COTTON YARN MANUFACTURE

PART 1

WINCHESTER

PUB. BY PHILA. TEXTILE SCHOOL

THE

PRINCIPLES AND PROCESSES

OF

COTTON YARN MANUFACTURE

BY

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PART I

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PREFACE

FOR a number of years there has been felt the need of a brief American treatise on the theory and practice of cotton yarn manufacture. A few excellent books have been written on the subject, notably, in German, the "Baumwoll-spinerei" of Otto Johannson, only one volume of which has thus far appeared, and in English, Taggart's "Cotton Spinning" and Nasmith's Student's "Cotton Spinning." The first of these is exceedingly exhaustive in scope, the others less so but very comprehensive. None of them is American nor is there any book on the market that satisfactorily meets the demands of the American textile school student. The subject is undoubtedly so broad that thoroughly to cover it volumes must be written. An elementary text-book, however, should not be too exhaustive, but should rather serve as a sort of skeleton to which much may be added from time to time. The little book here presented aims to supply in some measure the long-felt want. The writer has endeavored to set forth briefly the important underlying principles of yarn manufacture, together with descriptions of the machines used, treating no subject exhaustively but with ample scope for the purpose of early study. He has dealt with American machines almost entirely, and has tried to treat the subject from the point of view of American practice. While the book is primarily intended to be used as a basis for instruction and lectures at the Philadelphia Textile School, it is hoped that all students beginning the study of cotton yarn manufacture may be able to obtain some little profit from its pages.

W. E. WINCHESTER.

Philadelphia, July, 1902.

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CHAPTER I

VARIETIES AND CLASSIFICATION OF COTTONS

THE attempt to classify cotton has been difficult and not altogether successful. The botanical types are comparatively few, and cover a much broader area than the varieties as classified agriculturally and commercially. The aim here will be not to give exhaustive technical descriptions of the botanical species, but merely to mention the names of the more important varieties of the genus *Gossypium*, to which cotton belongs, and to devote most of our attention to the commercial names of the various cottons, together with the characteristics and uses of each.

Probably the most important botanical species are *Gossypium barbadense*, *G. herbaceum*, *G. arboreum* and *G. braziliense*. The adjectives used to distinguish the classes have many synonyms, and even expert opinions differ widely as to the correct classification. The promiscuous mixing of many species, which has gone on for hundreds of years, and the introduction of one species into a new territory, have only complicated the problem. The practical names in common use as applied to cottons are not difficult to master, however, and the attempt will be made to set them forth as clearly as possible, together with brief descriptions. The most common names are Sea Island, Egyptian, American, Peruvian, Indian and Brazilian.

SEA ISLAND COTTON

Sea Island cotton is by far the best cotton grown, and belongs to the *barbadense* variety. "It is a native of the islands off the coast of South Carolina, Georgia and Florida, the Lesser Antilles and probably of San Salvador, the Bahamas, Guadaloupe, Barbadoes and other islands between 12° and 26° north latitude." It is now most extensively cultivated on the mainland near the coast of South Carolina, Georgia and Florida, South Carolina producing the best. The fibre is soft, fine and silky; the diameter small, and the staple long. Its average length is about 1.7 inches, and its diameter about .000635. Hence it is adapted to the very best and finest qualities of yarn. It is commonly spun as fine as number 400, but seldom coarser than 80, except for an especially high class of work. In the manufacture of lace and sewing thread it is very extensively used. Cotton has a convolute form or natural twist, which enables the fibres to cling closely to each other after the operation of twisting. In Sea Island cotton the convolutions will be found to be particularly regular. The amount of lint, the name given to the good cotton fibre after passing through the gin, is less in Sea Island cotton than in any other variety. The yield is also comparatively small, but the market price is sufficiently high to warrant production wherever possible. While Sea Island cotton has been introduced into Peru, Brazil, Egypt and other places, its cultivation there has not been successful ; even where fairly so the cotton produced has been inferior to the genuine Sea Island.

EGYPTIAN COTTON

Egyptian cotton is classified as Brown Egyptian and as White Egyptian. There are three varieties of Brown Egyptian, namely : Mitafifi, Ashmouni and Bamia. The name given to the first Egyptian cotton introduced into Europe was Mako, or Mako Jumel, and it is known to some extent by that name even at present. The original variety has, however, experienced many changes, among others that of color, becoming brown from white. The changed variety is now known as Ashmouni, from the Valley of the Ashmouni River, where the change was first noticed.

Mitafifi is the most extensively cultivated, and really commands the market. It is of a rich dark brown color, long in staple, strong and soft. The percentage of lint is greater than in the other Egyptian varieties, 30 per cent. being about the average.

Bamia ranks next to Mitafifi in regard to extent of cultivation. It is inferior to it, however, in length of staple, strength and hardiness. It is light brown in color.

Ashmouni was, until recently, more extensively cultivated than Mitafifi, but has now fallen to third place, and the production continues to decrease. Its staple is a little over an inch in length, and its color is a light brown.

Of White Egyptian there are two varieties. One, Gallini, a kind of Sea Island, was by far the best class of Egyptian cotton. The quality deteriorated and has practically disappeared. The other, Abbasi, resembles Mitafifi in all its characteristics except color. "The lint is of a beautiful white color, fine, silky, very long, though not so strong as Mitafifi, and the first two pickings command the highest prices in the market."

All Egyptian cotton is coarser than Sea Island, having an average diameter of about .000745 inch. It has the property of giving goods in which it is used a smooth, lustrous appearance, and is capable of giving cloth a soft finish resembling silk. The average length of staple is 1⅜ inches, although this cotton contains a higher percentage of short fibre than any other kind. It is commonly mixed with the higher grades of American cotton. Number 130's yarn can be spun from Brown Egyptian. White Egyptian is seldom spun finer than 70's.

AMERICAN COTTON

Most of the cotton produced in the world comes under the head of American cotton. It controls the price in the world's markets. The broadest and most important classes of American cotton are New Orleans, Texas, Uplands and Mobile.

New Orleans cotton derives its name from the port whence it is shipped. It is raised in the low alluvial soils of the Delta country in Louisiana and Mississippi. It is the best American cotton, is white in color, soft and pliable, as well as quite strong; and the quality, owing to the careful cultivation, is very uniform. It is spun into yarn as fine as No. 60.

Uplands cotton is the most extensively raised of any variety. Its region is the highlands of Georgia, South Carolina, Alabama and parts of Arkansas and Tennessee. It is a very desirable cotton, being soft and elastic, averaging not quite one inch in length of staple, but not quite as strong as Orleans. It is used for all purposes to spin coarse and medium numbers, seldom being spun finer than No. 50. Owing to the immense production of this sort of cotton, it is the standard to which all other kinds are referred in the cotton markets of New York and Liverpool.

Texas cotton is a good variety, having a staple of an inch average length. It is not as strong as Orleans, nor has it such a clear color, being tinged with brown. The diameter is about .000758 inch, practically the same as Orleans. It can be spun as fine as 60's with good success.

Mobile cotton, raised in Alabama, is the least desirable American variety. Its length is about 7/8 inch; it is spun as fine as 40's or 45's, but for finer numbers does not give good results.

There is an infinite number of agricultural varieties, which, of course, come under the four broad classes just outlined. Most of their names refer to the discoverer of the class of cotton or the producer. Some special varieties are carefully cultivated, and are widely known by special names. Of these Peeler cotton is probably one of the most widely cultivated. It is a soft, white cotton, with a very strong and silky staple, averaging 1 1/8 inches in length. The fibre is fine, and lends itself admirably to the process of combing. It is used widely to make hosiery yarn. It is spun as fine as 70's, seldom finer.

Allen seed is another special variety, being grown most in the low moist regions of Mississippi. The fibre is long, fine and silky, averaging over $1\frac{3}{16}$ inches in length.

Another variety, Cook, much resembles Allen, and is raised on low, moist ground. All the long staple varieties are grown with most success on the low, moist lands, the shorter staples in the uplands, and almost entirely north of 32° latitude. In short staples the percentage of lint exceeds that in the long staple. Some short staples have 34 per cent. of lint, while nearly all the long and medium staples produce less than 30 per cent. of lint.

PERUVIAN COTTON

There are three classes of cotton grown in Peru: Sea Island, Rough and Smooth Peruvian. The Sea Island grown there is of a fairly good quality, but small in quantity.

The rough Peruvian, known as *Gossypium barbademe Peruvianum*, is a rough, harsh, hairy cotton. Its length of staple is about $1\frac{1}{4}$ inches. It is used largely in the United States to mix with wool. It gives a better lustre and finish to goods, prevents shrinking when mixed with wool, and is consequently much used in the manufacture of hosiery. It is not spun to fine numbers. When used alone it can be spun to 70's.

Smooth Peruvian differs from Rough mainly in the respect implied in the name. When a fine quality of yarn is desired, it is often mixed with American.

INDIAN COTTON

Next to the United States, India produces the greatest amount of cotton. Its product is used entirely in India, the East and Great Britain. There are several varieties, of which Hingunghat is the best. Broach cotton is a good cotton, about 7/8 inch in length of staple. It, of course, cannot be spun to fine numbers.

Dharwar and Oomra cottons have a length of .8 and .9 inches, respectively, scarcely as good as Broach. Dhollera cotton is the most widely known Indian cotton. It resembles Dharwar, but is $\frac{15}{16}$ inch in length.

BRAZILIAN COTTON

In Brazil, *G. Peruvianum* is grown, as well as other varieties, of which Pernambuco is the best. It has very regular convolutions, is $1\frac{1}{4}$ inches in length, and rather harsh. Ceara cotton resembles Pernambuco in most respects, except color, being a dull white, while Pernambuco is a light gold. Maranhams, the other principal variety, is not as good as Pernambuco, and is 1/4 of an inch shorter. All these cottons are exported to Europe, mainly to England.

Cotton is also raised in Russia, China, Japan, Korea, the East and West Indies, Mexico, The Levant and the South Sea Islands, as well as some parts of Africa, outside of Egypt. In all of these places the product is locally consumed.

