yarn .. .. | 2 | 12 | 0 | 0 | | |

## Reelers Rates.

| Counts. | Weight of 1 Ferra. Lb. | Oz. | Rate. Rs. | As. | P. | Per. | Remarks. |
|---|---|---|---|---|---|---|---|
| 10½'s Grey .. | 8 | 13 | 1 | 15 | 6 | Ferras 100 | |
| 14½'s ,, .. | 2 | 12 | 1 | 11 | 9 | | |
| 20's ,, .. | 2 | 0 | 1 | 9 | 0 | | |
| 22's ,, .. | 1 | 13 | 1 | 8 | 0 | | |

## Stores Consumed.

| Description. | Quantity. No. | Lbs. | Per. | Remarks. |
|---|---|---|---|---|
| Wood screws .. .. | 1 dozen | | M. | |
| Doff card .. .. | 100 | | ,, | |
| Spindle oil .. .. | | 5 | | |

* Hands employed and stores consumed are given here by way of information and guide.

# CHAPTER XXIII.

## BUNDLING PRESS.

When yarn is sold in reeled form for export, especially when it has to be shipped long distances or sent on rail from place to place, it is customary first to put up the yarn in small pressed bundles varying from 8 to 11 pounds in weight, more commonly 10 pounds. A number of these bundles are then packed into bales of from 300 to 600 pounds or very often 400 lbs in weight by means of a hydraulic baling press. It is customary in the yarn bazaar or market to sell this yarn (whether imported or manufactured locally) to retail customers in small lots, which is the reason for first making up the yarn in bundles. The machine used for putting up reeled yarn in these small bundles is known as a yarn bundling press.

The machine employed does not require much care beyond occasional oiling. It consists essentially of a metal box or framing having top, bottom, and sides but no ends. The sides are formed of vertical bars arranged side by side and leaving four spaces sufficiently wide to admit twine. The top consists of five similar bars hinged to the back row. The bottom is a solid wood block grooved from back to front to coincide with the spaces between the bars. Before the knots are packed one end of press twine is passed through each bar-space from back to front. A bottom cardboard backing is laid on the block, and the knots are arranged so that the diamond-shaped heads are all at the left hand side and perfectly straight. The facing paper is then placed so that one part hangs over the face of the bundle on the left and another part on the top of the bundle, while over all is applied the top card-board backing. When packing has been effected, the top bars are brought down and locked with the front bars, and the bottom rises until sufficient pressure has been applied. The package is tied with the twine, making four 'strings' to the bundle. The box most generally in use is one for a normal 10 lb. bundle, and measures 12″ long, 8½″ wide, and about 9 inches from the wood bottom to the top bars. In making smaller sized bundles thicker and narrower bottoms are used, and a hard wood packing is placed in front of the back bars. These can be varied to make any size of bundles from 5 to 10 lbs. in weight. The quality and colour of paper and twine should be specified in the make-up in accordance with quality or other variation in the thread. The bundling machine is worked either by hand or power. 184 bundles of 10 lbs. each can be made per day of 10 hours. The bundling press requires about ¼ I.H.P.

## Bundling.

A bundle of 10 lbs. means that each bundle must be of 10 lbs. weight of nett yarn. Some of the mills give 1 to 4 ozs. extra of yarn per bundle of grey yarn as an inducement for more business from the hand loom weavers or the consumers whereas in the case of coloured yarn the nett weight of actual yarn is less from 10 ozs. to about 2½ lbs. per bundle, as follows :—

### Weight of Coloured Yarn as Packed in Bundles.

| Counts of Yarn. | Nominal Weight. | | Gross Weight. | | Tare Weight. | | Net Weight. | |
|---|---|---|---|---|---|---|---|---|
| | Lbs. | Ozs. | Lbs. | Ozs. | Lbs. | Ozs. | Lbs. | Ozs. |
| 28's—24's .. | 5 | .. | 4 | 15½ | .. | 9½ | 4 | 6 |
| " .. .. | 10 | .. | 10 | 0¾ | 1 | 6½ | 8 | 10¼ |
| 28's—20's .. | 5 | .. | 4 | 6¾ | .. | 12 | 3 | 10¾ |
| " .. .. | 10 | .. | 9 | 0¾ | 1 | 11 | 7 | 5¾ |
| 40's .. .. | 5 | .. | 5 | 6¾ | .. | 10¼ | 4 | 11½ |
| " .. .. | 10 | .. | 11 | 9 | 1 | 3¾ | 10 | 5¼ |
| " .. .. | 5 | .. | 5 | 6½ | .. | 7½ | 4 | 15 |

### Particulars of Machine.

| Description | No. | Size. | Remarks. |
|---|---|---|---|
| Bundling Press .. | 4 | 12″ × 8½″ | |

## Stores Consumed.

| Description. | Quantity No. | Quantity lbs. | Per | Remarks. |
|---|---|---|---|---|
| Hessian cloth .. .. | 453 yds | | M. | |
| Paper (black casing) .. | 4 Reams | | ,, | |
| Jute twine .. | | 112 | ,, | |
| Rivets .. .. .. | | 4 | ,, | |
| Cardboards .. .. | 4 Cases | | ,, | |
| Yellow Paper .. .. | 2 Reams | | ,, | |
| Brown Packing paper .. | 5 Reams | | ,, | |

## Hands Employed.

| Designation. | No. | Amount Rs. | As. | P. | Per | Remarks. |
|---|---|---|---|---|---|---|
| Pressmen | 4 | 24 | 0 | 0 | M. | Each. |
| Knotters | 8 | 16 | 8 | 0 | ,, | ,, |
| Scale man | 1 | 20 | 0 | 0 | ,, | ,, |
| Bundler | 4 | 14 | 0 | 0 | ,, | ,, |
| Checker | 1 | 20 | 0 | 0 | ,, | ,, |
| Balers | 2 | 18 | 0 | 0 | ,, | ,, |
| Coolie | 2 | 14 | 0 | 0 | ,, | ,, |

## Weights and Measures.

### USEFUL GENERAL INFORMATION. ENGLISH STANDARDS OF WEIGHTS. AND MEASURES.

### Signs and Abbreviations used.

| | |
|---|---|
| ÷ | Plus, addition. |
| + | Positive. |
| + | Compression. |
| — | Negative. |
| — | Subtraction. |
| — | Minus, tension. |
| × | Multiplied by. |
| ÷ | Divided by. |
| = | Equal to. |
| ≠ | Unequal to. |
| > | Greater than. |
| ≯ | Not greater than |
| < | Less than. |
| ≮ | Not less. |
| ⊥ | Perpendicular to |
| ∥ | Parallel to. |
| ∦ | Not Parallel. |
| ∵ | Because. |
| ∴ | Therefore. |
| ∠ | Angle |
| ∟ | Right Angle. |
| △ | Triangle. |
| ▭ | Parallelogram. |
| □ | Square. |
| ○ | Circumference. |
| ○ | Circle. |
| ⌒ | Semicircle. |
| ◔ | Quadrant. |
| ∞ | Infinity. |
| ⌒ | Arc. |
| ‿ | Difference. |
| ( ) [ ] { } | Vin cula denoting that the numbers are to be taken together. |
| *c.* | Constant. |
| *d* | Differential. |
| *g* | Gravity =32.2. |
| *k* | Co-efficient. |
| *n* | Any number. |
| √ | Square root. |
| ∛ | Cube root. |
| 2 | Over a number signifies that number has to be squared. |
| 3 | Over a number signifies that it has to be cubed. |
| % | Stands for per cent. |

### Roman Numbers.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| I | II | III | IV | V | VI | VII | VIII | IX | X |
| 40 | 50 | 60 | 100 | 200 | 400 | 500 | 600 | 900 | |
| XL | L | LX | C | CC | CD | D | DC | CM | |
| 1000 | 1650 | 2000 | | | | | | | |
| M | MDCL | MM | | | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Α | α | Alpha | Ν | ν | Nu |
| Β | β | Beta | Ξ | ξ | Xi |
| Γ | γ | Gamma | Ο | ο | Omicron |
| Δ | δ | Delta | Π | π | Pi |
| Ε | ϵ | Epsilon | Ρ | ρ | Rho |
| Ζ | ζ | Zeta | Σ | σ ς | Sigma |
| Η | η | Eta | Τ | τ | Tau |
| Θ | θ ϑ | Theta | Υ | υ | Upsilon |
| Ι | ι | Iota | Φ | φ | Phi |
| Κ | κ | Kappa | Χ | χ | Chi |
| Λ | λ | Lambda | Ψ | ψ | Psi |
| Μ | μ | Mu | Ω | ω | Omega |

## Arithmetical Terms.

A Figure, called also Numeral and Digit is a sign used to represent a number.

**Unit**—a single thing, anything considered in itself.

Number, is either a figure or several figures.

Numeration, is the art of expressing numbers in words.

A Multiple, of a number is that which contains it without a remainder.

**Measure**—A number which divides another an exact number of times.

*Common Measure*—A number which will divide two or more numbers without any remainder.

*Abstract Numbers*—when we consider numbers in their general nature, without referring them to any particular subject, they are then called abstract, as 8, 7, 10.

**Concrete or Applicate Numbers**—When we consider number not in its general nature, but as applied to certain particular things as two pounds, three pounds, etc.—it is termed concrete or applicate.

**A whole Number**—consists of one or more units.

**A Fraction,** consists of one or more parts of unity. Thus, if we divide a rupee into 16 equal parts, 9 annas would be represented by $\frac{9}{16}$.

If the vulgar fraction $\frac{9}{16}$ the lower line indicates the number of equal sub-divisions of the unit, and is called the Denominator; the upper line shows the number taken to form the fraction and is called the Numerator.

When the denominator is 10, 100, 1000 etc., it is not expressed except by a dot, marking the point in ordinary notation at which units cease, and such fractions of a unit (called decimal) begin thus:—

$$72.64 \ (72\tfrac{64}{100}).$$

Denotes 72 and Sixty-four hundredths.

**A Mixed Number**—is a whole number and a fraction, as $1\frac{1}{4}$.

**A Compound Number**—consists of several concrete numbers joined together in expression, as Rs. 1 annas 2 Ps. 8.

**An Even Number**—can be divided into two equal whole numbers.

**A Odd Number**—cannot be divided into two equal whole numbers.

**A Prime Number**—can only be divided by itself and unity without a remainder as 7.

**A Factor**—One of the numbers multiplier or multiplicand—which, when multiplied together produce a product.

**A Square Number**—is the product of any number by itself.

**A Cube Number**—is the product of a number and its square.

**Square Root.**—That factor of a number which when multiplied by itself will produce that number; thus, 2 is the square root of 4, because 2 multiplied by itself produces 4.

**Cube Root**—The number which when multiplied by itself, and then by the product produces a certain number; thus 3 is the cube root of 27 because $3 \times 3 = 9$ and $9 \times 3 = 27$.

*Power*—The term power is the opposite of root. It is shown by a small figure placed to the right of the number; thus $2^2 = 2 \times 2 = 4$, $3^3 = 3 \times 3 \times 3 = 27$. These small figures are called indices or exponents.

**A Composite Number**—is that produced by multiplying two or more numbers together, thus $28 = (4 \times 7)$ is a composite number, and 4 and 7 are called its component parts.

**An Aliquot Part**—is a number which is contained in a greater an exact number of times: thus 6 is an aliquot part of 18, as it is contained in it exactly 3 times.

**An Aliquant Part**—is a number that will not divide another number exactly, or without a remainder, thus 7 is an aliquant part of 18.