CHAPTER II

COTTON GINNING AND BALING

After cotton has been picked, its first mechanical treatment is received from a machine known as a cotton gin. The function of this machine is to remove from the good cotton all the seeds. There are two types of cotton gin, the roller gin and the saw gin. The roller gin is constructed on a very old principle, in use for hundreds of years. The

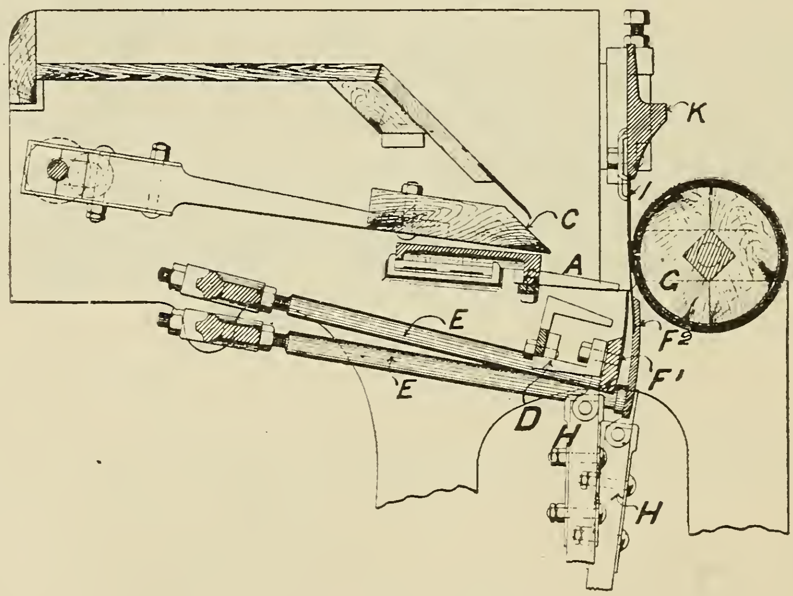


Fig. 1.

saw gin is the well-known invention of Eli Whitney. While these machines are used in the vicinity of cotton fields, and in no case within cotton mills, nevertheless a brief description of them at this point may not be out of place, since many of the impurities found in cotton when received at a mill are due to faulty ginning.

From very early time the roller gin in some form has been used in India. In its simplest shape it consisted of a flat stone and wooden roller. The seed cotton was placed on the stone, and the wooden roller, moved by the foot, was employed to press the seeds out. Of course the roller gin has been vastly improved, but it is doubtful if the quality of the product surpasses that of the old Hindoos. The modern type of roller gin, as made by Platt Bros. & Co., is shown in Fig. 1. The cotton is fed on a feed table to a leather roller G. A feeder bar C is given a horizontal reciprocating motion by means of a crank, and thus

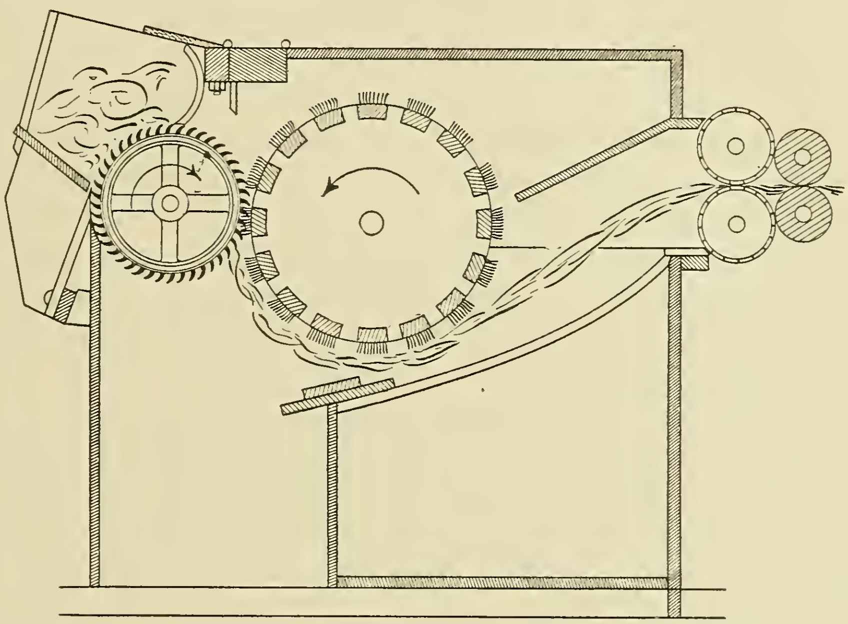


FIG. 2.

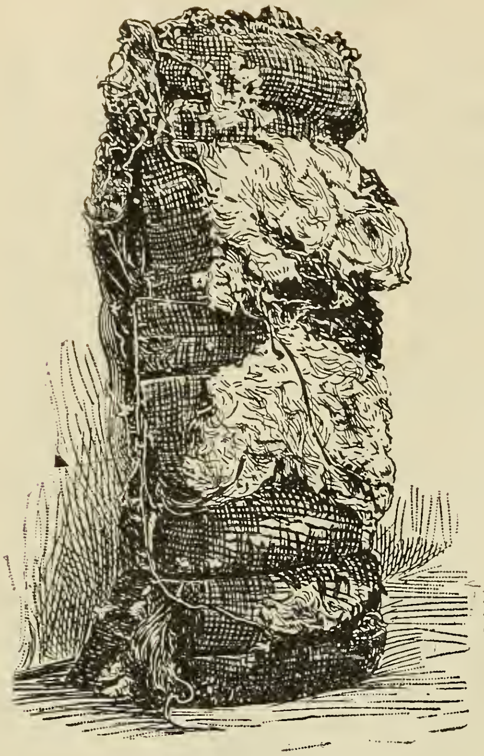
moves new seed cotton up to the leather roller G at each of its forward motions. The leather roller has a rough surface, and readily catches the cotton, carrying it forward. Very near the leather roller is placed a thin steel plate, I, known as the "doctor knife." This plate ordinarily occupies a vertical position, and is tangent to the leather roller's circumference. It is capable of being adjusted, and is set near enough to the leather roller to prevent the forward passage of seeds. The leather roller makes about 150 revolutions per minute. This speed would naturally tend to pull some of the fibres away from the seeds which are detained by the doctor knife. The fibres, however, cling very tenaciously, and further means is provided for liberating them. Two beater blades, F^1 and and F^2, placed directly behind the doctor knife, are given a rapid vertical reciprocating motion. Their upper ends are blunt, and by continually beating against the seeds, they separate them from the fibres, which pass on unhindered. The seeds fall to the floor, through the grids A, in the bottom of the feed table. The lint cotton is stripped from the leather roller by a stripping board, and falls to the floor in a continuous sheet.

The plan of the saw gin is distinctly different. A view of one is shown in Fig. 2. The seed cotton is placed in a hopper, one side of which is made of bars or grids. Through the spaces between these, thin steel discs with notched peripheries, resembling circular saws, protrude. Very little space is left between the bars and the saws. By the rapid revolution of the saws, the cotton is grasped, and forcibly separated from the seeds, which cannot pass through the spaces. The seeds fall through grids at the bottom of the hopper. The lint cotton is stripped from the saws by a cylindrical brush. The centrifugal force is so great that the light lint is blown from 20 to 60 feet from the gin. A mechanical draft is sometimes established, so that the cotton is conveyed to revolving cages, where it is condensed into a continuous sheet. The gin shown is provided with these condensing cages.

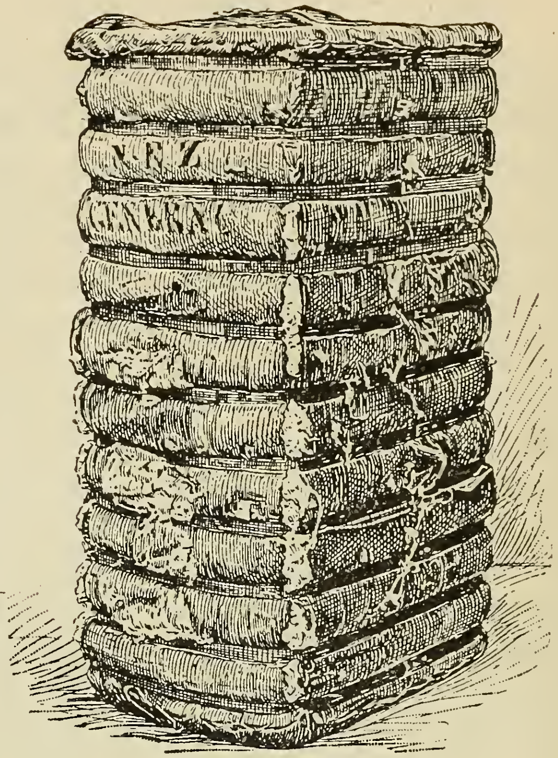
There has been, and is, much discussion in regard to the relative merits of the two classes of cotton gin. The defects of both are, however, much the same. Neither succeeds in removing all the leaf, dirt, and immature seeds, known as motes. Both types form "neps," which is the name given to tightly rolled balls of fibre. Saw ginned cotton is probably more free from trash and dirt than that which is roller ginned. The saw gin is also better adapted to cotton in which the lint clings most tightly to the seeds, roller ginning being successfully used only where cotton has naked seeds. On common Uplands cotton seeds, the down causes them to adhere to each other, and hence the saw treatment is necessary. The saw gin, through its rough, forcible action, does in certain cases, especially if speeded too high, injure the fibres. This is naturally more applicable to the longer staples. Sea Island and the other better classes are worked on a roller gin.

After cotton has been freed of seeds, the lint is made into bales. The standard size of an American bale is 54 x 27 inches and is supposed to contain 500 pounds. There is, however, a very wide range of variation in length, width, thickness and density. They are tightly compressed by a sudden pressure of a mighty compress. The mass of cotton which was 27 inches high, is pressed into a space of 7 or 8 inches. Later when the pressure is removed, it expands. The density of American bales is never higher than 35 pounds per cubic foot, and often runs as low as 25 pounds. The bales are covered with loose, easily torn, jute bagging, and are bound by six iron hoops. The bales are by no means fitted to withstand the rough handling which they receive. As a result they are often in a very bad condition when received at mills at a great distance from where they are made. It is generally admitted that "the American bale is the clumsiest, dirtiest, most expensive and most wasteful package in which cotton, or, in fact, any commodity of like value, is anywhere put up." To overcome its bad feature, cylindrical bales of two types have been invented. In one the sheet of cotton delivered by the condenser of a cotton gin is fed between two heavy, powerful condensing rolls. These press nearly all the air out of the cotton, giving it a density of more than 35 pounds to the cubic foot, as well as making the bale of a uniform size. The cotton is wound on a spool and can be conveniently unrolled at the mill. The bale is covered with cotton cloth with no metal ties. It can be as conveniently sampled as the ordinary bale; it cannot burn, and is in very many respects much superior. In the second type the strand of cotton is coiled up and submitted to a powerful endwise pressure.

All other kinds of cotton than American, except some Brazilian, are much more satisfactorily baled. Egyptian bales are heavier than American bales, having an average weight of over 700 pounds. They are about 50 inches long, 31 inches wide, and 31 inches thick. The covering of these bales, like that from all countries except the United States, is a strong, light canvas. About 11 ties are used. Indian bales are a little smaller than American bales, and are more densely packed. Their average weight is a little less than 400 pounds. About 13 ties are used.

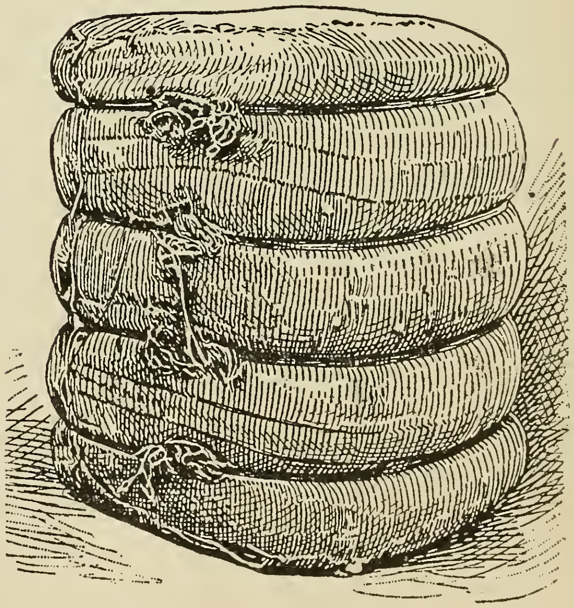


American bale.



Egyptian bale.

Indian bale.



Turkish bale.

Fig. 3.

CHAPTER III

PREPARATORY PROCESSES AND MACHINES

BALE BREAKING.

In whatever form of bale cotton is received at a mill, there is the necessity of tearing apart a very tightly compressed mass. The bales are usually stored in a house very near the portion of the mill where they are to receive their first treatment. In this part of the mill the bagging and hoops are removed from the bales. There are two methods employed in tearing the bales apart, one by hand, the other by machine. In either case, however, there must be considerable handling. In one case the cotton is pulled out and scattered through bins provided for it, being given some mixing by the intermingling of cotton from different bales. In the other case, a machine called a bale breaker is used. In this country the hand process is very largely adopted, and it is undoubtedly very satisfactory, especially where loosely baled American cotton is used. There are obviously many advantages to be gained from the employment of bale breakers and their accompanying mixing appliances. The more tightly compact the bale, the greater must these appear.

The bale breaker is an exceedingly simple machine. A sectional view is shown in Fig. 4. It consists essentially of four sets of rollers and a feeding arrangement. Large hunks of cotton torn from the bale by hand are thrown upon a moving lattice apron. The cotton is thereby carried along to the back set of rollers. These are placed one above the other, and made to revolve at a fixed speed. The rollers have long blunt teeth, suited to penetrate the cotton and to aid later in the pulling apart. The rollers are made up of narrow discs fitted upon a shaft, so that any breakages can be readily repaired. After passing through the first set of rollers, the cotton is acted upon by the second set. Of these the lower is fluted lengthwise, while the upper resembles the back rollers. As they revolve at a greater speed than the first set, the lumps of cotton will at this point receive some pulling apart. The third set of rollers is similarly constructed, while the fourth set, or front rolls, are both longitudinally fluted. The speed of each succeeding set is accelerated, so that the surface covered by the front rolls is about 30 times that covered by the back. The effect upon the cotton must then be a loosening up to a very large extent of the compact mass. All the top rolls are held in contact with

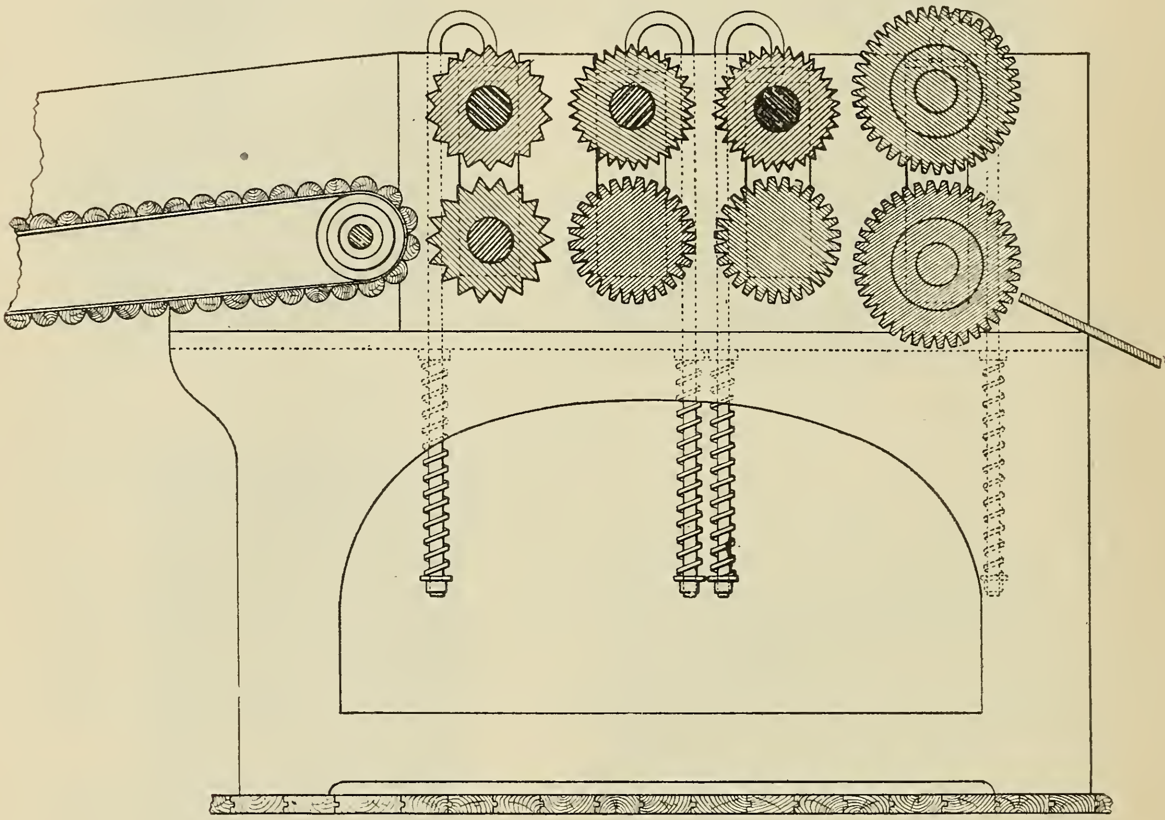


Fig. 4.

the bottom ones by strong springs ; yet these are sufficiently sensitive to contract upon the passage through of any hard large foreign substance, of which cotton bales are not always free. Some bale breakers have two or three, instead of four sets of rolls, and others have a beater attachment similar to beaters used in the machines soon to be described. The production of all types is large, 70,000 or, 80,000 pounds being a possible output for a week.

The great value of bale breakers lies in the uniformity of the breaking up of the cotton, and the speed and facility with which the work can be done. Attached to bale breakers are oftentimes distributing or mixing lattices. The cotton falls from the front rolls of the breaker on a moving lattice apron. It is then carried to an inclined double lattice, which conveys it up to other horizontal lattices by which it can be carried to any part of the room desired and dropped into its proper bin. A view of these mixing devices is shown in Fig. 5, and will be easily understood.

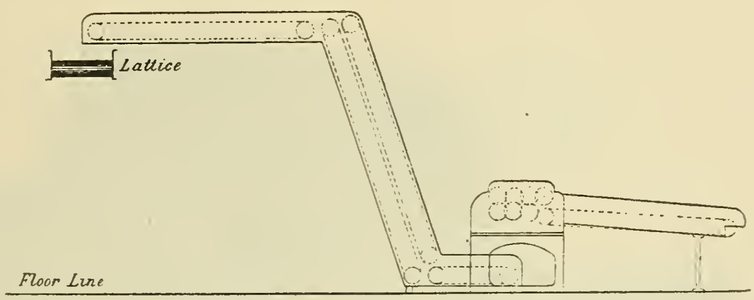


FIG. 5.

OPENERS.

The cotton has now arrived at the stage where it is to be fed to the first of the machines, known in colloquial cotton-mill parlance as "pickers." These machines, also known as the opener, breaker lapper, intermediate lapper and finisher lapper, together with bale breakers, are placed in a room or rooms separated by fire walls from the cotton mill proper. The construction of the machines is conducive to fires, and cotton in a loose state burns most easily. It is quite common in modern mills to use a separate building for the pickers. This would be known as the "picker house," while in other cases "picker room" answers for a name. One, two or three floors are variously used for the machines in question; but a discussion and views of different arrangements may more suitably follow a description of the processes and the machines. The first machine in the list is called an opener. Its function is described in general terms by its very name. The object of the opening of the cotton is to remove dirt, seed and foreign substances, all of which exist in abundance even after ginning. A view in perspective of an opener is given in Fig. 6, and a sectional view of one manufactured by the Kitson Machine Co. in Fig.

7. All openers are at present provided with a hopper feed. The hoppers are made large; most of them will hold nearly a bale of cotton. The shape is well shown in the drawing. In the sectional view of an opener fitted with an automatic hopper feed, A represents the hopper into which the cotton is thrown by hand. To insure the carrying into the machine of an uniform amount of cotton, it is advisable always to keep the cotton in the hopper at nearly the same height. The regularity of feeding is rather an important point to be emphasized from the very beginning. Various mechanical arrangements are applied to machines to

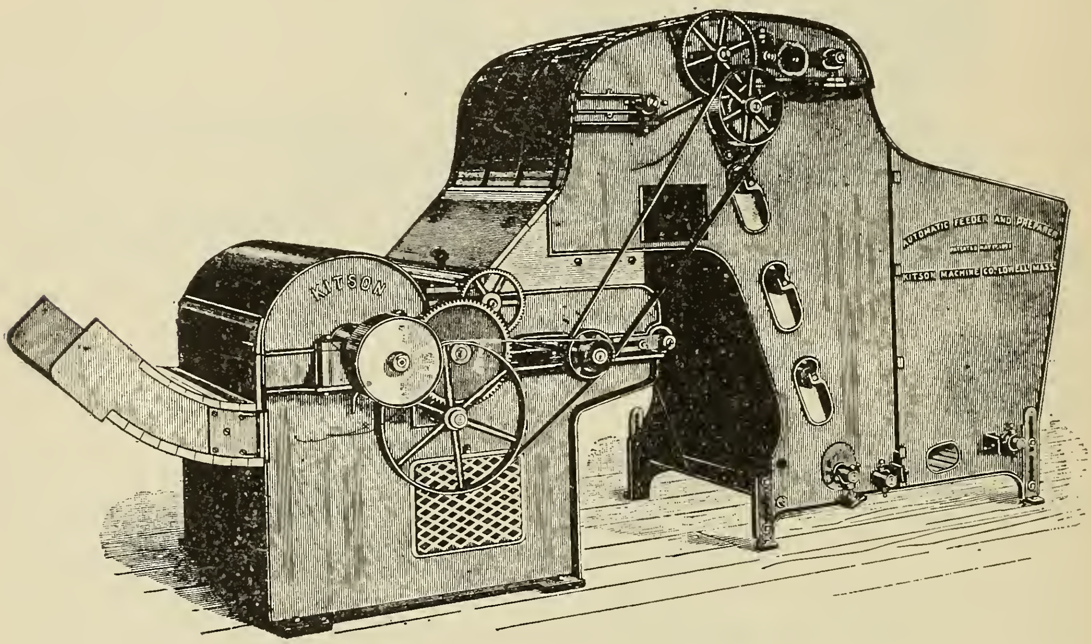


Fig. 6.