**An Integer** *is any whole number*—as a ton, a mile, etc., or 1, 2, 3, etc.

## GENERAL NUMBERS.

| | | | |
|---|---|---|---|
| 12 Articles | = 1 Dozen | 20 Articles | = 1 Score. |
| 12 Dozens | = Gross | 5 Scores | = 1 Hundred. |
| 12 Gross | = 1 Great Gross | 6 Scores | = 1 Great Hundred |

## LENGTH.

| | |
|---|---|
| 1 Inch | = diameter of half penny |
| $2\frac{1}{4}$ ,, | = 1 Nail (1/16) |
| 3 ,, | = 1 Palm. |
| 4 ,, | = 1 Hand. |
| 7.92 ,, | = 1 Link. |
| 9 ,, | = 1 Span. |
| 12 ,, | = 1 Foot. |
| 18 ,, | = 1 Cubit. |
| 36 ,, | = 1 Yard. |
| 2 Feet 6 ,, | = Pace, Military. |
| 5 ,, | = Pace, Geometrical. |
| 6 ,, | = 1 Fathom. |
| $5\frac{1}{2}$ Yards. | = 25 Links, = 1 rod, pole or perch. |
| 100 Links | = 66 Feet = 1 Chain = 4 poles. |
| 220 Yards | = 40 Poles = 10 Chains = 1 furlong. |
| 8 Furlongs | = 80 chains = 1760 yards = 5280 feet = 1 mile. |
| 6080 feet per hour. | = 1 Admiralty Knot = 1.1515 miles per hour. |
| 6080 Feet. | = 1 Nautical mile (British) = 1/60 of a degree of longitude (approximately). |

## Surface.

| | |
|---|---|
| 144 square inches | = 1 square foot. |
| 9 square feet | = 1 square yard. |
| 30¼ square yards | = 1 square pole, rod, or perch. |
| 40 square poles | = 1 rood. |
| 4 roods | = 4840 square yards = 1 acre |
| 640 acres | = 1 square mile. |
| 33 square yards | = 1 Rod of Building. |
| 100 square feet | = square of Flooring |
| 272¼ square feet | = Rod of Bricklayer's work. |

## Weight—Avoirdupois.

| | |
|---|---|
| 27.344 grains | = 1 dram. |
| 16 drams | = 437½ grains = 1 ounce. |
| 16 ounces | = 7000 grains = 1 pound. |
| 14 pounds | = 1 stone * |
| 28 pounds | = 1 quarter. |
| 4 quarters | = 112 pounds = 1 hundredweight. |
| 20 hundredweights | = 2240 pounds = 1 ton. |
| 3 pennies | = 5 halfpennies = 1 oz. |

*N. B.*—The grain Troy is the same as the grain Avoirdupois.

* Butcher's Stone is 8 lbs.

## Weights.

| | | | | |
|---|---|---|---|---|
| 1 lb. | = 16 oz | = 256 drm. | = 7,000 gr. | = 454 grm. |
| 1 oz. | = 16 drm. | = 437.5 gr. | = 28.35 grm. | |
| 1 grm. | = 15.43 gr. | = 1 gr. | = 0.0645 grm. | |
| 1 kg. | = 35.27 oz. | = 2.2 lb. | | |

## Weight—Troy.

| | |
|---|---|
| 3.17 Grains | = 1 Carat. |
| 24 Grains | = 1 Pennyweight. |
| 20 Pennyweights | = 1 Ounce. = 480 Grains. |
| 12 Ounces | = 1 Pound. = 5760 „ |
| 100 Pounds | = 1 Hundredweight. |

The standard for gold coin is 22 carats fine gold and 2 carats alloy; silver for coinage consists of one-half silver, one-half alloy.

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## WEIGHTS & MEASURES—

### Surveyors' Measure.

7.92 inches = 1 link. 4 rods = 1 chain.

25 links = 1 rod.

10 sq. chains or 160 sq. rods = acre.

640 acres = 1 sq. mile.

86 sq. miles (6 miles sq.) = 1 township.

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### Cubic Measure.

1.728 cubic in. = 1 cubic ft. 128 cubic ft. = 1 cord (wood)

27 cubic ft. = 1 cubic yd. 40 cubic ft. = 1 ton (shpg)

2,150.42 cubic inches = 1 standard bushel.

277.274 cubic inches = 1 standard gallon.

1 cubic ft. = about ¾ of a bushel.

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### Cubic or Solid Measure.

| | |
|---|---|
| Cubit foot | = 1728 Cubic inches. |
| Cubic yard | = 27 Cubic feet = 21,088 bushels. |
| Stack of wood | = 108 Cubic feet. |
| Shipping ton | = 40 Cubic feet of merchandise. |
| Shipping ton | = 42 Cubic feet of timber. |
| Ton of displacement of a ship | = 85 Cubic feet. |

## Paper.

| | |
|---|---|
| 20 Sheets | = 1 Quire of Outsides. |
| 24 Sheets | = 1 Quire of Insides. |
| 20 Quires | = 1 Ream. |
| 21½ Quires | = 1 Printer's Ream. |
| 2 Reams | = 1 Bundle. |
| 10 Reams | = 1 Bale. |
| 60 Skins, or 5 dozs. | = 1 Roll of Parchment. |

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## Circular Measure.

The diameter is to the circumference about as 7 is to 22 or more nearly as I is to 3.1416.

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## Measures of Space—Angular Measure.

| | |
|---|---|
| 60 Seconds | = 1 Minute. |
| 60 Minutes | = 1 Degree. |
| 30 Degrees | = 1 Sign. |
| 45 Degrees | = 1 Octant. |
| 60 Degrees | = 1 Extant. |
| 90 Degrees | = 1 Quadrant. (a Right Angle). |
| 180 Degrees | = 1 Semi-circle. |
| 360 Degrees | = 1 Circle. |

1 Second may be measured by the swing of a pendulum 3 ft. 3⅛ inch (3.262 ft.) long.

A strong wind travels 20 to 25 miles per hour, a high wind 35, a storm 50 to 60, and a hurricane 80 to 100 miles per hour will uproot trees.

In 1 Second sound travels 1,123 feet.

In 1 Second a stone of about 1 oz. in weight will drop 32 feet.

## Pounds Avoirdupois to Tons, Cwts., &c.

| Pounds. | Cwts. Qrs. Lbs. | Pounds. | Tons. Cwts. Qrs. Lbs. |
|---|---|---|---|
| 10 | 10 | 2,000 | 17—3–12 |
| 20 | 20 | 2,500 | 22—1—8 |
| 30 | 1—2 | 3,000 | 1—6—3—4 |
| 40 | 1–12 | 4,000 | 1–15—2–24 |
| 50 | 1–22 | 5,000 | 2—4—2–16 |
| 60 | 2—4 | 6,000 | 2–13—2—8 |
| 70 | 2–14 | 7,000 | 3—2—2—0 |
| 80 | 2–24 | 7,500 | 3—6—3–24 |
| 90 | 3—6 | 8,000 | 3–11—1–20 |
| 100 | 3–16 | 9,000 | 4—0—1–12 |
| 110 | 3–26 | 10,000 | 4—9—1—4 |
| 120 | 4—8 | 20,000 | 8–18—2—8 |
| 130 | 4–18 | 25,000 | 11—3—0–24 |
| 140 | 1—1—0 | 30,000 | 13—7—3–12 |
| 150 | 1—1–10 | 40,000 | 17–17—0–16 |
| 160 | 1—1–20 | 50,000 | 22—6—1–20 |
| 170 | 1—2—2 | 60,000 | 26–15—2–24 |
| 180 | 1—2–12 | 70,000 | 31—5—0—0 |
| 190 | 1—2–22 | 75,000 | 33—9—2–16 |
| 200 | 1—3—4 | 80,000 | 35–14—1—4 |
| 210 | 1—3–14 | 90,000 | 40—3—2—8 |
| 220 | 1—3–24 | 100,000 | 44–12—3–12 |
| 230 | 2—0—6 | 200,000 | 89—5—2–24 |
| 240 | 2—0–16 | 250,000 | 111–12–0—16 |
| 250 | 2—0–26 | 300,000 | 133–18—2—8 |
| 300 | 2—2–20 | 400,000 | 178–11—1–20 |
| 350 | 3—0–14 | 500,000 | 223—4—1—4 |
| 400 | 3—2—8 | 600,000 | 267–17—0–16 |
| 450 | 4—0—2 | 700,000 | 312–10—0—0 |
| 500 | 4—1–24 | 750,000 | 334–16—1–20 |
| 550 | 4—3–18 | 800,000 | 357—2—3–12 |
| 600 | 5—1–12 | 900,000 | 401–15—2–24 |
| 650 | 5—3—6 | 1,000,000 | 446—8—2—8 |
| 700 | 6—1—0 | 2,000,000 | 892–17—0–16 |
| 750 | 6—2–22 | 2,500,000 | 1116—1—1–20 |
| 800 | 7—0–16 | 3,000,000 | 1339—5—2–24 |
| 850 | 7—2–10 | 4,000,000 | 1785–14—1—4 |
| 900 | 8—0—4 | 5,000,000 | 2232—2—3–12 |
| 950 | 8—1–26 | 7,500,000 | 3348—4—1—4 |
| 1,000 | 8—3–20 | 10,000,000 | 4464—5—2–24 |

## DECIMAL EQUIVALENTS OF A TON.

### Pounds to Decimals.

| lbs. | Decimal of a ton. | Lbs. | Decimal of a Ton. |
|---|---|---|---|
| 1 | .00044 | 15 | .00669 |
| 2 | .00089 | 16 | .00714 |
| 3 | .00134 | 17 | .00758 |
| 4 | .00178 | 18 | .00803 |
| 5 | .00223 | 19 | .00848 |
| 6 | .00268 | 20 | .00893 |
| 7 | .00312 | 21 | .00937 |
| 8 | .00357 | 22 | .00982 |
| 9 | .00401 | 23 | .01026 |
| 10 | .00446 | 24 | .01071 |
| 11 | .00491 | 25 | .01116 |
| 12 | .00535 | 26 | .01160 |
| 13 | .00580 | 27 | .01205 |
| 14 | .00625 | 28 | .01250 |
| Qrs. | | Qrs. | |
| 1 | .0125 | 3 | .0375 |
| 2 | .250 | 4 | .05 |

### Decimals to Pounds, etc,

| Dec. of 1 Ton. | Cwts. | Dec. of 1 Ton. | Cwts. | Dec. of 1 Ton. | Cwts. |
|---|---|---|---|---|---|
| .1 | 2 | .4 | 8 | .7 | 14 |
| .2 | 4 | .5 | 10 | .8 | 16 |
| .3 | 6 | .6 | 12 | .9 | 18 |

| Dec. of 1 Ton. | | Qwts. | Qrs. | Lbs. | Ozs. | Dec. of 1 Ton. | | Lbs. | Ozs. |
|---|---|---|---|---|---|---|---|---|---|
| .01 | .. | .. | .. | 22— | 6.4 | .001 | .. | 2— | 3.84 |
| .02 | .. | .. | 1— | 16— | 12.8 | .002 | .. | 4— | 7.68 |
| .03 | .. | .. | 2— | 11— | 3.2 | .003 | .. | 6— | 11.52 |
| .04 | .. | .. | 3— | 5— | 9.6 | .004 | .. | 8— | 15.36 |
| .05 | .. | 1— | 0— | 0— | 0 | .005 | .. | 11— | 3.2 |
| .06 | .. | 1— | 0— | 22— | 6.4 | .006 | .. | 13— | 7.04 |
| .07 | .. | 1— | 1— | 16— | 12.8 | .007 | .. | 15— | 10.88 |
| .08 | .. | 1— | 2— | 11— | 3.2 | .008 | .. | 17— | 14.72 |
| .09 | .. | 1— | 3— | 5— | 9.6 | .009 | .. | 20— | 3.84 |

## Decimal Equivalents of an Inch.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $\frac{1}{32}$ | 0.03125 | $\frac{9}{32}$ | 0.28125 | $\frac{17}{32}$ | 0.53125 | $\frac{25}{32}$ | 0.78125 |
| $\frac{1}{16}$ | 0.0625 | $\frac{5}{16}$ | 0.3125 | $\frac{9}{16}$ | 0.5625 | $\frac{13}{16}$ | 0.8125 |
| $\frac{3}{32}$ | 0.09375 | $\frac{11}{32}$ | 0.34375 | $\frac{19}{32}$ | 0.59375 | $\frac{27}{32}$ | 0.84375 |
| $\frac{1}{8}$ | 0.125 | $\frac{3}{8}$ | 0.375 | $\frac{5}{8}$ | 0.625 | $\frac{7}{8}$ | 0.875 |
| $\frac{5}{32}$ | 0.15625 | $\frac{13}{32}$ | 0.40625 | $\frac{21}{32}$ | 0.65625 | $\frac{29}{32}$ | 0.90625 |
| $\frac{3}{16}$ | 0.1875 | $\frac{7}{16}$ | 0.4375 | $\frac{11}{16}$ | 0.6875 | $\frac{15}{16}$ | 0.9375 |
| $\frac{7}{32}$ | 0.21875 | $\frac{15}{32}$ | 0.46875 | $\frac{23}{32}$ | 0.71875 | $\frac{31}{32}$ | 0.96875 |
| $\frac{1}{4}$ | 0.25 | $\frac{1}{2}$ | 0.5 | $\frac{3}{4}$ | 0.75 | 1 | 1.0 |

## Decimals Equivalents of Pounds and Ounces.

| ozs. | lbs. | ozs. | lbs. | ozs. | lbs. | ozs. | lbs. | ozs. | lbs. |
|---|---|---|---|---|---|---|---|---|---|
| ¼ | .015625 | 3 | .1875 | 6½ | .40625 | 10 | .625 | 13½ | .84375 |
| ½ | .03125 | 3½ | .21875 | 7 | .4375 | 10½ | .65625 | 14 | .875 |
| ¾ | .046875 | 4 | .25 | 7½ | .46875 | 11 | .6875 | 14½ | .90625 |
| 1 | .0625 | 4½ | .28125 | 8 | .5 | 11½ | .71875 | 15 | .9375 |
| 1½ | .09375 | 5 | .3125 | 8½ | .53125 | 12 | .75 | 15½ | .96875 |
| 2 | .125 | 5½ | .34375 | 9 | .5625 | 12½ | .78125 | 16 | 1.0 |
| 2½ | .15625 | 6 | .375 | 9½ | .59375 | 13 | .8125 | .. | .. |

## Equivalents of Metric and Imperial Weight and Measures.

### Imperial

1 Grain = 0.648 Grame.

1 Drachm = 1.772 Grammes.

1 **Pound** = 0.45359243 Kilogram.

1 Hundredweight = 50.80 Kilograms.

1 Ton (20 cwt.) = 1.0160 Tonnes, or 1016 Kilograms.

1 Pint = 0.568 Litre.

1 **Gallon** = 4.5459631 Litres.

1 Inch = 25.400 Millimetres.

1 **Yard** = 0.914399 Metre.

1 Mile = 1.6093 Kilometres.

1 Square Inch = 6.4516 Sq. Centimetres.

1 „ Yard = 0.836126 Sq. Metre.

1 Acre = 0.40468 Hectare.
1 Square Miles = 259.00 Hectares.
1 Cubic Inch = 16.387 Cubic Centimetres.
1 „ Foot = 0.028317 Cubic Metre.
1 „ Yard = 0.764553 Cubic Metre.

## Metric.

1 Milligramme = 0.015 grain.
1 Gramme = 15.432 grains.
1 **Kilogram** (kilo.) = 2.2046223 lb.
1 Quintal (100 kilog) = 1.968 cwts.
1 Tonne (1000 kilog) = 0.9842 ton.
1 **Litre** = 1.75980 pints.
1 Dekalitre (10 litres) = 2.200 gallons.
1 Hectolitre (100 litres) = 2.75 bushels
1 Millimetre (mm) = 0.03937 inch.
1 **Metre** (m) = 39.370113 inches, 3.280843 feet, 1.09361425 yds.
1 Kilometre (km) = 0.62137 mile, 1093.61425 yds.
1 Square Centimetre = 0.15500 square inch.
1 Square Metre = 10.7639 square feet,
1.1960 square yards.
1 Are = 119.60 square yards.
1 Hectare (100 Ares or 10,000 Square Metres) = 2.4711 acres.
1 Cubic Centimetre = 0.0610 cubic inch.
1 Cubic Metre = 35,3148 cubic feet,, 1.307954 cubic yards.

## Metric Equivalents.

*Linear Measure.*

| | |
|---|---|
| 1 centimeter = 0.3937 in. | 1 in. = 2.54 centimeters. |
| 1 decimeter = 3.937 in = 0.328 feet. | 1 ft. = 3.048 decimeters. |
| 1 meter = 39.37 inches = 1.0936 yards. | 1 yd. = 0.9144 meter. |
| 1 dekameter = 1.9884 rods. | 1 rod = 0.5029 dekameter, |
| 1 kilometer = 0.62137 mile. | 1 mile = 1.6093 kilometers. |

*Square Measure.*

| | |
|---|---|
| 1 sq. centimeter = 0.1550 sq. in. | 1 sq. in. = 6.452 square centimeters. |
| 1 sq. decimeter = 0.1076 sq ft. | 1 sq. foot = 9.2903 square decimeters. |

| | |
|---|---|
| 1 sq. meter = 1.196 sq. yd. | 1 sq. yd. = 0.8361 sq. m'r. |
| 1 are = 3.954 sq. rd. | 1 rood = 10.117 ares. |
| 1 hektar = 2.47 acres. | 1 acre = 0.4047 hektar. |
| 1 sq. kilometer = 0.386 square mile. | 1 sq. mile = 2.59 square kilometers. |

*Measure of Volume.*

| | |
|---|---|
| 1 cu. centimeter = 0.061 cu. in. | 1 cu. in. = 16.39 cu. centimeters. |
| 1 cu. decimeter = 0.0353 cu. ft. | 1 cu. ft. = 28.317 cu. decimeters. |
| 1 cu. mr. / 1 stere = 1.308 cu. yd. / 0.2759 cd. | 1 cu.yd. = 0.7646 cu. m'r. |
| | 1 cord = 3.624 steres. |
| 1 liter = 0.908 qt. dry. / 1.0567 qt. liq. | 1 qt. dry = 1.101 liters. |
| | 1 qt. liq. = 0.9463 liter. |
| 1 dekaliter = 2.6417 gal. / .135 pks. | 1 gal. = 0.3785 dekaliter. |
| | 1 peck = 0.881 dekaliter. |
| 1 hektoliter = 2.75 bush. | 1 bush. = 0.3524 hektoliter. |

*Weights.*

| | |
|---|---|
| 1 gram. = .03527 ounce. | 1 ounce = 28.35 grams. |
| 1 kilogram = 2.2046 lbs. | 1 lb. = 0.4536 kilogram. |
| 50.8 kilograms = 1 cwt. | |
| 1 metric ton = 0.9842 English ton. | 1 English ton = 1.0160 metric ton. |

*Approximate Metric Equivalents.*

| | |
|---|---|
| 1 decimeter = 4 inches. | 1 liter = 1.06 qt. liquid. / 0.9 qt. dry. |
| 1 meter = 1.1 yards. | |
| 1 kilometer = $\frac{5}{8}$ of a mile. | 1 hektoliter = $2\frac{5}{8}$ bus. |
| 1 hektar = $2\frac{1}{2}$ acres. | 1 kilogram = $2\frac{1}{5}$ lbs. |
| 1 stere, or cu. meter = $\frac{1}{4}$ of a cord. | 1 metric ton = 2.200 lbs. |

## 1.—MEASURES OF LENGTH.

| | | | |
|---|---|---|---|
| 10 millimetres (*mm*) | = 1 centimetre (*cm.*) | = | 0.3937079 inch. |
| 10 centimetres | = 1 decimetre (*dm.*) | = | 0.328084 foot. |
| 10 decimetres | = 1 **Metre** (*m*) | = | 1.093614 yard. |
| 10 metres | = 1 dekametre (dom.) | = | 1.9884 poles. |
| 10 dekametres | = 1 hectometre (*hm.*) | = | 0.4971 furlong. |
| 10 hectometres | = 1 kilometre (*km.*) | = | 0.6214 mile. |

A kilometre is approximately $\frac{5}{8}$ mile, so that 8 kilometres may be regarded by pedestrians as 5 miles.

### 2.—Measures of Weight.

| | | |
|---|---|---|
| 10 milligrams (*mg.*) | .. 1 centigram (*cg.*) | = 0.1543 grains. |
| 10 centigrams | = 1 decigram (*dg.*) | = 1.5432 „ |
| 10 decigrams | = 1 gramme (*grm.*) | = 15.4323 „ |
| 10 grammes | = 1 dekagram (*dag.*) | = 5.6438 drams. |
| 10 dekagrams | = 1 hectogram (*hg.*) | = 3.5274 oz. |
| 10 hectograms | = 1 **Kilogram** (*kg.*) | = 2.2046 lb. |
| 10 kilograms | = 1 myriagram | = 1.5747 stones. |
| 10 myriagrams | = 1 quintal (*q.*) | = 1.9684 cwt. |
| 10 quintals | = 1 tonne (*t.*) | = 0.9842 ton. |

### 3.—Measures of Capacity.

| | | |
|---|---|---|
| 10 millilitre (*mil.*) | = 1 centilitre (*cl.*) | = 0.0704 gill. |
| 10 centilitres | = 1 decilitre (*dl.*) | = 0.1759 pint. |
| 10 decilitres | = 1 **Litre** (*lit.*) | = 0.8799 quart. |
| 10 litres | = 1 dekalitre (*dal.*) | .. 2.1997 gals. |
| 10 dekalitres | = 1 hectolitre (*hl.*) | .. 2.7497 bushels. |

### 4.—Measures of Land.

| | | |
|---|---|---|
| 10 sq. metres | = 1 are (*a.*) | = 0.0988 rood. |
| 100 ares | = 1 hectare (*ha.*) | = 2.4711 acres. |
| 100 hectares | = 1 sq. kilometre | ≐ 0.3861 sq. mile. |

### Notes.

| | |
|---|---|
| 1 hectolitre | = 2.75 bushels. |
| 1 hectolitre per hectare | = 1.11 bushels per acre. |
| 1 quintal | = 3.67 bushels. |
| 1 quintal per hectare | = 1.49 bushels per acre. |

### Metric to British

Measures of Length

| | Inches | Feet | Yards. | Miles. |
|---|---|---|---|---|
| Millimetre .. .. | 0.03937 | — | — | — |
| Centimetre .. .. | 0.3937 | 0.0328 | — | — |
| Metre .. .. .. | 39.3708 | 3.2809 | 1.093 | — |
| Kilometre .. .. | — | 3280.8836 | 1093.6112 | 0.62137 |

### Measure of Capacity

| | Cubic ins. | Cubic Feet. | Pints | Gallons |
|---|---|---|---|---|
| Litre or Cubic Decim. | 61.027 | 0.0353 | 1.0760 | 0.220 |
| Kilolitre or Cub. Metre | 61027.051 | 35.316 | 1760.773 | 220.096 |

### Measure of Weight

| | Grains | Avoirdupois lbs. | Cwt=112 lbs. | Ton=20 cwt. |
|---|---|---|---|---|
| Milligramme | .. 0.015 | — | — | — |
| Gramme | ..15.432 | 0.002 | — | — |
| Kilogramme | 15432.348 | 2.204 | 0.019 | 0.001 |

### Square or Measures of Surface

| | sq. ft. | sq. yds. |
|---|---|---|
| Square Metre .. .. .. .. | 10.7643 | 1.196 |

## BRITISH TO METRIC

### Measures of Length

| | Millimetres. | Centimetres. | Metres. | Kilometres |
|---|---|---|---|---|
| Inch .. .. .. | 25.4 | 2.54 | 0.0254 | — |
| Foot .. .. .. | 304.8 | 30.48 | 0.3048 | — |
| Yard .. .. .. | — | 91.44 | 0.9144 | 0.0009 |
| Mile .. .. .. | — | — | 1609.33 | 1.609 |

### Measure of Capacity

| | Litres. | Kilolitre (Cu. Metres) |
|---|---|---|
| Cubic Inch .. .. | 0.016387 | — |
| Cubic Ft. .. .. | 28.316 | 0.0283 |
| Pint .. .. .. | 0.5676 | — |
| Gallon .. .. .. | 4.5409 | 0.00454 |