facilitate this, but much depends upon the carefulness of the machine tender. At the bottom of the hopper is a moving lattice apron B. This consists of thin wooden slats attached to strips of canvas. The lattice is endless, and runs around the rollers *a*, *b* in the direction shown by the arrow. The cotton is by it moved forward to another lattice whose slats are fitted with short spikes. This lifting lattice carries the cotton to the top of the machine. At the top of the hopper, a short distance from the lifting lattice, is an endless leather apron D, which receives its motion as shown from the rollers d^1 and d^2 around which it is stretched. One of the rollers, d^1, is a pin roller, having about six rows of pins in its periphery. The pins are allowed to pass through slots in the leather apron D. Their function is to prevent the onward passage of large lumps of cotton, enabling the amount fed with the machine to be made somewhat uniform. The lumps which engage with these pins will receive some little pulling apart, and will be forced back into the hopper. The function of the leather apron is to strip the cotton from the pins. As the roller d^1 revolves, the pins recede within the apron ; the cotton cannot pass through the small holes, through which the pins recede, and must fall back into the hopper. In some cases the space between the two aprons

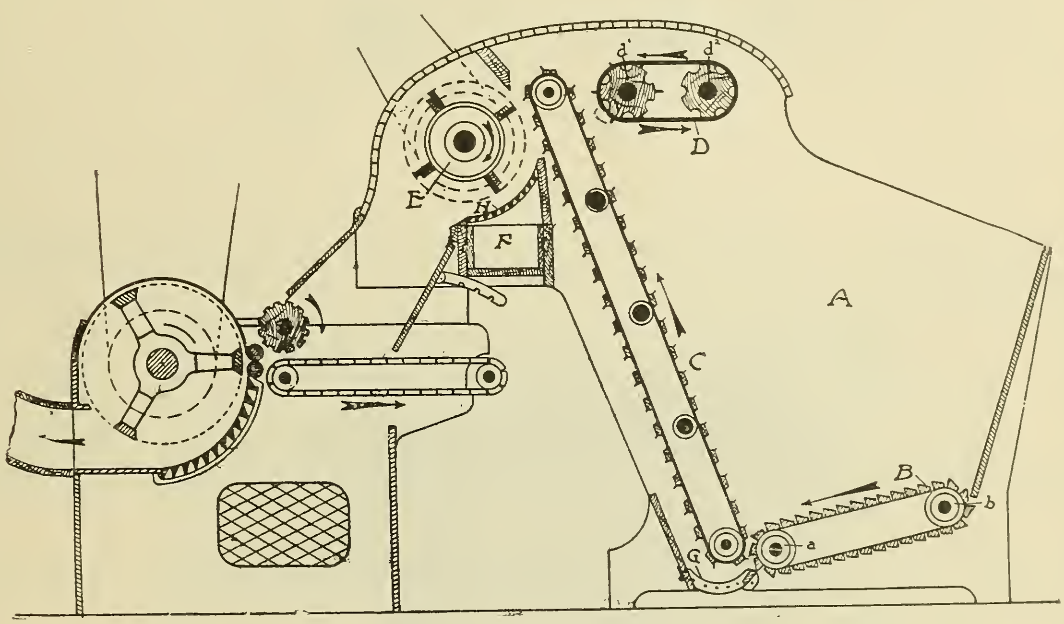


FIG. 7.

can be changed by moving the position of the rolls d^1 and d^2. On some makes of machines there is an arrangement for changing the speed of the lifting lattice; in this manner regulation of the feeding is obtained. The leather apron and pin roller are not the only types of apparatus adopted for regulating the feed. All devices have the same function, however, and work in a much similar manner. The one explained is as simple as any, and performs the work as well.

The cotton which has been allowed to pass the pin roller is carried around by the lifting lattice until it comes within the action of a doffer E. As its name implies, the duty of E is to remove all the cotton from the lattice. The doffer is a cylindrical drum, having straps carrying strips of leather extending lengthwise of its surface. This revolves at a high speed, about 800 revolutions per minute, pulls the cotton away from the lattice, and beats it against grid bars H. Through the spaces, heavy impurities, seeds, dirt, etc., will fall into a receptacle F. The throwing of the cotton against the grids, as well as the high speed at which the

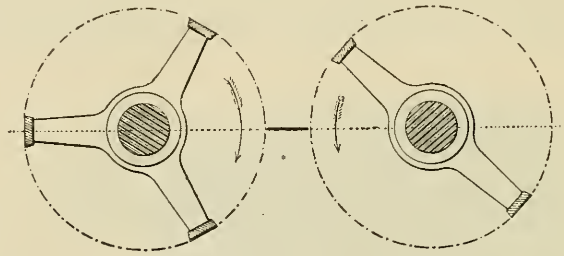


Fig. 8.

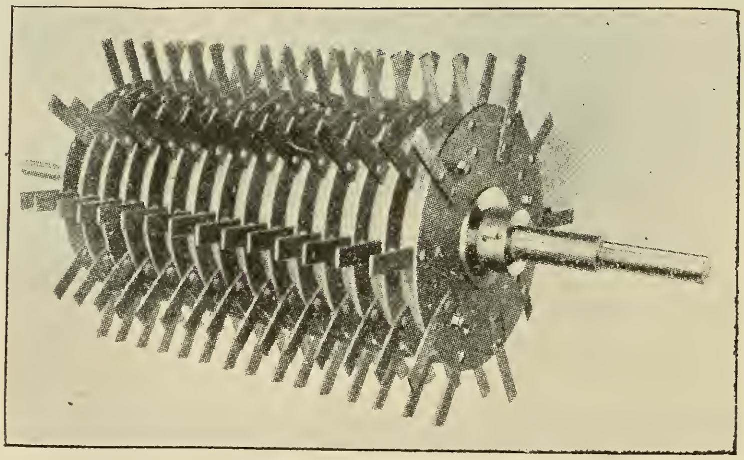


Fig. 9.

doffer beats the cotton from the lattice, tend to open the cotton sufficiently to free much of the useless dirt. Besides the grid bars H, there are at the bottom of the lifting lattice grids G, through which the impurities may fall. After leaving the action of the doffer, the cotton falls down an inclined metal plate upon a feeding lattice I. This lattice moves continually forward, carrying the cotton first beneath a corrugated wooden pressing roller, whose duty is to compress the cotton into a semblance of sheet, and next between two fluted feed rolls. These rolls, similarly to all feed rolls, are longitudinally fluted so as the better to grip the cotton, and to hold it firmly while feeding to the next organ, whatever that organ may be. In the machine under discussion the cotton is by means of the feed rolls mentioned, fed to a beater. The type of beater may vary, but the duty is the same, namely: to beat the cotton away from the feed roll in small lumps, and to throw it forcibly against grid bars. A style of beater commonly used consists of three arms cast upon a shaft. There are commonly four sets of these arms upon a shaft, which stretches the width of the machine. Flat blades at their extremities extend from one set of arms to the next. A large beater, of a different style entirely, as shown in Fig. 9, is quite commonly used in openers.

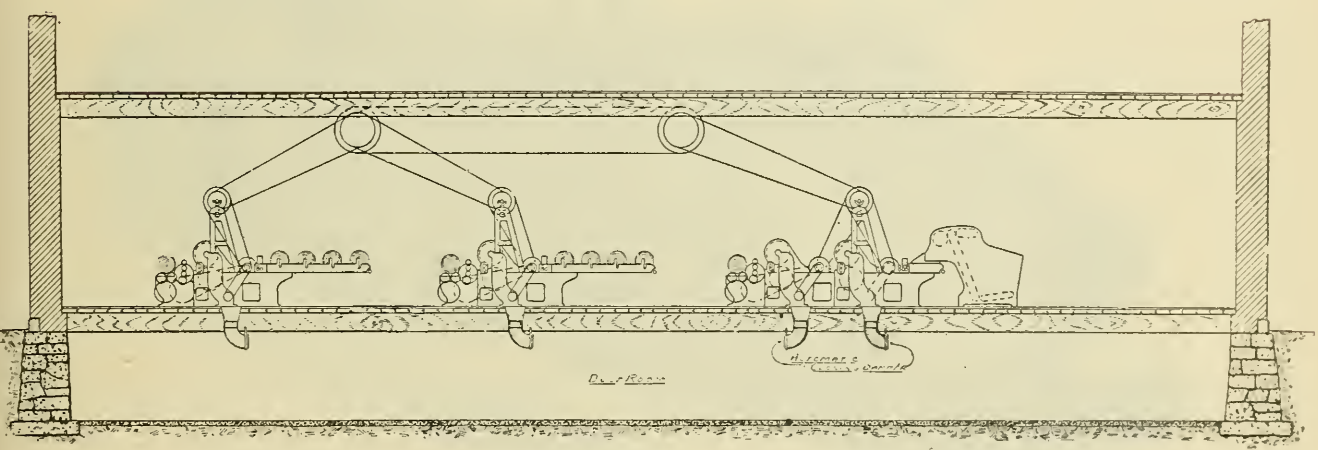


FIG. 12.

BREAKER LAPPERS.