### Measures of Weight

| | Milligrammes | Grammes | Kilogrammest |
|---|---|---|---|
| Grain .. .. .. | 64.799 | 0.064799 | — |
| Pound (avdp).. .. | 453590 | 453.59 | 0.453 |
| cwt .. .. .. | — | — | 50.802 |
| Ton .. .. .. | — | — | 1016.048 |

### Square or Measure of Surface

| | Square Metre | | Square Metre. |
|---|---|---|---|
| Square Foot .. .. | 0.093 | Square Yard. .. | 0.836 |

## MEASURE OF CAPACITY.

| | |
|---|---|
| 1 Minim | = 1 Drop. |
| 1 Dram | = 1 Teaspoonful. |
| 2 Drams | = 1 Dessertspoonful. |
| 4 Drams | = 1 Tablespoonful. |
| 60 Minims | = 1 Dram. |
| 8 Drams | = 1 Ounce. |
| 20 Ounces | = 1 Pint (nearly ½ litre) |
| 4 Gills* | = 1 Pint (34.659c. in.). |
| 2 Pints | = 1 Quart (1-1/10 litre). |
| 2 Quarts | = 1 Bottle. |
| 4 Quarts | = 1 Gallon (277.274c.in) |
| 2 Gallons | = 1 Peck. |
| 4 Pecks (8 gall.) | = 1 Bushel (1.2837c.ft.). |
| 2 Bushels | = 1 Strike. |
| 3 Bushels | = 1 Sack. |
| 4 Bushels | = 1 Coomb. |
| 8 Bushels | = 1 Quarter. |
| 12 Sacks | = 1 Chaldron. |
| 5 Quarters | = 1 Wey or Load (51.347c.ft.). |
| 10 Quarters | = 1 Last. |

An Imperial Gallon of distilled water weighs 10 lb. avoirdupois.

A wineglass holds about 2 ozs., a teacup about 3 ozs.

*In the North of England half a pint is called a gill, and a true gill a "noggin."

Corn is sometimes sold by weight. The average weight of a bushel of barley is 47 lbs., oats 38 lbs., wheat 60 lbs.

## MEASURES.

| | | c. Inches. |
|---|---|---|
| 5 oz. avoir. of pure water at 62°F | =1 gill or quarter | = 8.665 |
| 4 gills | = 1 pint | = 34.659 |
| 2 pints | = 1 quart | = 69.318 |
| 4 quarts | = 1 gallon | = 277.274 |
| 6.2355 gallons | = 1 cubic foot. | |

## Apothecaries' Weight.

| | |
|---|---|
| 20 Grains | = 1 Scruple. |
| 3 Scruples (60 grs.) | = 1 Drachm. |
| 8 Drachms (480 grs.) | = Ounce. |
| 12 Ounces (5760 grs.) | = 1 Pound. lb. |

Drugs are compounded by this weight.

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## Who is normal, overweight or underweight

WEIGHT. In deciding whether one is over-weight, normal or underweight, it is necessary to consider age as well as height. As a general rule, if in good health there should be little variation in weight between the ages of twenty and thirty. After that, however, there should be a definite increase, averaging from ten to twelve ounces a year, until the age of fifty. Here is a rough table which shows the average increase in weight of a man or a woman. The weights allow for normal clothes without shoes or outdoor coats.

| Height. | Weight | | | |
|---|---|---|---|---|
| | Age 20. | Age 35. | Age 40. | Age 50. |
| 4 ft. 10 ins. | 6 st. 7 | 7 st. 0 | 7 st. 7 | 8 st. 0 |
| 5 ft. 0 ins. | 7 st. 0 | 7 st. 7 | 8 st. 0 | 8 st. 7 |
| 5 ft. 2 ins. | 7 st. 7 | 8 st. 0 | 8 st. 7 | 9 st. 0 |
| 5 ft. 4 ins. | 8 st. 4 | 8 st. 11 | 9 st. 4 | 9 st. 11 |
| 5 ft. 6 ins. | 9 st. 6 | 9 st. 13 | 10 st. 6 | 10 st. 13 |
| 5 ft. 8 ins. | 10 st. 0 | 10 st. 7 | 11 st. 0 | 11 st. 7 |

Girls in their middle teens generally put on weight fairly rapidly; but by the time they are twenty to twenty-one they usually have settled down to about the normal weight for their height.

*N.B.*—Your inches above 5 ft. multiplied by 5½, and the result added t0 110. gives your correct weight in pounds.

## HOOP IRON.

### Dimensions and Weight in lbs per running foot.

| | | | | | | |
|---|---|---|---|---|---|---|
| Breadth .. .. .. | $\frac{5}{8}''$ | $\frac{3}{4}''$ | $\frac{7}{8}''$ | 1″ | $1\frac{1}{8}''$ | $1\frac{1}{4}''$ |
| B. W. Gauge .. .. | 21 | 20 | 19 | 18 | 17 | 16 |
| Weight per lineal foot .. | .70666 | .0875 | .1216 | .1636 | .21 | .27 |
| Breadth .. .. .. | $1\frac{3}{8}''$ | $1\frac{1}{2}''$ | $1\frac{3}{4}''$ | 2″ | $2\frac{1}{4}''$ | $2\frac{1}{2}''$ |
| B. W. Gauge .. .. | 15 | 15 | 14 | 13 | 13 | 12 |
| Weight per lineal foot .. | .33 | .33 | .484 | .684 | .714 | .91 |

## INDIAN WEIGHTS AND MEASURES.

### Cloth Measures.

| | | | |
|---|---|---|---|
| 3 Jaubs make | 1 Ungli | =about | 3/4 in. |
| 3 Unglies ,, | 1 Girah | = ,, | 2¼ ins. |
| 8 Girahs ,, | 1 Hath | = ,, | 18 ,, |
| 2 Haths ,, | 1 Guj | = ,, | 1 yd. |

N.B.—The Guj varies from 24 to 36 inches according to locality.

There are no Indian measures of capacity for dry and liquid goods sold by weight. When measures are employed, they are supposed to represent a specific weight, e.g., a Seer, a Powah, a Chittack, and so on.

A Matman's Hath is equal to 13 cubits × 1 cubit = 13 square cubits.

---

### Grain Measure.

| | |
|---|---|
| 5 Chataks | = 1 Koonkee |
| 4 Koonkees | = 1 Raik |
| 2 Raiks | = 1 Pally |
| 16 Pallied | = 1 Maund |
| 2½ Maunds | = 1 Sali |

## Official Weights

| | | | dr. Avoir. |
|---|---|---|---|
| 4 Punko | = 1 Dhàn | = | 3/175 |
| 4 Dhans | = 1 Ruttee | = | 12/175 |
| 8 Ruttees | = 1 Masha | = | 96/175 |
| 12 Mashas | = 1 Tola | = | 6 102/175 |
| 5 Tolas | = 1 Chittack | = | 2 2/35 oz. |
| 16 Chittacks | = 1 Seer | = | 2 2/35 lb. |
| 40 Seers | = 1 Maund | = | 82 2/7 lb. |

The Indian Maund is 82 2/7 lb.
The Factory Maund is 74 lb. 10 oz. 11 drs.
The Bazaar Maund is 82 lb. 2 oz. 8 drs.
1 cwt. = 112 lb. = Bazaar 1 Md. 14 Seers 8 8/11 Chittacks.

## Bazaar Weights

*Sicki* and *Kancha* are used in Bengal only.

| | |
|---|---|
| 5 Sicki or ¼ Rupee | = 1 Kancha |
| 4 Kanchas | = 1 Chittack |
| 4 Chittacks or 20 Tolas | = 1 Powah |
| 4 Powahs | = 1 Seer |
| 5 Seers | = 1 Passeree |
| 8 Passerees, or 40 Seers | = 1 Maund. |

The Bazaar Seer is equal to 80 Tolas or Sicca Rupee weight. The Factory Seer is equal to 72⅗ Tolas.

To convert Indian into Avoirdupois, multiply the weight in Seers by 72, and divide by 35, the result will be lb. Avoirdupois; or multiply the weight in Maunds by 36, and divide by 40, the result will be cwt. Avoirdupois. By reversing the operation, Avoirdupois may be converted into Seers and Maunds. A ton is equal to nearly 27¼ Maunds.

To convert Bazaar into Factory Weight, add one-tenth.

To reduce Bazaar weight into cwt., add one-tenth and deduct one-third of the total from itself, the remainder will be cwt.

To reduce Factory Maunds into Tons divide by 30 and the quotient will be the answer.

**Lineal Measure**

| | |
|---|---|
| 1 Hath (Cubit) | = 18 ins. |
| 4 Haths | = 1 Danda = 2 yds. |
| 2,000 Dandas | = 1 Coss. |

The Coss or Bengali mile is equal to 1 mile, 1 furlong, 8 poles, 3½ yards English.

The Indian Imperial Coss is equal to nearly 2¼ miles.

In the N. W. Provinces the average is about 2 miles, but it varies with locality. In Agra and Muttra the Coss is about 1¾ miles; towards the Hills the Coss is fully 1 mile; in Bundelcund, three times as long as in some other parts, and is called a Pucca Coss; while in the Doab the Cow Coss is current, or as far as the lowing of a cow can be heard at dead of night.

**Indian Money Tables**

| | |
|---|---|
| 3 Pies | = 1 Pice |
| 12 Pies or 4 Pice | = 1 Anna |
| 16 Annas | = 1 Rupee |
| 15 Rupees | = 1 Sovereign |
| 16 Rupees | = 1 Gold Mohur |
| 100,000 Rupees | = 1 Lac. |
| 100 Lacs | = 1 Karor (crore) |

Weight of Gold Mohur and Rupee is 180 Grs. Troy.

**Specific Gravity of Oils, Tallow, Wax, and Fat.**—For all practical purposes seeds oils can be considered to weigh 9¼ lbs. to the gallon.

| | | | |
|---|---|---|---|
| Mineral Oils | .890 | Oil of Almonds | .917 |
| Tallow | .942 | Colza Oil | .914 |
| Oil of Linseed | .932 | Lard Oil | .948 |
| Train Oil | .928 | Oil of Lavender | .894 |
| Oil of Filberts | .916 | Whale Oil | .923 |
| „ Linseed | .940 | Oil of Rape | .920 |
| „ Olives | .915 | Fat Beef | .923 |
| „ Poppies | .924 | „ Mutton | .924 |
| Cod Liver Oil | .920 | „ Veal | .934 |
| Oil of Hempseed | .926 | „ Hogs | .937 |
| „ Cloves | 1.036 | Wax, white | .969 |
| „ Turpentine | .870 | „ yellow | .965 |
| Parafin Oil | .820 | „ shoemakers' | .857 |

## SPECIFIC GRAVITY

The Specific gravity of a substance is the ratio which the weight of its volume bears to the weight of an equal volume of a standard substance. For solids and liquids the standard substance is distilled water at 4°c. For Gases, hydrogen is the standard.

$$\text{S. G. of a Solid} = \frac{\text{Weight of body in air}}{\text{Weight of equal volume of water}}$$

S. G. of a Gas is found by means of a glass globe.

$$\frac{\text{wt of gas}}{\text{Wt. of equal vol. of hydrogen.}}$$

## SPECIFIC GRAVITY OF LIQUIDS

| | | | |
|---|---|---|---|
| Alcohol | .79 | Petroleum | 0.88 |
| Glycerine | 1.02 | Petrol | 0.68 |
| Milk | 1.03 | Water | 1.00 |

To find the weight of a cubic foot, multiply 62.321 lb. by the S. G.

To find the number of cu. ft. in 1 ton, divide 35.943 by the S.G.