The next machine in use is called a "breaker lapper," or a "breaker picker." It has two functions, one to open the cotton still further for the purpose of cleaning, and the other to deliver the cotton in a cylindrical roll called a "lap." There is always an intimate connection between the opener and the breaker lapper. Two general arrangements are in vogue for connecting the opener and breaker lapper ; first, the two may be on the same floor and mechanically connected so as to appear as one machine; second, the opener may be on one floor, the breaker lapper on another, and the two connected by what is called a dust trunk (or cleaning trunk). The first arrangement will receive attention at the beginning owing to its simplicity. Fig. 10 shows a machine constructed in this manner, all in front of the line *a* representing the lapper, and that behind it the opener with an automatic feeder. Partially opened cotton is carried from the beater of the opener by what we call suction, and drawn upon two cylinders known as "dust cages." They are large hollow cylinders having a surface of wire screening. They are arranged one above

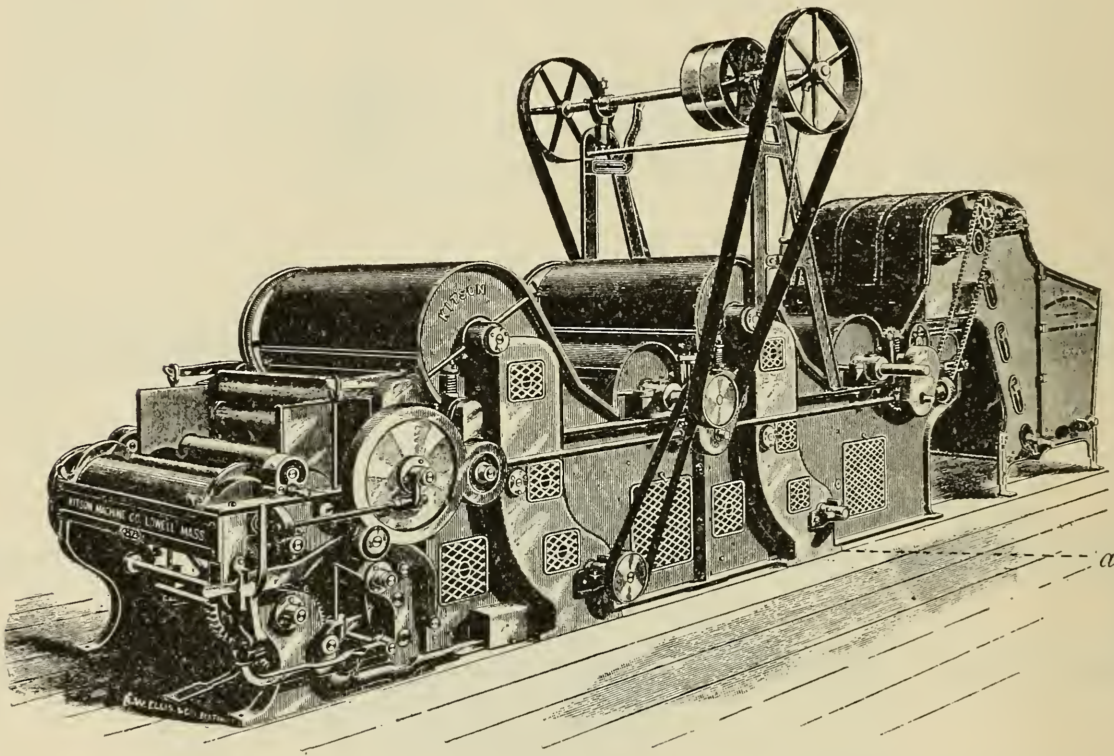


FIG. 10.

the other, and the cotton passes between them. Reference to Fig. 11 will help to make the description clear. In this figure is shown a section of a lapper through the dust cages. The shafts which support the cages are shown at *a* and B. Fitted on these shafts are the sleeves *s* and s^1. On the sleeves *s* and s^1 are the gears R and R^1 by which, through suitable driving mechanism, the sleeves are made to revolve loosely on the shafts *a* and B. The cages are firmly attached to the sleeves by five armed spiders seen in Fig. 27; they consequently revolve loosely around the shafts *a* and B. The ends of the cages open into chambers separated from the rest of the machine. The depth of these chambers is readily seen in Fig. 11, and their width and appearance outside of the machine in Fig. 10. These chambers are called dust flues. Inside the flues in the middle of the machine is placed a fan F, 18 or 20 inches in diameter. It revolves at a speed of about 1,200 revolutions a minute, and as it is

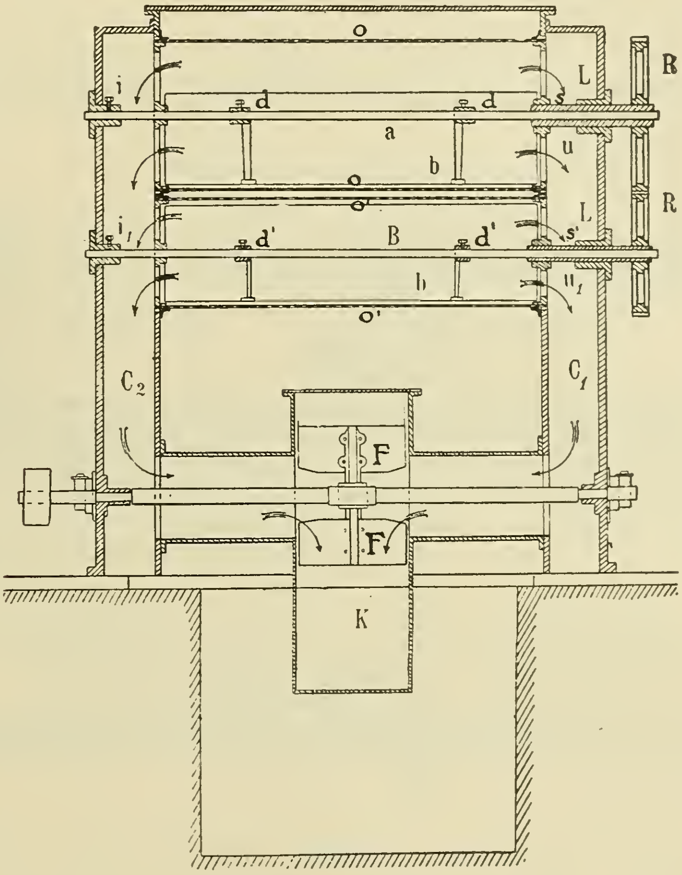


FIG. 11.

situated directly over the junction of the two flues from the machine, which unite at K, and are connected with a dust room, which in turn opens into the outside air, its rapid revolution exhausts the air from the wire cylinders. The cotton being in a light and fluffy condition is easily carried on to the cylinders by the atmospheric pressure behind, or as we commonly say, by suction. The holes in the screen covering are too small to allow cotton fibre to pass through, yet the strong draught induced by the fan pulls light dust through. This takes the course shown by the arrow, finally reaching the dust room. Attached to the shafts *a* B at *d* and *d* [1] are dampers, by adjusting which some of the surface of the dust cages may be covered, and the draft at any point regulated.

At present there appears to be a preference for the second arrangement mentioned, namely: the connecting of the two machines by means

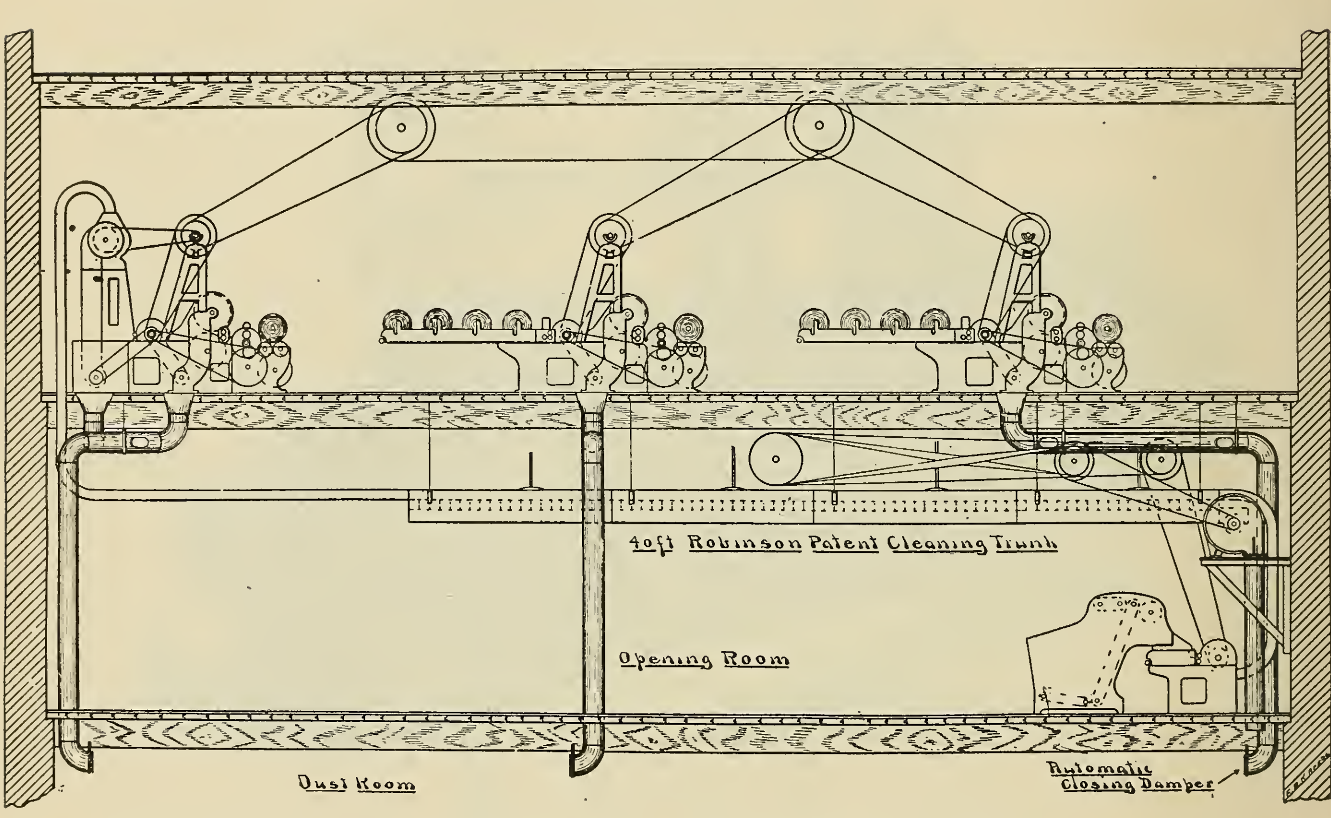


Fig. 13.

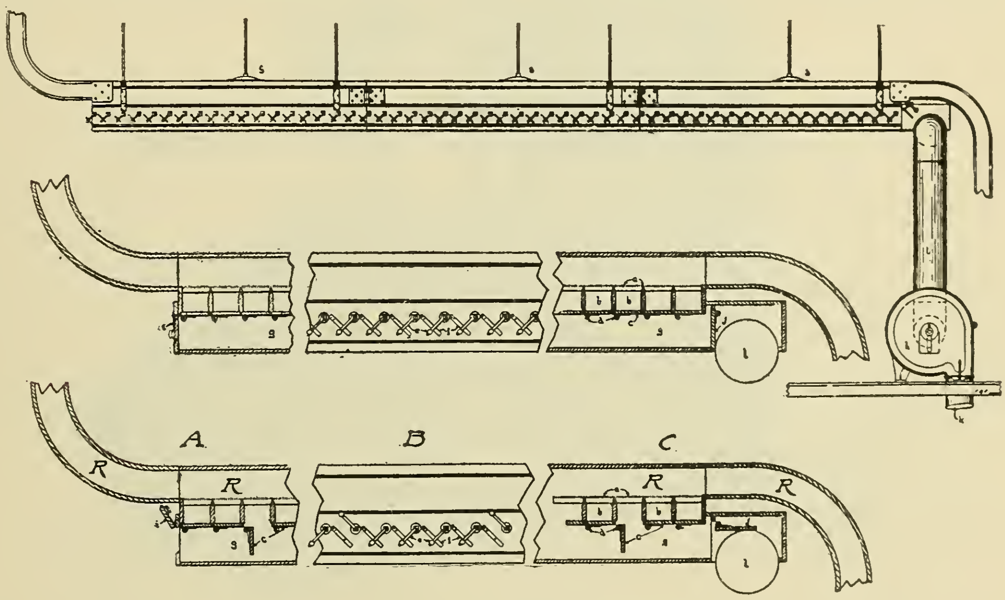
of a dust trunk, the opener being at a considerable distance from the breaker lapper. The trunk is thought to give greatly added cleaning power. A view showing the opener on one floor and the breaker lapper on another is shown at Fig. 13, in which the long wooden cleaning trunk can readily be seen. Detached views of the trunk are shown in Figs. 14, 15, 16, 17.