The S. G. of a liquid is found by means of a S. G. Bottle.

$$\text{S. G. of a liquid} = \frac{\text{wt. of Liquid.}}{\text{wt. of equal vol. of water.}}$$

## TABLE OF EQUIVALENTS OF WEIGHT IN TOLAS, OUNCES AND GRAMMES.

| A Tola=11.66381 Grames or .41142 Ounce. | | | | An Ounce=2.43055 Tolas or 28.34952 Grammes. | | | | A Gramme=.03527 Ounce or .08573 Tolas. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Tolas | Grammes | lb. | oz. | lb. | oz. | Tolas. | Grammes. | Gram's | lb. | oz. | Tolas. |
| 1 | 11.6638 | 0 | .4114 | 0 | 1 | 2.4306 | 28.3495 | 1 | 0 | .0353 | .0857 |
| 2 | 23.3276 | 0 | .8229 | 0 | 2 | 4.8611 | 56.6991 | 2 | 0 | .0705 | .1715 |
| 3 | 34.9914 | 0 | 1.2243 | 0 | 3 | 7.2717 | 85.0486 | 3 | 0 | .1058 | .2572 |
| 4 | 46.6552 | 0 | 1.6457 | 0 | 4 | 9.7222 | 113.3981 | 4 | 0 | .1411 | .3429 |
| 5 | 58.3191 | 0 | 2.0571 | 0 | 5 | 12.1528 | 141.7476 | 5 | 0 | .1764 | .4287 |
| 6 | 69.9829 | 0 | 2.4686 | 0 | 6 | 14.5833 | 170.0972 | 6 | 0 | .2116 | .5144 |
| 7 | 81.6467 | 0 | 2.8800 | 0 | 7 | 17.0139 | 198.4467 | 7 | 0 | .2469 | .6001 |
| 8 | 93.3105 | 0 | 3.2914 | 0 | 8 | 19.4444 | 226.7962 | 8 | 0 | .2822 | .6859 |
| 9 | 104.9743 | 0 | 3.7029 | 0 | 0 | 21.8750 | 235.1457 | 9 | 0 | .3175 | .7716 |
| 10 | 116.638 | 0 | 4.114 | 0 | 10 | 24.3056 | 283.4953 | 10 | 0 | .353 | .857 |
| 20 | 233.276 | 0 | 8.229 | 0 | 11 | 26.7361 | 311.8448 | 20 | 0 | .705 | 1.715 |
| 30 | 349.914 | 0 | 12.343 | 0 | 12 | 29.1667 | 340.1943 | 30 | 0 | 1.058 | 2.872 |
| 40 | 466.552 | 1 | 0.457 | 0 | 13 | 31.5972 | 368.5438 | 40 | 0 | 1.411 | 3.429 |
| 50 | 583.191 | 1 | 4.571 | 0 | 14 | 34.c278 | 396.8934 | 50 | 0 | 1.764 | 4.287 |
| 60 | 699.829 | 1 | 8.686 | 0 | 15 | 36.4583 | 425.2429 | 60 | 0 | 2.116 | 5.144 |
| 70 | 816.467 | 1 | 12.800 | 1 | 0 | 38.9 | 454 | 70 | 0 | 2.469 | 6.001 |
| 80 | 933.105 | 2 | 0.914 | 2 | 0 | 77.8 | 907 | 80 | 0 | 2.822 | 6.859 |
| 90 | 1049.743 | 2 | 5.029 | 3 | 0 | 116.7 | 1361 | 90 | 0 | 3.175 | 7.716 |
| 100 | 1166.38 | 2 | 9.14 | 4 | 0 | 155.6 | 1814 | 100 | 0 | 3.53 | 8.57 |
| 200 | 2332.76 | 5 | 2.29 | 5 | 0 | 194.4 | 2268 | 200 | 0 | 7.05 | 17.15 |
| 300 | 3499.14 | 7 | 11.43 | 6 | 0 | 233.3 | 2722 | 300 | 0 | 10.58 | 25.72 |
| 400 | 4665.52 | 10 | 4.57 | 7 | 0 | 272.2 | 3175 | 400 | 0 | 14.11 | 34.29 |
| 500 | 3831.91 | 12 | 13.71 | 8 | 0 | 311.1 | 3629 | 500 | 1 | 1.64 | 42.87 |
| 600 | 6998.29 | 15 | 6.86 | 9 | 0 | 350.0 | 4082 | 600 | 1 | 5.16 | 51.44 |
| 700 | 8164.67 | 18 | 0.00 | 10 | 0 | 388.9 | 4536 | 700 | 1 | 8.69 | 60.01 |
| 800 | 9331.05 | 20 | 9.14 | 20 | 0 | 777.8 | 9072 | 800 | 1 | 12.22 | 68.59 |
| 900 | 10497.43 | 23 | 2.29 | 30 | 0 | 1166.7 | 13608 | 900 | 1 | 15.75 | 76.16 |
| 1000 | 11663.8 | 25 | 11.4 | 40 | 0 | 1555.6 | 18144 | 1000 | 2 | 3.3 | 85.7 |
| 2000 | 23327.6 | 31 | 6.8 | 50 | 0 | 1944.4 | 22680 | 2000 | 4 | 6.5 | 171.5 |

## TABLE SHOWING INTEREST AT VARIOUS RATES FOR 1 YEAR.

| Amount. | ½ P. C. | 1 P. C. | 2 P. C. | 3 P. C. | 4 P. C. | 5 P. C. | 6 P. C. |
|---|---|---|---|---|---|---|---|
| 1 | 0 0 1 | 0 0 2 | 0 0 4 | 0 0 5 | 0 0 7 | 0 0 9 | 0 0 11 |
| 2 | 0 0 2 | 0 0 4 | 0 0 8 | 0 0 11 | 0 1 3 | 0 1 7 | 0 1 11 |
| 3 | 0 0 3 | 0 0 6 | 0 1 0 | 0 1 5 | 0 1 11 | 0 2 4 | 0 2 10 |
| 4 | 0 0 4 | 0 0 8 | 0 1 3 | 0 1 11 | 0 2 6 | 0 3 2 | 0 3 10 |
| 5 | 0 0 5 | 0 0 10 | 0 1 7 | 0 2 4 | 0 3 2 | 0 4 0 | 0 4 9 |
| 10 | 0 0 10 | 0 1 7 | 0 3 2 | 0 4 9 | 0 6 4 | 0 8 0 | 0 9 7 |
| 20 | 0 1 7 | 0 3 2 | 0 6 5 | 0 9 7 | 0 12 9 | 1 0 0 | 1 3 2 |
| 30 | 0 2 5 | 0 4 10 | 0 9 7 | 0 14 4 | 1 3 2 | 1 8 0 | 1 12 9 |
| 40 | 0 3 2 | 0 6 5 | 0 12 10 | 1 3 2 | 1 9 7 | 2 0 0 | 2 6 4 |
| 50 | 0 4 0 | 0 8 0 | 1 9 0 | 1 8 0 | 2 0 0 | 2 8 0 | 8 0 0 |
| 100 | 0 8 0 | 1 0 0 | 2 0 0 | 3 0 0 | 4 0 0 | 5 0 0 | 6 0 0 |
| 500 | 2 8 0 | 5 0 0 | 10 0 0 | 15 0 0 | 20 0 0 | 25 0 0 | 30 0 0 |
| 1000 | 5 0 0 | 10 0 0 | 20 0 0 | 30 0 0 | 40 0 0 | 50 0 0 | 60 0 0 |

## Properties of the Elements.

(Bureau of Standards—1912)

| Element | Symbol | Automic Weight | Density | Specific Heat | Melting Point (deg. cent.) |
|---|---|---|---|---|---|
| Aluminium .. | Al | 27.1 | 2.70 | 0.212 | 658.7 |
| Antimony .. .. | Sb | 120.2 | 6.69 | 0.049 | 630 |
| Argon .. .. | A | 39.88 | 1.40 | .. | −188 |
| Arsenic .. .. | As | 74.96 | 5.73 | 0.084 | 850 |
| Barium .. .. | Ba | 137.37 | 3.75 | 0.068 | 850 |
| Bismuth .. .. | Bi | 208.0 | 9.78 | 0.030 | 271 |
| Boron .. .. | B | 11.0 | 2.55 | 0.307 | 2350 |
| Bromine .. .. | Br | 79.92 | 3.15 | 0.107 | −7.3 |
| Cadmium .. .. | Cd | 112.4 | 8.67 | 0.055 | 320.9 |
| Caesium .. .. | Cs | 132.81 | 1.88 | 0.048 | 26 |
| Calcium .. .. | Ca | 40.07 | 1.52 | 0.170 | 810 |
| Carbon .. .. | C | 12.00 | 3.51 | 0.113 | 3600 |
| Cerium .. .. | Ce | 140.25 | 7.02 | 0.045 | 640 |
| Chlorine .. .. | Cl | 35.46 | 1.507 | 0.226 | −101.5 |
| Chromium .. .. | Cr | 52.0 | 6.92 | 0.104 | 1520 |
| Cobalt .. .. | Co | 58.97 | 8.71 | 0.103 | 1478 |
| Columbium.. .. | Cb | 93.5 | 7.25 | .... | 2200 |
| Copper .. .. | Cu | 63.57 | 8.89 | 0.092 | 1083.0 |
| Dysprosium .. | Dy | 162.5 | .... | .... | .... |
| Erbium .. .. | Er. | 167.4 | 4.77 | .... | .... |
| Eropium .. .. | Eu | 152.0 | .... | .... | .... |
| Fluorine .. .. | F | 19.0 | 1.14 | .... | −223 |
| Gadolinium .. | Gd | 157.3 | .... | .... | .... |
| Gallium .. .. | Ga | 69.9 | 5.93 | 0.080 | 30 |
| Germanium .. | Ge | 72.5 | 5.46 | 0.074 | 958 |
| Glucinum .. .. | Gl | 9.1 | 1.96 | .... | .... |
| Gold .. .. | Au | 197.2 | 19.33 | 0.032 | 1063.0 |
| Helium .. .. | He | 3.99 | .... | .... | −271 |
| Holmium. .. .. | Ho | 163.5 | .... | .... | .... |
| Hydrogen .. .. | H | 1.008 | 0.070 | .... | −259 |
| Indium .. .. | In | 114.8 | 7.27 | 0.057 | 155 |
| Iodine .. .. | I | 126.92 | 4.8 | 0.054 | 113.5 |
| Iridium .. .. | Ir | 193.1 | 22.42 | 0.032 | 2300 |
| Iron .. .. | Fe | 55.84 | 7.865 | 0.115 | 1530 |
| Krypton .. .. | Kr | 82.92 | .... | .... | −169 |
| Lanthanum .. | La | 139.0 | 6.15 | 0.045 | 810 |
| Lead .. .. | Pb | 207.10 | 11.37 | 0.030 | 327.4 |
| Lithium .. .. | Li | 6.94 | 0.534 | 0.85 | .... |
| Lutecium .. .. | Lu | 174.0 | .... | .... | .... |
| Magnesium .. | Mg | 24.32 | 1.72 | 0.249 | 651 |
| Manganese .. .. | Mn | 54.93 | 7.4 | 0.111 | 1260 |