Fig. 17 shows clearly a sectional view. There are three compartments to the trunk shown. Through the upper passage *a*, the light cotton slowly passes, being drawn on by the induced air draught in the breaker lapper. The bottom of the passage consists of grid bars through which dirt may fall into the pockets *b*. The bottoms of these are hinged at *d*, so that they may be let down when it is desired to remove the dirt. The bottoms *d* are held in position by springs *f*, on the outside of the trunk, which press against short levers *e*, attached to the hinges *d*. Beneath the pockets is a passage *g* connected with a fan. This fan can be seen at *h*, in Fig. 15. It is over a dust flue connected with the dust room. At the ends of the passage *g* are the doors, *i* and *j*, Fig. 15, by

FIG. 14.

FIG. 15.

FIG. 16.



which it may be tightly closed. When it is desired to remove the dirt from the pockets *d*, the exhaust fan *h* is first started. The doors *i* and *j* are then both opened so that a strong draught of air is induced through the passage *g*. By releasing the springs *f*, the bottom of the pockets may be opened when they would assume the position shown at Fig. 16, sections A and C in section B in Fig. 16, showing the outside of trunk. The strong air draught in the passage *g* carries the dust out into the dust room. Any number of pockets may be cleaned at the same time, the fan being adapted to the cleaning of all of them at once. At *s* is shown an automatic sprinkler, which is now quite universally applied to cleaning trunks, and which proves to be very effective in extinguishing the many fires which are likely to occur therein.

The breaker lapper which is very commonly used in America with the arrangement now under discussion can be seen in Fig. 18 and a sectional view thereof in Fig. 19. Referring to Fig. 19, a description of the working of the machine may be given. The only difference between it and any other breaker lapper is the manner in which the cotton is received from the opener, and the feeding device with which it is fitted. The trunk through which the cotton comes from the opener is seen at T. It leads to the top of the machine as shown, where the cotton is drawn upon a single dust cage *a*. This dust cage is exactly like those previously

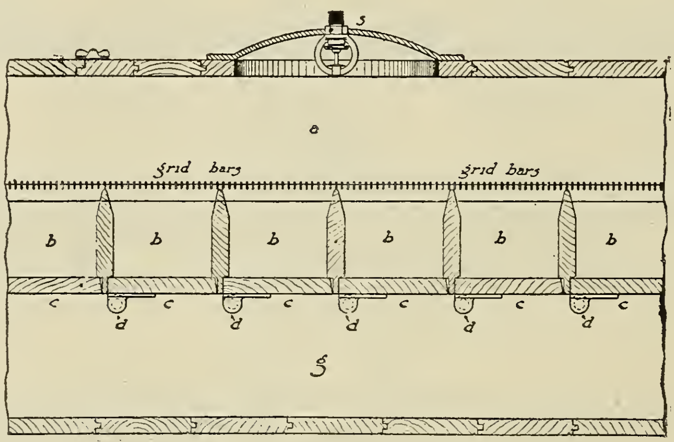


FIG. 17.

described. Only one is used here, however. The air current through it is induced by the fan *f*, the flue which communicates with the ends of the cage being shown in dotted lines. The cage revolves in the direction indicated by the arrow, carrying the cotton between itself and a wooden roll *b*. *b* is held against *a* by the lever and weight shown in dotted lines. The cotton then passes between *b* and *c*, being easily stripped from the cage, owing to the position of the damper *d* which prevents the current of air from exerting influence upon the part of the cage behind the rollers. The cotton then drops down into what is called a "gauge box." An adjustable back is provided for this, so that the amount held by the box may be regulated, any surplus falling over the top and on to the shelf *s*. The object of the gauge box is to keep the amount fed to the lapper uniform. When the lapper is stopped, considerable cotton is passing between the opener and the lapper. On restarting the breaker, if there were no regulation of the feed, an extra large amount of cotton would be fed, followed by a small amount. By keeping the gauge box full of cotton, the amount fed to the machine will always be uniform, or practically so.

At the bottom of the gauge box is an endless lattice apron, whose

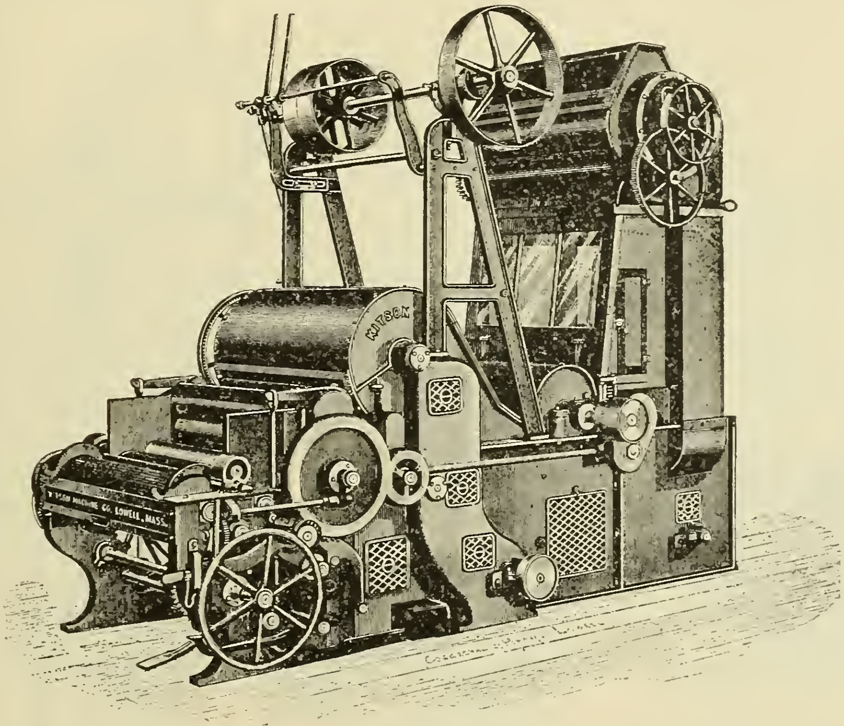


FIG. 18.

duty is to carry the cotton along to the feed rollers, which feed it to the beater K. Grids *g* beneath the beater allow dirt to fall out on the floor beneath. The good cotton is drawn on over the grids *j* to a pair of dust cages LM. These are similar to the first ones described, and have the duty, first, of condensing the cotton into a sheet; second, of evening it slightly; and third, of allowing light dust to be drawn through themselves into the dust flues and to the dust room.

Directly in front of the dust cages are two small stripping rolls *q*, similar to feed rolls. Their duty is to strip the cotton from the cages and to compress it a little. This work of stripping is aided by dampers at the ends of the dust cages. These confine the action of the air draught to the back of the cages. After leaving the stripping rolls, the cotton, now in a continuous but thick sheet, passes along a plate and then between two heavy calender rolls, around the front of the lower one, between it and a

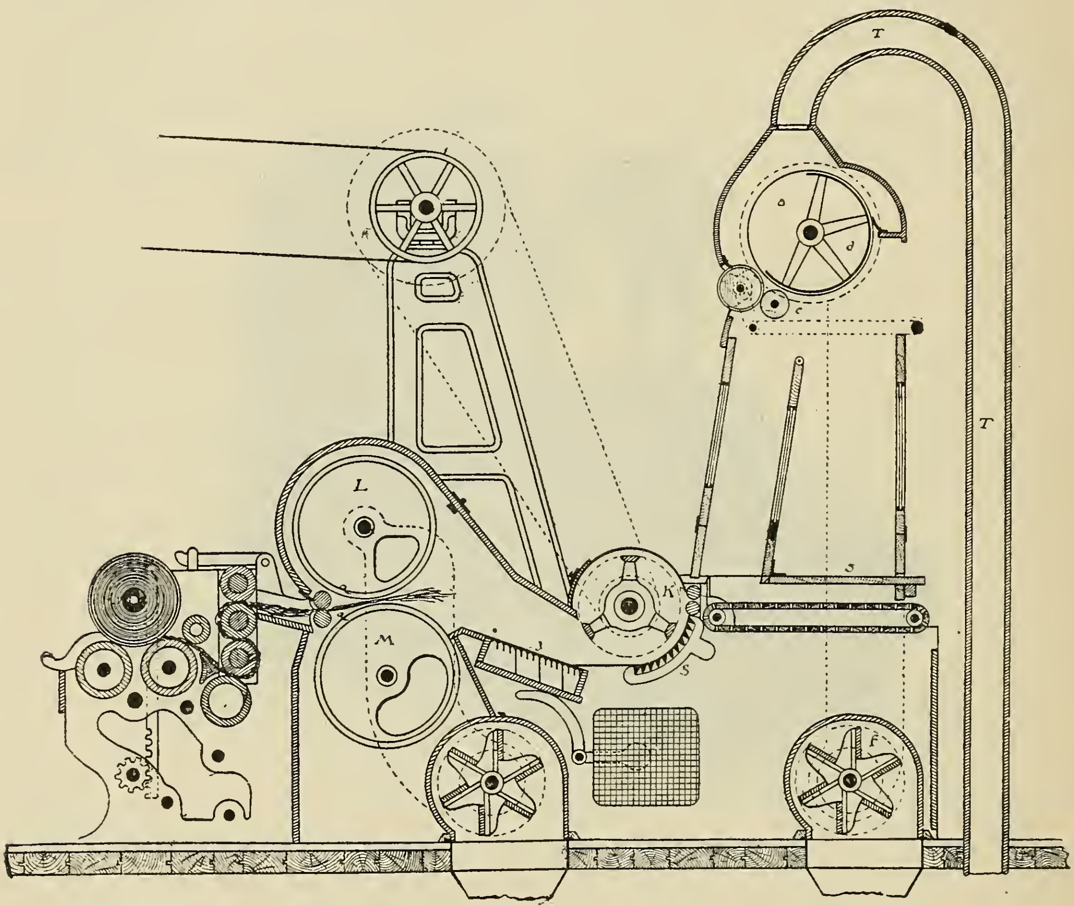


FIG. 19.

third, around the back of the third, and between it and a fourth. The course of the cotton is clearly shown in the drawing. By this time the sheet is quite thin. It is then carried over a large fluted roll to a second similar one. Between these two, on the top of the sheet of cotton, an iron rod is placed. About this the cotton is trained, and the revolution of the large fluted rolls keeps the mass in motion and rolls it up. In order to make the lap tightly compressed so that much may be put into little space, a weighing device is applied which will soon be described. The calender rolls, heavy of themselves, and additionally weighted by levers and weights, make the sheet of cotton quite thin; but the elasticity of the cotton would make the lap expand unless it were formed under pressure. Figs. 20 and 21 show the lap-forming mechanism at the front of the machine.

The sheet of cotton can be seen passing between the two lowest calender rolls, and its course is indicated from that point to the lap by dotted

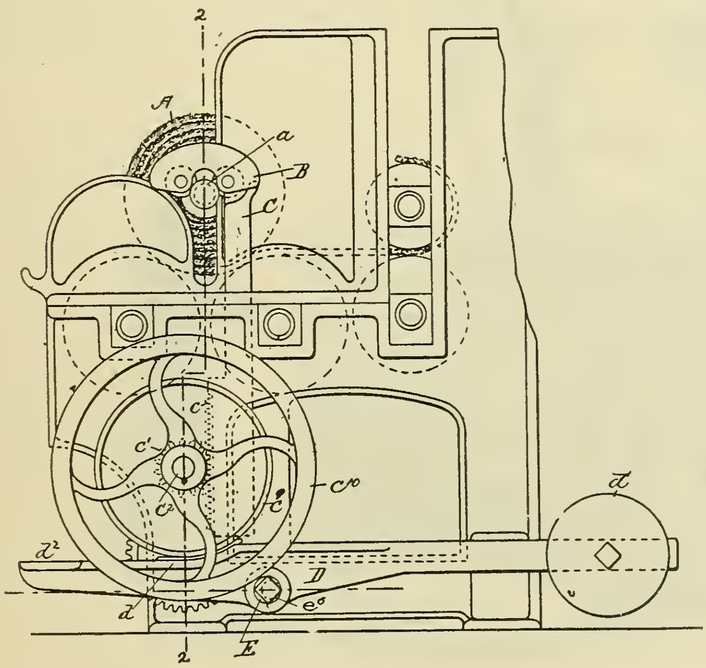


Fig. 20.

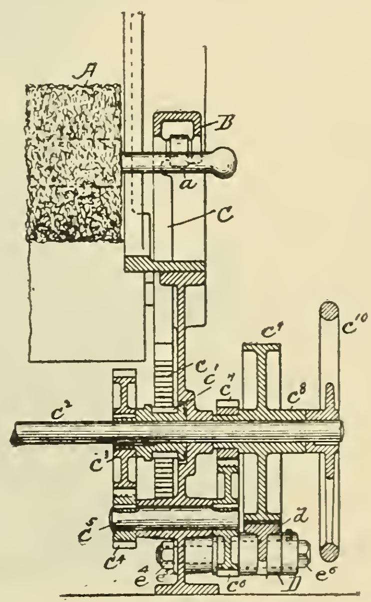


Fig. 21.

lines. The lap nearly formed is shown at A. Protruding from the end of the lap is the lap rod *a*, around which the sheet of cotton is being wound by the revolution of the two large fluted rolls on which it rests. On each end of the lap rod, one end only being shown here, rest two rollers B, attached to C. C has on its inner side a rack *c* gearing with a pinion c^1 on the shaft c^2. By a train of spur gearing, concealed from view, in Fig. 20, by the side of the machine, but shown in section in Fig. 21, the pinion c^1 is connected with a tension wheel c^9, running loosely around the same shaft c^2. Resting against the wheel c^9 is a brake shoe *d*, formed on the lever D, on one end of which is the overbalancing weight d^1 and at the other end is formed a treadle d^2. As the lap increases in size, the lap rod presses against the hangers B, and the sliding rack bars C are raised. The train of gearing is set in motion, the amount which it may move depending upon the tension exerted upon the tension wheel by the brake-shoe on the weighted lever D. In the device shown there is a patented arrangement by which the tension can easily be varied by shifting the

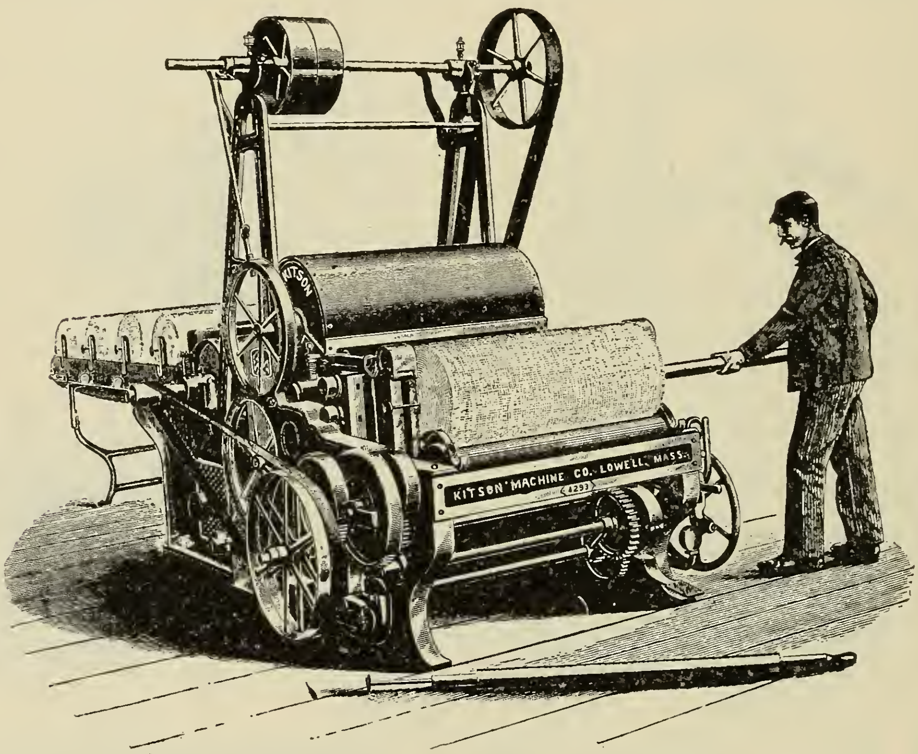


Fig. 22.

position of the fulcrum of the weighted lever D. When the lap is to be removed, the treadle d^2 is pressed down by the foot, and the pressure on the tension wheel c^9 is removed. Then by means of the hand wheel c^{10}, which is fastened to the shaft c^2 the sliding racks C can be raised, thus freeing the lap rod. The rod is then pulled out of the lap, and the lap is removed. When the lap rod for a new lap has been replaced and the sheet of cotton formed around it, the hangers B are again pressed down upon it, and the weighted lever again allowed to exert its power. The arrangement shown is the one adopted by the Pettee Machine Works, but is in its essential features a typical lap-forming device. The same means for making a lap is applied to the intermediate and finisher lappers, so a description of one suffices for all.

INTERMEDIATE AND FINISHER LAPPERS

The laps formed on the breaker lapper are fed to the intermediate. The functions of the intermediate lapper are three; first, to clean the cotton still more; second, to form a lap; and third, to make this lap more uniform in weight, if possible, than the ones formed on the breaker. The

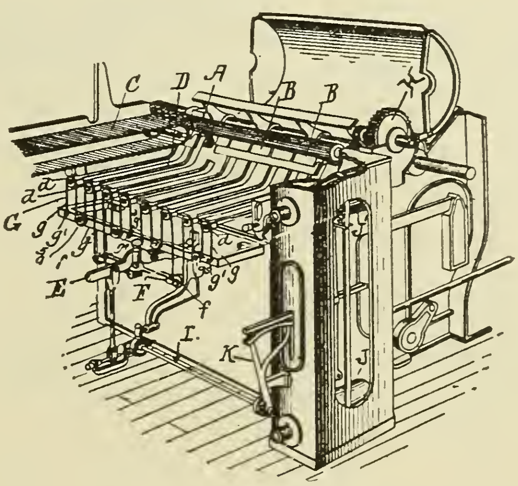


FIG. 23.

first two functions are performed as on a breaker lapper; the chief differ ences between the breaker and the intermediate lapper are in the manner of feeding, and in the additional evening device with which the intermediate lapper is fitted.

Fig. 22 is a view in perspective of an intermediate lapper made by the Kitson Machine Co. It is a typical lapper, the English name scutcher being seldom used in America. The feeding arrangement is clearly shown. Four laps from the breaker lapper are placed upon the endless lattice of the feed table. From the ends of the laps protrude wooden or iron lap rods which rest against shoulders on each side of the machine. The onward movement of the lattice unrolls the laps, which are retained in their position by the pressure of the rod against the shoulders. By feeding four laps instead of one, or instead of having a continuous passage of the cotton from one machine to another, opportunity is given to assist in producing a more uniformly weighted lap. If four laps of a definite weight per yard are made into one lap of about the same weight, the lap formed is apt to have fewer inequalities than any one of those fed.

While this principle of doubling does undoubtedly assist in producing evenness, its influence is not sufficient. A device called an "evener" has consequently been made use of. A view of the style of evener constructed by the Pettee Machine Shops is shown in Fig. 23. Referring to this view a description of the working of this particular evener can be given. The lattice feeding apron is shown at C with a part of the cotton shown coming within the action of the feed roll A. Before the cotton is fed to the beater, it passes under the upper or larger feed roll and over a feed plate. The feed plate shown partly in Fig. 23 is made in eight independent sections B, each attached to levers D, either working upon pivots or resting upon knife edges. The tail pieces of the levers are sufficiently heavy to press the plates against the roller. By means of the chains G a connection is made between the plate levers D and the lever E. Any upward movement of the tail ends of D produces a corresponding movement of E, and *vice versa*. Any movement of E causes by means of the connections shown a partial revolution of the shaft I. To the shaft I is attached a quadrant K. The teeth in the quadrant engage the teeth in a rack on the rod L. L has attached to it a belt connecting two cone drums J and J^1. These are of a special shape to be discussed later, the driving cone being concave and the driven convex. These cones are so placed that the large end of one is opposite the small end of the other. Any movement of the quadrant must move the position of the belt on the cone. A change from the large end of the driving cone to the smaller, would, of course, mean a decreased speed of the driven cone. Hence a movement of the belt along the cones will mean an increase or a decrease in the number of revolutions made by the driven cone in a given time. On the end of the shaft of the top or driven cone is a worm, driving a worm gear H on the feed roll. By tracing the connection just outlined, it can be seen that an upward or downward movement of the sectional feed plate causes an increased or a decreased speed of the feed roll A. Of course the speed of the feed roll determines the amount of cotton fed to the machine. If a thick place in the lap passes between the feed roll and the feed plate, the section of the feed plate over which it passes will be immediately depressed. The connection of chains and levers will move the belt along the cones so that the feed roll will be decreased in speed just sufficiently to compensate for the thick place which has passed. If a thin place passes through, the opposite effect is produced, the speed of the feed roll increasing. Of course not one, but generally all of the sections of the feed plate are moving at the same time, some up, some down. Each exerts its influence on the lever