## Properties of the Elements.—*contd.*

(Bureau of Standards—1912)

| Element | Symbol | Atomic Weight | Density | Specific Heat | Melting Point (deg. cent.) |
|---|---|---|---|---|---|
| Mercury .. .. | Hg | 200.6 | 13.55 | 0.033 | -38.7 |
| Molybdenum .. | Mo | 96.0 | .... | .... | .... |
| Neodymium .. | Nd | 144.3 | .... | .... | 840 |
| Neon .. .. | Ne | 22.2 | .... | .... | -253 |
| Nickel .. .. | Ni | 58.68 | 8.80 | 0.109 | 1452 |
| Niton .. .. | Nt | 222.4 | .... | .... | .... |
| Nitrogen .. .. | N | 14.01 | 0.88 | .... | -210 |
| Osmium .. .. | Os | 190.9 | 22.5 | 0.031 | 2700 |
| Oxygen .. .. | G | 16.00 | 1.14 | .... | -230 |
| Palladium .. .. | Pd | 106.7 | 11.4 | 0.059 | 1549 |
| Phosphorous .. | P | 31.04 | 2.34 | 0.19 | 44 |
| Platinum .. .. | Pt | 195.2 | 21.45 | 0.032 | 1755 |
| Potassium .. .. | K | 39.10 | 0.87 | 0.170 | 62.3 |
| Praseodynium .. | Pr | 140.6 | 6.475 | .... | 940 |
| Radium .. .. | Ra | 226.4 | .... | .... | .... |
| Rhodium .. .. | Rh | 102.9 | 12.4 | 0.058 | 1940 |
| Rubidium .. .. | Rb | 85.45 | 1.532 | .... | 38 |
| Ruthenium .. | Ru | 101.7 | 12.3 | 0.061 | 1950 |
| Samarium .. | Sa | 150.4 | 7.75 | .... | 1350 |
| Scandium .. .. | Sc | 44.1 | .... | .... | .... |
| Selenium .. .. | Se | 79.2 | 4.55 | 0.68 | 218.5 |
| Silicicon .. .. | Si | 28.3 | 2.1 | 0.175 | 1420 |
| Silver .. .. | Ag | 107.88 | 10.6 | 0.055 | 960.5 |
| Sodium .. .. | Na | 23.0 | 0.971 | 0.253 | 97.5 |
| Scrontium .. .. | Sr | 87.63 | 2.54 | .... | .... |
| Sulphur .. .. | S | 32.07 | 2.05 | 0.173 | 112.8 |
| Tantalum .. .. | Ta | 181.5 | 16.6 | 0.033 | 2850 |
| Tellurium .. .. | Te | 127.5 | 6.25 | 0.048 | 452 |
| Terbium .. .. | Tb | 159.2 | .... | .... | .... |
| Thallium .. .. | Tl | 204.0 | 11.85 | 0.033 | 302 |
| Thorium .. .. | Th | 232.4 | 11.0 | 0.027 | 1700 |
| Thulium .. .. | Tm | 168.5 | .... | .... | .... |
| Tin .. .. .. | Sn | 119.0 | 7.30 | 0.054 | 231.9 |
| Titanium .. .. | Ti | 48. | 3.5 | 0.110 | 1795 |
| Tungsten .. .. | W | 184.0 | 18.85 | 0.034 | 3000 |
| Uranium .. .. | U | 238.5 | 18.7 | 0.028 | .... |
| Vanadium .. .. | V | 51.0 | 5.5 | 0.115 | 1720 |
| Xenon .. .. | Xe | 130.2 | 3.52 | .... | -140 |
| Yitterbiun .. .. | Yb | 172.0 | .... | .... | .... |
| Yttrium .. .. | Y | 89.0 | 3.8 | .... | .... |
| Zinc .. .. | Zn | 65.37 | 7.19 | 0.093 | 419.4 |
| Zirconium .. .. | Zr | 90.6 | 4.14 | 0.066 | 1700 |

## ELEVATIONS OF STATIONS IN AND NEAR INDIA.

| Name of Places | Height above Sea Level. | Mean Annual Temperature. |
|---|---|---|
| | *Feet* | ° |
| Agra .. .. .. .. .. .. | 657 | 78 |
| Allahabad .. .. .. .. .. | 316 | 81 |
| Arcot .. .. .. .. .. .. | 599 | 82 |
| Bangalore .. .. .. .. .. | 2,989 | 74 |
| Bellary .. .. .. .. .. | 1,538 | 80 |
| Bombay .. .. .. .. .. | 38 | 80 |
| Calcutta .. .. .. .. .. | 18 | 78 |
| Calicut .. .. .. .. .. | 0 | 81 |
| Cannanore .. .. .. .. .. | 0 | 81 |
| Cochin .. .. .. .. .. | 0 | 81 |
| Coimbatore .. .. .. .. .. | 1,483 | 77 |
| Colombo .. .. .. .. .. | 18 | 80 |
| Delhi .. .. .. .. .. .. | 827 | 74 |
| Guntur .. .. .. .. .. | 0 | 82 |
| Lahore .. .. .. .. .. | 839 | 75 |
| Lucknow .. .. .. .. .. | 535 | 76 |
| Madras .. .. .. .. .. | 2 | 82 |
| Madura .. .. .. .. .. | 600 | 85 |
| Mangalore .. .. .. .. .. | 0 | 81 |
| Nagpore .. .. .. .. .. | 935 | 82 |
| Nellore .. .. .. .. .. | 81 | 82 |
| Ootacamund .. .. .. .. .. | 7,490 | 56 |
| Pondicherry .. .. .. .. .. | 0 | 85 |
| Poona .. .. .. .. .. .. | 1,784 | 75 |
| Rajahmundry .. .. .. .. | 81 | 82 |
| Rangoon .. .. .. .. .. | 40 | 79 |
| Secunderabad .. .. .. .. | 1,800 | 77 |
| Simla .. .. .. .. .. .. | 7,057 | 58 |
| Tinnevelly .. .. .. .. .. | 120 | 85 |
| Trichinopoly .. .. .. .. .. | 448 | 85 |
| Trivandrum .. .. .. .. .. | 0 | 79 |
| Vizagapatam .. .. .. .. .. | 0 | 83 |
| Wellington .. .. .. .. .. | 5,860 | 67 |

The variation of time depends on Longitude: every degree WEST OF GREENWICH the clock is 4 minutes later, every degree EAST OF GREENWICH 4 minutes earlier.

Table showing the time when NOON AT GREENWICH.

Aberdeen 11.52 a.m.
Adelaide, 9.15 p.m.
Amsterdam, 12.20 p.m.
Athens, 1.35 p.m.
Berlin, 12.54 p.m.
Birmingham, 11.52 a.m.
Bombay, 4.52 p.m.
Brisbane, 10.12 p.m.
Bristol, 11.49 a.m.
Brussels, 12.17 p.m.
Buenos Ayres, 8.7 a.m.
Cairo, 2.5 p.m.
Calais, 12.7 p.m.
Calcutta, 5.54 p.m.
Cape Town, 1.14 p.m.
Cardiff, 11.47 a.m.
Chicago, 6.10 a.m.
Constantinople, 1.56 p.m.
Copenhagen, 12.50 p.m.
Cork, 11.26 a.m.
Drogheda, 11.35 a.m.
Dublin, 11.35 a.m.
Edinburgh, 11.47 a.m.
Exeter, 11.45 a.m.
Flint, 11.47 a.m.
Florence, 12.45 p.m.
Folkestone, 12.5 p.m.
Gibraltar, 11.39 a.m.
Glasgow, 11.48 a.m.
Hamburg, 12.40 p.m.
Harwich, 12.5 p.m.
Holyhead, 11.41 a.m.
Hull, 11.59 a.m.
Ilfracombe, 11.44 a.m.
Jamaica, 6.32 a.m.
Jersey, 11.52 a.m.
Johannessburg, 1.52 p.m.
Lisbon, 11.24 a.m.
Liverpool, 11.48 a.m.
LLANELLY, 11.43 a.m.
Londonderry, 11.31 a.m.
Madras, 5.21 p.m.
Madrid, 11.46 a.m.
Malta, 12.58 p.m.
Manchester, 11.51 a.m.
Margate, 12.6 p.m.
Marseilles, 12.21 p.m.
Melbourne, 9.40 p.m.
Montreal, 7.6 a.m.
Moscow, 2.30 p.m.
New York, 7.4 a.m.
Nottingham, 11.55 a.m.
Oxford, 11.55 a.m.
Paris, 12.9 p.m.
Pekin, 7.46 p.m.
Penzance, 11.37 a.m.
Perth (Aus.), 7.43 p.m.
Petrograd, 2.1 p.m.
Quebec, 7.15 a.m.
Queenstown, 11.27 a.m.
Rio Janeiro, 9.7 a.m.
Rome, 12.50 p.m.
Rotterdam, 12.18 p.m.
San Francisco, 3.50 a.m.
Stockholm, 1.12 p.m.
Suez, 2.10 p.m.
Sydney, 10.5 p.m.
Tokyo, 9.18 p.m.
Truro, 11.40 a.m.
Vancouver, 3.38 a.m.
Vienna, 1.5 p.m.
Washington, 6.52 a.m.
Whitby, 11.57 a.m.
Winnipeg, 6.0 a.m.

Twelve o'clock noon, Standard Time in India, as compared with the clock in the following places.

| | | |
|---|---|---|
| Adelaide 4.0 p.m. | Jerusalem 8.30 a.m. | Rangoon 1.0 p.m. |
| Amsterdam 6.50 a.m. | Leningrad 9.30 a.m. | Rio de Janeiro 3.30 a.m. |
| Athens 8.30 a.m. | Lisbon 6.30 ,, | Rome 7.30 a.m. |
| Auckland, N.Z. 6.0 p.m | London 6.30 ,, | San Francisco*10.30 p.m. |
| Berlin 7.30 a.m. | Madeira 5.30 ,, | St. Helena 6.7 a.m. |
| Brindisi 7.30 a.m. | Madrid 6.30 ,, | St. John's (N.F) 2.59 a.m. |
| Brisbane 4.30 p.m. | Malta 7.30 ,, | St. Louis, Miss.1 2.30 ,, |
| Brussels 6.30 p.m. | Mauritins 10.30 ,, | Singapore 1.30 p.m. |
| Bucharest 8.30 a.m. | Melbourne 4.30 p.m. | Sofia 8.30 a.m. |
| Budapest 7.30 a.m. | Montreal 1.30 a.m. | Stockholm 7.30 a.m. |
| Buenos Ayres 2.30a.m | Moscow 9.30 ,, | Suez 8.30 a.m. |
| Cairo 8.30 a.m. | New Orleans 12.30 ,, | Sydney 4.30 p.m. |
| Calcutta 12.23 p.m. | New York 1.30 ,, | Tokyo 3.30 p.m. |
| Cape Town 8.30 a.m. | Oslo 7.30 ,, | Toronto 1.30 a.m. |
| Chicago 12.30 a.m. | Ottawa 1.30 ,, | Vancouver *10.30 p.m. |
| Copenhagen 7.30 a.m. | Panama 1.30 ,, | Vienna 7.30 a.m. |
| Dublin 6.30 a.m. | Paris 6.30 a.m. | Washington, D.C. 1.30a.m. |
| Gibraltar 6.30 a.m. | Peiping 2.30 p.m. | Wellington, N.Z. 6.0 p.m. |
| Hobart 4.30 p.m. | Perth (W.A.) 2.30 ,, | Winnipeg 12.30 a.m. |
| Hong Kong 2.30 p.m. | Prague 7.30 a.m. | Yokohama 3.30 p.m. |
| Istanbul 8.30 a.m. | Quebec 1.30 a.m. | |
| | | *previous day. |

On the North American continent, five different standard times are in use, viz.*t* Atlantic time, 4 hours slow on Greenwich; Eastern, 5 hours slow, Central, 6 hours slow; Mountain, 7 hours slow; and Pacific, 8 hours slow. In Europe the time 2 hours fast on Greenwich is called East-European, the time 1 hour fast, Mid-European. In Australia standard time ranges from 8 hours to to hours fast on Greenwich, in Brazil, from 3 hours to 5 hours slow. In Rhodesia and the Union of South Africa, standard time is 2 hours fast on Greenwich time. Time in Holland is 19 min. 32.1 sec. fast on Greenwich, and in Aden and British Somaliland it is 2 hours 59 min. 54 sec. fast on Greenwich.

## Mensuration.

A " Square " has all its sides equal in length and all its angles are right—angles (90°). It is also a rectangle.

A " Rectangle" has its two opposite sides equal in length and all its angles right—angles.

A " Parallelogram " has its two opposite sides equal in length and paralled to one another, and its two opposite angles equal to one another.

A " Rhombus " is a parallelogram having all its sides equal but its angles are not right—angles.

A " Trapezium " is a four—sided figure which has two of its sides parallel.

A " Quadrilateral " is any four—sided figure.

Areas are expressed in square measure i.e. square inches. square feet, etc.

Area of a Surface of a Sphere—

Dia.$^2$ Squared $\times 3.1416$.

Area of a Circle—Dia.$^2 \times .7854$

Area of a circle $\times .6366 =$ area of inscribed Square.

Area of an Ellipse = the product of two axes $\times .7854$.

Area of egg-shaped Sewer = One-half the square of the depth.

Area of a rectangle = length $\times$ breadth.

Area of a parallelogram = base $\times$ altitude.

The altitude is the perpendicular distance between one of the sides taken as base, and the apex.

Area of a Rhombus = half the product of the diagonals.

A Triangle is any three-sided figure.

An equilateral triangle is a triangle which has all its three sides equal in length and its three angles equal (60° each).

An Isosceles triangle is a triangle having two of its sides and two of its angles equal.

A " Right—Angled triangle" is a triangle which has one of its angles 90°.

An " Obtuse " angle is an angle over 90°.

An acute angle is an angle under 90°.

The three angles of any triangle total 180°, or half the number of degrees there are in a circle.

The circle—The circumference of a circle is nearly equal to 22 times the diameter divided by 7. The diameter of a circle is nearly equal to 7 times the circumference divided by 22.

The difference of the diameters of any two circles, multiplied by 3.1416, will give the difference of their circumference.

Radius of a Circle $\times 6.2832$ = Circumference Square of the Radius of a circle $\times 3.1416$ = Area

Circumference of a circle = diameter $\times 3.1416$.

Diameter of a circle = Circumference $\div 3.1416$.

Diameter of a circle = Square root of the quotient of the area divided by .7854.

*Square of the Circumference of a Circle* $\times 0.07958$ = Area
*Half the Circumference of a Circle* $\times$ half its Diameter = Area
Circumference of a Circle $\times 0.15915$ = Radius.

Square Root of the Area of a Circle $\times 0.56419$ = Radius
Circumference of a Circle $\times 0.31831$ = Diameter

Square Root of the Area of a Circle $\times 1.12838$ = Diameter

Diameter of a Circle $\times 0.8660$ = Side of an Inscribed Equilateral Triangle.

Diameter of a Circle $\times 0.7071$ = Side of an Inscribed Square

Circumference of a Circle $\times 0.2251$ = Side of an Inscribed Square.

Circumference of a Circle $\times 0.2821$ = Side of an Equal Square.

Diameter of a Circle $\times 0.8862$ = Side of an Equal Square.

Base of a Triangle $\times$ one-half the Altitude = Area.

Surafce of a Sphere $\times$ one-sixth of its Diameter = Cubical Contents.

Circumference of a Sphere $\times$ its Diameter = Surface Area.

Square of the Diameter of a Sphere $\times 3.1416$ = Surface Area.

Square of the Circumference of a Sphere $\times 0.3188$ = Surface Area

Cube of the Diameter of a Sphere $\times 0.5326$ = Cubical Contents.

Cube of the Circumference of a Sphere $\times 0.016887$ = Cubical Contents

Radius of a Sphere $\times 1.1547$ = Side of inscribed cube.

Square Root of one–third of the square of the diameter of a sphere = side of inscribed cube.

Area of its Base ×one-third of its Altitude = Cubical contents of a cone of Pyramid, whether round, square, or triangular.

Altitude of Trapezoid ×one-half the sum of its Parallel Sides = Area.

| | |
|---|---|
| Area of parabola | =Base ×2/3 height. |
| Frustum of a parabola | $= \frac{2}{3}$ height $\dfrac{\text{base}^3 - \text{top}^3}{\text{base}^2 - \text{top}^2}$ |
| Area of ellipse | =Long axis ×0.7854 short axis. |
| ,, cycloid .. | =Area of generating circle ×3. |
| Surface of cylinder | =Area of both ends ×length ×circum-ference. |
| ,, cone .. .. | =Area of base ×circumference of base ×1/2 slant height. |
| ,, sphere .. | =Diameter$^2$ ×3.14159. |
| ,, frustum .. | =Sum of girt at both ends ×1/2 slant height ×area of both ends. |
| Surface of zone on sphere between parallel planes | $= \pi$ r ×distance between planes. |

Square inches × .00695 = Square feet.
Cubic inches × .000578 = cubic feet.
Cubic inches ×0.26 = Weight in cast iron.
Cubic inches ×0.28 = Weight in Steel.
Cubic inches ×0.30 = Weight in Brass.
Cubic inches ×0.41 = Weight in lead.
Cubic inches ×0.097 = Weight in aluminium.
Cubic feet ×0.037 = Cubic yards.
Cylindrical inches × .0004546 = Cubic feet.
Cylindrical feet × .0290946 = Cubic yards.
183,346 circular inches = 1 Square foot.
2,200 cylindrical inches = 1 cubic foot.
lbs. avoirdupois ×1.2153 = lbs. troy or apothecary.
lbs. troy or apothecary ×0.829 = lbs. avoirdupois.
lbs. avoirdupois ×0.00893 = cwts.
lbs. avoirdupois ×0.00447 = tons.

**Volumes**.... Volumes are expressed in cubic measure, i.e. cubic inches, cubic feet, etc.

Volume of a rectangular body = Length × Breadth × height.
Volume of a cylinder = area of base ($\pi r^2$) × length.

## GRAPHS.

In making periodical records of any description, the fluctuations or steadiness of the records can be seen more plainly by graphs than by tabulated data.

To find the height of the fall in feet.

*Rule ;* Multiply the Square of the time in Seconds by 16.1

To find the time in falling in seconds.

*Rule ;* Divide the velocity in feet per second by 32.2.

To find the velocity in feet per second for a given height.

*Rule ;* Multiply the height of the fall in feet by 64.4, and take the square root of the product.

To find the distance in feet a ball will traverse before coming to a state of rest, say, on a bowling green, at a velocity of 50 feet per second; weight of ball, 20 lbs., and the frictional resistance to its motion being $\frac{1}{10}$th the weight of the ball, then

$$\frac{50^2 \text{ velocity} \times 20 \text{ lbs. weight}}{2 \text{ lbs. frictional resistance} \times 64.4} = 338 \text{ feet.}$$

To find the distance in feet a train will move on a level rail, whose frictional resistance is 8 lbs. per ton, and supposing that there is no other resistance; the weight of the train being, say 100 tons, and its velocity when the steam is shut off, 50 feet per second; then

$$\frac{50^2 \text{ velocity} \times 100 \text{ tons wt. of train} \times 2240 \text{ lbs.}}{100 \text{ tons weight} \times 8 \text{lbs. per ton frictional resistance} \times 64.4} =$$

10869.5 feet before coming to rest.

---

## METRIC CONVERSION TABLE

Millimeters × .03937 = Inches
Millimeters ÷ 25.4 = Inches
Cent meters × .3937 = Inches
Centimeters ÷ 2.54 = Inches.
Meters × 39.37 = Inches
Meters × 3.281 = Feet
Meters × 1.094 = Yards
Kilometers × .6214 = Miles
Kilometers × 3280.8 = Feet

Kilometers ÷ 1.6093 = Miles
Square Milimeters × .001550 = Square Inches
Square Milimeters—645.2 = Square Inches
Square Centimeters × .155 = Square Inches.
Square Centimeters ÷ 6.452 = Square Inches
Square Meters × 10.764 = Square Feet
Square Kilometers × 247.1 = Acres
Hectare × 2.471 = Acres
Cubic Centimeters ÷ 16.387 = Cubic Inches
Cubic Centimeters ÷ 3.697 = Fluid Drahms (U.S.P.)
Cubic Centimeters ÷ 29.57 = Fluid Ounces (U.S.P.)
Cubic Meters × 35.315 = Cubic Feet
Cubic Meters × 1.308 = Cubic Yards
Cubic Meters × 264.2 = Gallons (231 Cubic Inches)
Cubic inches × .028848 = pints.
Cubic inches × .014424 = quarts.
Cubic inches × .003606 = gallons.
Cubic inches × .0163 = French litres.
Cubic inches in imperial gallon = 277.274.
Cubic feet × 6.232 = imperial gallons.
Cubic feet × .779 = bushels.
Circular inches × .7854 = Square inches.
Square inches divided by .7854 = circular inches.
Circular inches multiplied by .00456 = Square feet.
Square inches multiplied by .00695 = Square feet.
Square feet multiplied by .111 = Square yards.
Cubic inches multiplied by .00058 = cubic feet.
Cylindrical feet multiplied by .02909 = cubic yards.
Pounds avoirdupois multiplied by 7000 = grains.
Pounds avairdupois multiplied by .009 = cwts.
Pounds avoirdupois multiplied by .00045 = tons.
OZS per linear yards multiplied by 30.98 = Grams per metre.
Grms per linear metre multiplied by 0.0323 = Ounces per yard.
OZS per Square yard multiplied by 33.88 = Grams per sq. metre.
Grms per Square metre multiplied by 0.0295 = Ounces per sq.yd.
Liters × 61.022 = Cubic Inches
Liters × 33.81 = Fluid Ounces (U.S.P.)
Liters × .2642 = Gallons (231 Cubic Inches)
Liters ÷ 3.785 = Gallons (231 Cubic Inches)
Liters ÷ 28.316 = Cubic Feet
Hectoliters × 3.531 = Cubic Feet
Hectoliters × 2.838 = Bushels (2150.42 Cubic Inches)
Hectoliters × .1308 = Cubic Yards

Hectoliters ×26.42 =Gallons (231 Cubic Inches)
Grams ×15.432 =Grains
Grams ×980.7 =Dynes
Grams (water)÷29.57 =Fluid Ounces.
Grams÷28.35 =Ounces Avoirdupois
Grams per Cubic Centimeter÷27.68 =lbs. per Cubic Inch.
Joule × .7375 =Foot Pounds
Kilograms ×2.2046 =Pounds
Kilograms ×35.274 =Ounces (Avoirdupois)
Kilogrames÷907.19 =Tons (2000 Pounds)
Kilograms per Square Centimeter ×14.223 =Lbs. per Sqr. inch.
Kilogram-meters ×7.233 =Foot Pounds
Kilos per Meter × .6720 =Pounds per Foot.
Kilos per Cubic Meters × .06243 =Pounds per Cubic Foot
Kilos-Watts ×1.340 =Horse Powers
Watts × .7375 =Foot Pounds per Second
Calorie (large) ×3.971 =B.T.U.
Cheval Vapeur × .9863 =Horse Powers
Gravity =980.665 Centimeters per Second
Gravity =981.2 at London, at 45° Latitude and sea level

## "THE THERMOMETER"

*"Measures of Heat"*

The temperature of things is measured by an instrument called the "Thermomet er", of which there are three kinds.

(a) **"Centigrade Thermometer"**.....Freezing point marked 0° and boiling point 100°. Generally used in most Countries, chiefly for Scientific purposes.

(b) **Réaumur's Thermometer**......Freezing point marked 0° and boiling point 80°.

(c) **Fahrenheit's Thermometer**......Freezing point marked 32° and boiling point 212°.

| Fahrenheit | Centigrade | Réaumur | Remarks. |
|---|---|---|---|
| 212* | 100* | 80* | *Boiling Point. |
| 200 | 93.3 | 74.6 | **Blood Heat. |
| 180 | 82.2 | 65.7 | ***Freezing-point. |
| 160 | 71.1 | 56.8 | |
| 140 | 60 | 48 | |
| 120 | 48.8 | 39.1 | Conversion of Thermometer Readings. |
| 100 | 37.8 | 30.2 | |
| 98.6** | 37** | 29.6** | $\frac{\text{Degrees Fah.}-32}{9} = \frac{\text{Degrees cent}}{5} = \frac{\text{Degrees Reaumur}}{4}$ |
| 90 | 32.2 | 25.7 | |
| 80 | 26.6 | 21.3 | |
| 70 | 21.1 | 16.8 | |
| 60 | 15.5 | 12.4 | |
| 50 | 10 | 8 | |
| 40 | 4.4 | 3.5 | |
| 32*** | 0*** | 0*** | |

## "HEAT"

### *Coefficient of Expansion.*

If a bar of any substance is heated 1°C. to length will increase by a certain fraction of its length called the coefficient of Linear Expansion.

Coefficients of Linear Expansion for 1°c of :—

| | | | |
|---|---|---|---|
| Glass | =.0000085 | Copper | =.000017 |
| Platinum | =.0000085 | Brass | =.000019 |
| Iron | =.000012 | Lead | =.000028 |
| Steel | =.000012 | Zinc | =.00003 |

The Coefficient of Square Expansion is double than the above.

The Coefficient of Cubic Expansion is treble than the above.

The Coefficient of Cubic Expansion is used in measuring the expansion of liquids.

The Coefficient of Expansion of all Gases is the same.

A gas expands $\frac{1}{273}$ of its volume for each degree centigrade rise in temperature.

## THERMAL UNIT.

A British Thermal Unit or Heat Unit, is the amount of heat that will raise 1 lb. of Water 1° Fah.

A Calorie is the amount of heat that will raise 1 gram of water 1° Cent.

A Therm is 100.000 B. T. U. It contains heat sufficient to raise 1000 lbs. of water 100° Fah.

## LATENT HEAT.

Latent heat is the number of Heat Units required to change one unit (i.e. 1 lb. or 1 gram) from a Solid to a liquid, or from a liquid to a vapour at the same temperature.

The Latent Heat of Fusion of Ice is 80, of Vaporisation of water is 536.2.

## CONVERSION FACTORS

### *Angles.*

1rd. =57.2958 deg. =3437.75 min. =206,265 Sec.

### *Areas.*

1 Sq. mile = 640 acres = 258.999 hectares.
1 Hectare = 100 ares = 10,000 Sq. meters = 2.471 acres.
1 Acre = 10 Sq. chains = 43,560 Sq. ft.
1 Sq. yd. = 9 Sq. ft. = 0.836 Sq. meter.
1 Sq. meter = 10.764 Sq. ft. = 1.196 Sq. yd.

### *Densities.*

1 lb. per cu. ft = 16.018 Kg per cu. meter.
1 lb. per cu. in = 27.680g. per cu. cm.
1 Kg. per cu. meter = 0.06243 lb per cu. ft.
1 g. per cu. cm. = 0.03613 lb. per cu. in.

### *Discharge*

1 cu. ft. per sec. = 448.9 gal. per min. =1.9835 acre–ft per day.
1 Acre–ft. per day = 0.5042 cu. ft. per sec.
1,000,000 gal. per day = 30689 acre = ft. per day = 1.547cu.ft per sec.
1 cu. ft. per sec. = 40 miner's inches.
1 miner's inch = 1.5 cu. ft. per min. = 11.22 gal. per min.
1 in. of rainfall per hr. = 1.008 cu. ft. per sec. per acre.

## *Energy.*

1 ft–lb. = 1.356 joules or watt–sec.
1 joule = $\frac{7}{10}$ ergs = $\frac{7}{10}$ dyne–cm.
1 Horse-power-hr = 1.98 $\times\frac{6}{10}$ ft-lb = 0.7457 Kw-hr. = 2544 Btu.
1 Kw-hr. = 1.341 horse-power-hr. = 3411 Btu. = 2.654 $\times\frac{6}{10}$ ft-lb.
1 Btu. = 778.4 ft-lb. = 0.252 Kg-cal.
1 meter–kilogram = 7.233 ft-lb.

## *Force.*

1 lb = 0.4536 Kg. = 444,822 dynes.
1 Kg. = 2.2046 lb = 980,665 dynes.
1,000,000 dynes = 2.2481 lb. = 1.020 Kg.

## *Temperature.*

Deg. C. = (deg. F.—32) × 0.55556.
Deg. F. = (1.8 × deg. c.) + 32.

## *Length.*

1 mile = 5280 ft = 80 chains = 320 rods = 1.6094 kilometers.
1 meter = 39.37 inches = 3.2808 ft. = 1.0936 yd.
1 inch = 2.54 cm. = 25.4 mm.
1 yd. = 0.9144 meter.
1 ft. = 30.48 cm. = 0.3048 meter.

## *Power.*

1 horse-power = 33,000 ft.–lb. per min. = 550 ft. lb. per sec.
1 horse–power = 0.7457 kw. = 0.7066 Btu. per sec.
1 kw. = 1.341 horse-power = 737.5 ft-lb. per sec.
1 horse–power = 1.0139 metric horse-power.

## *Pressure.*

1 ft. of water = 62.4 lb. per sq. ft. = 0.433 lb. per sq. in.
1 in. of mercury = 1.134 ft. of water = 0.4912 lb. per sq. in.
1 armosphere = 14.697 per sq. in. = 33.9 ft. of water.
1 lb. per sq. ft. = 4.8824 kg. per sq. meter.
1 lb. per sq. in. = 0.07031 kg. per sq. cm.
1 kg. per sq. cm. = 14.223 lb. per sq. in. = 32.8 ft. of water.
1 ton per sq. ft. = 13.889 lb. per sq. in.

## *Velocity.*

1 rod. per sec. = 9.5496 rev. per min. = 0.15916 rev. per sec.
1 rev. per min. = 6.0000 deg. per sec.
1 ft. per sec. = 0.6818 miles per hr.
1 miles per hr. = 88 ft. per min. = 1.4667 ft. per sec.

### *Volume.*

1 cu. yd. = 27 cu. ft. = 21.696 bushels.
1 cu. meter = 1000 litres = 1.308 cu. yds.
1 bu. = 8 gal. (dry) = 1.2445 cu. ft. = 2150.4 cu. in.
1 gal. (dry measure) = 1.1637 gal. (liquid measure)
1 cu. ft. = 7.481 gal. (liquid measure)

### *Weight.*

1 lb. Avoir. = 1.2153 lb. Troy or Apoth.,
1 lb. Avoir = 16 ozs. = 7000 grains = 0.4536 kg.
1 kg. = 2.2046 lb. Avoir.
1 Short ton = 2000 lb. = 0.90718 metric ton.
1 long ton = 2240 lb. = 1.120 Short tons.
1 metric ton = 1000 kg. = 2204.6 lb.

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## COTTON.

Table for converting prices per Maund of $82\frac{2}{7}$ lbs. to prices per Candy of 784 lbs. nett.

| Per Maund | | | Equivalent per Candy. | | | Per Maund. | | | Equivalent per Candy. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rs. | A. | P. | Rs. | A. | P. | Rs. | A. | P. | Rs. | A. | P. |
| 0 | 0 | 1 | 0 | | 10 | 0 | 8 | 0 | 4 | 12 | 3 |
| 0 | 0 | 2 | 0 | 1 | 7 | 0 | 9 | 0 | 5 | 5 | 9 |
| 0 | 0 | 3 | 0 | 2 | 5 | 0 | 10 | 0 | 5 | 15 | 3 |
| 0 | 0 | 4 | 0 | 3 | 2 | 0 | 11 | 0 | 6 | 8 | 9 |
| 0 | 0 | 5 | 0 | 4 | 0 | 0 | 12 | 0 | 7 | 2 | 4 |
| 0 | 0 | 6 | 0 | 4 | 9 | 0 | 13 | 0 | 7 | 11 | 11 |
| 0 | 0 | 7 | 0 | 5 | 7 | 0 | 14 | 0 | 8 | 5 | 5 |
| 0 | 0 | 8 | 0 | 6 | 4 | 0 | 15 | 0 | 8 | 15 | 0 |
| 0 | 0 | 9 | 0 | 7 | 2 | 1 | 0 | 0 | 9 | 8 | 5 |
| 0 | 0 | 10 | 0 | 7 | 11 | 2 | 0 | 0 | 19 | 0 | 11 |
| 0 | 0 | 11 | 0 | 8 | 9 | 3 | 0 | 0 | 28 | 9 | 4 |
| 0 | 1 | 0 | 0 | 9 | 6 | 4 | 0 | 0 | 38 | 1 | 9 |
| 0 | 2 | 0 | 1 | 3 | 1 | 5 | 0 | 0 | 47 | 10 | 3 |
| 0 | 3 | 0 | 1 | 12 | 7 | 6 | 0 | 0 | 57 | 2 | 8 |
| 0 | 4 | 0 | 2 | 6 | 1 | 7 | 0 | 0 | 66 | 11 | 1 |
| 0 | 5 | 0 | 2 | 15 | 7 | 8 | 0 | 0 | 76 | 3 | 7 |
| 0 | 6 | 0 | 3 | 9 | 2 | 9 | 0 | 0 | 85 | 12 | 0 |
| 0 | 7 | 0 | 40 | 2 | 8 | 10 | 0 | 0 | 95 | 4 | 6 |

Table for Converting Pounds to Candies of 784 lbs.

| Pounds | Candies. | cwts 112 lbs. | Candies | Cents 112 lbs. | Candies. |
|---|---|---|---|---|---|
| 1 | .0013 | 1 | .1429 | 450 | 64.2857 |
| 2 | .0026 | 2 | .2857 | 500 | 71.4286 |
| 3 | .0038 | 3 | .4286 | 550 | 78.5714 |
| 4 | .0051 | 4 | .5714 | 600 | 85.7143 |
| 5 | .0064 | 5 | .7143 | 650 | 92.8571 |
| 6 | .0077 | 6 | .8571 | 700 | 100.0000 |
| 7 | .0089 | 7 | 1.0000 | 750 | 107.1429 |
| 8 | .0102 | 8 | 1.1429 | 800 | 114.2857 |
| 9 | .0115 | 9 | 1.2857 | 850 | 121.4286 |
| 10 | .0128 | 10 | 1.4286 | 900 | 128.5714 |
| 20 | .0255 | 20 | 2.8571 | 950 | 135.7143 |
| 30 | .0383 | 30 | 4.2857 | 1000 | 142.8571 |
| 40 | .0510 | 40 | 5.7143 | 1050 | 150.0000 |
| 50 | .0638 | 50 | 7.1429 | | |
| 60 | .0765 | 60 | 8.5714 | | |
| 70 | .0893 | 70 | 10.0000 | | |
| 80 | .1020 | 80 | 11.4286 | | |
| 90 | .1148 | 90 | 12.8571 | | |
| 100 | .1276 | 100 | 14.2857 | | |
| | | 150 | 21.4286 | | |
| | | 200 | 28.5714 | | |
| | | 250 | 35.7143 | | |
| | | 300 | 42.8571 | | |
| | | 350 | 50.0000 | | |
| | | 400 | 57.1429 | | |

American Cotton Crop Informations including Californians.

| Year | Production Thusands of 500 lbs. gross Bales. | Average Thousands of Acres. | Yield per Acre. | Remarks. |
|---|---|---|---|---|
| 1928 | 14,478 | 42,484 | 168.8 | |
| 1929 | 14,825 | 42,282 | 164.2 | |
| 1980 | 18,982 | 42,444 | 157.1 | |
| 1981 | 17,096 | 38,704 | 211.5 | |
| 1982 | 18,002 | 85,891 | 178.5 | |
| 1988 | 18,047 | 29,888 | 212.7 | |
| 1984 | 9,687 | 26,866 | 171.6 | |
| 1985 | 10,688 | 27,509 | 185.1 | |
| 1986 | 12,899 | 29,755 | 199.4 | |
| 1987 | 18,945 | 33,628 | 269.9 | |
| 1988 | 11,944 | 24,248 | 235.8 | |

OTHER COTTON CORPS.

| Year. | Indian in thousands of 400 lbs bales nett. | Egyptian in thousands of 750 lbs bales nett. | Year | Uganda in thousands of 400 lbs bales nett. | California including Arizona, New Mexico in thousands of running bales. |
|---|---|---|---|---|---|
| 1981/82 | 4,178 | 861 | 1982 | 274 | 278 |
| 1982/88 | 5,188 | 688 | 1988 | 295 | 404 |
| 1988/84 | 6,042 | 1,144 | 1984 | 286 | 462 |
| 1984/85 | 5,248 | 1,002 | 1985 | 295 | 441 |
| 1985/86 | 6,654 | 1,156 | 1986 | 821 | 741 |
| 1986/87 | 7,076 | 1,225 | 1987 | 888 | 1,205 |
| 1987/88 | 6,500 | 1,477 | 1988 | 420 | 718 |
| 1988/89 | 5,600 | 1,088 | 1989 | 808 | — |