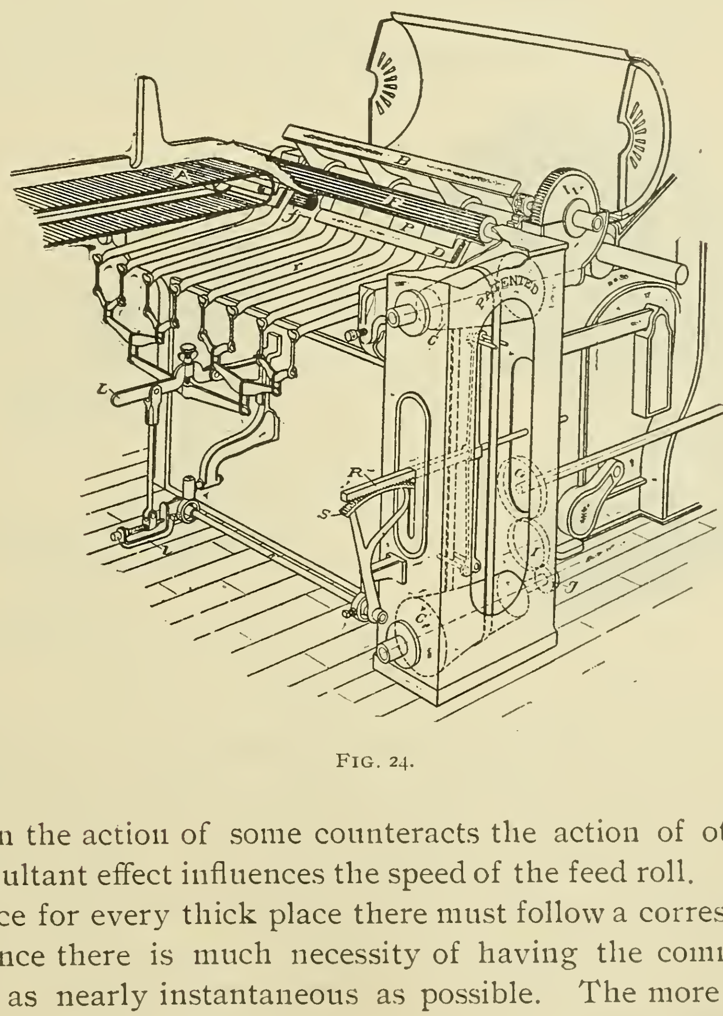


FIG. 24.

E, but often the action of some counteracts the action of others, so that only the resultant effect influences the speed of the feed roll. No evener is perfect, since for every thick place there must follow a corresponding thin place. Hence there is much necessity of having the communication of the motion as nearly instantaneous as possible. The more sensitive the evener, the better the result. The importance of producing even laps makes the evener an especially important part of the lapper.

Another style of evener is shown in Fig. 24. In this case levers do all the work, no chains at all being used. The claim of the maker of this type is that it surpasses any where cords or chains are used, since levers are more sensitive in their action, owing to the tendency of chains and cords to stretch ; while the claim for the other style is an increased sensitiveness owing to the dependence upon circular motion rather than linear.

The third type of evener, which is also of American make, the product of the Kitson Machine Co., differs much in construction from the two very similar types shown. The evening is done by sectional plates above the cotton. An outside view of this device is shown in Fig. 25, and a sectional view in Fig. 26. Referring first to Fig. 26, the relation between the plates and the feed roll can best be seen, and the course of

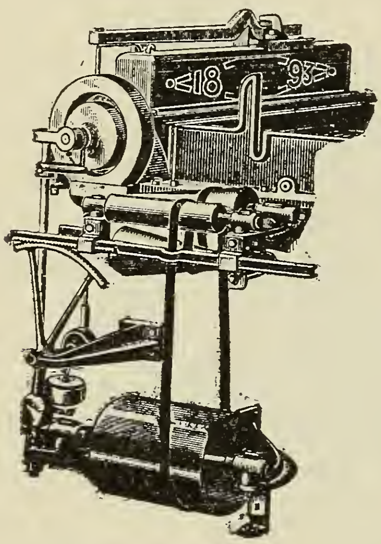


FIG. 25.

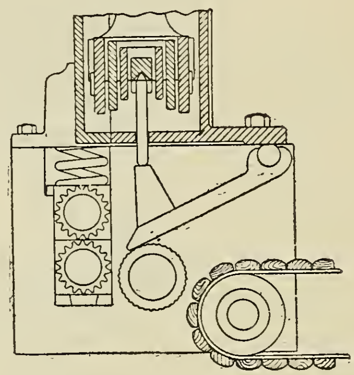


FIG. 26.

the cotton traced. There are sixteen sections of the evening plate; they are joined by saddles in sets of two, the saddles being surmounted by others, as are these in turn until the number is reduced to one. Any movement of the plates actuates this one, and it in turn by suitable connections shifts the belt along the cones, thus regulating the speed of the evening roll. In this special type there are used two cylindrical drums in addition to cones. Their use is to obviate all possible slipping of the cone belt, and to facilitate rapid change of its position. In front of the evening roll are two feed rolls, from which the cotton is beaten or picked, as in the breaker lapper. In every intermediate lapper, after passing the evener, the cotton is acted upon by a bladed beater, drawn upon dust cages, compressed by them, passed through calender rolls, and formed into a lap as previously described. The finisher picker or lapper is the exact counterpart of the intermediate, and in mills, where the production is small, the same machine may be used to perform both processes. Fig. 27 shows a sectional view of the finisher or intermediate lapper. The close resemblance to the breaker lapper will be seen and the differences usually recognized. The one shown is a German and English type. American makers now commonly construct the dust cages of the same size.

All through the picker room processes the aim is to remove all the foreign substances from the cotton, and to produce a roll of cotton every yard of which should be of a uniform weight and thickness. At the same time it is essential that the cotton fibres be not injured. A consideration

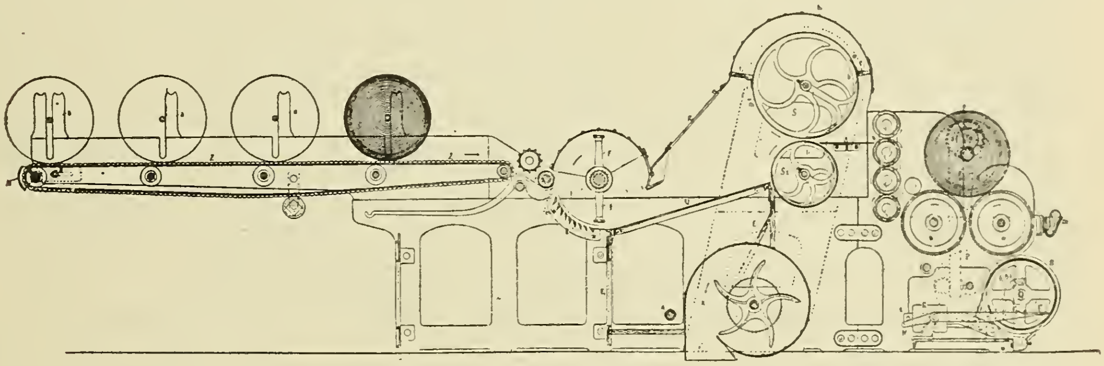


FIG. 27.

of each object above set forth may well be made here, and important principles of working be emphasized.

Cleaning, as already described, is done by means of beaters, grid bars and dust cages, and can be only partially regulated after the machine has been constructed. There must be a relation between the beaters and the grid bars beneath, but this relation is usually fixed by the machine maker and is unchangeable. The grid bars, within whose action the cotton first comes, are placed nearer to the beater than those farther around. Their inclination is also sharper. Some machine builders make it possible to adjust the grid bars in their relation, both to the beater and to each other. The principle underlying their adjustment is that the dirtier the cotton, the nearer must the grid bars approach the line of action of the beater, yet never must they be so near as to injure the fibre. The length of the fibre and the thickness of the sheet of cotton will be additional factors in determining the proper setting distance. Much must be got by experience, but a little thought will usually enable one to settle upon the proper course to pursue.

Another influence upon the cleanliness of the product of pickers is the air draft induced by the exhaust fan. It has been pointed out hitherto that one of the requisites is an even draft. Another is that the draft be not too great, nor yet too small. The influence of an excessive air draft on the cleanliness is considerable. This will readily be understood, when the reason for having any air draft is considered. The centrifugal force of the beater is sufficient to carry the cotton in its fleecy condition a considerable distance away. Yet, if the action of this force alone were depended upon, the fleecy cotton would be carried along in a by no means uniform condition. Hence it will be seen that the artificial air draft is introduced in order to direct the cotton upon a certain area, and should be only sufficient to do that. Too much draft would tend to draw more cotton than just enough to cover the cages used. The result, with which we are now concerned, would be that the cotton would be drawn on so quickly that some dirt, which ought to leave it, would not be allowed to do so, and there would also be a great chance of causing unevenness in the fleece. Too little air draft would not influence cleanliness as much as evenness. If there were not sufficient draft to attract the cotton to the cages, so that it would cling tightly, a chance, and a wide one too, would exist that there would be places on the cages to which the cotton would not cling; the effect on the lap produced is evident. Too much emphasis therefore cannot be laid upon the maintenance of an even air draft of just sufficient strength to draw the cotton evenly over the whole receiving surface of the cages. Experience has shown that a large fan gives more uniform draft. Consequently fans are usually made 18 inches or 22 inches in diameter, and of the shape shown in figures. They are given a high rate of speed, 1,200 to 1,400 revolutions per minute. Their speed of course influences the strength of the draft, while the evenness thereof depends mainly upon the cleanliness of the flues which connect the air chambers in the lappers with the outside air. These must not be allowed to become at all clogged, if even air draft is expected. To summarize it may be said that the factors influencing cleanliness of the lap produced by a picker are (1) the relation between the beater and the grid bars, (2) the relation between the grid bars themselves, (3) the strength of the air draft.

Upon the uniformity or evenness of the lap, one of the greatest influences has already been discussed. The uniform air draft tends to make the sheet of cotton even in weight throughout its width by drawing the same amount upon all parts of the receiving area of the dust cages simultaneously. Since the greater surface is offered in the direction of the width of the machine, the greater amount of evening will occur in that direction. Each yard of width of the lap produced and each yard of length should always be the same. In other words, it is desirable that a square yard taken from one part of the lap should weigh exactly what a square yard from any other part weighs. The uniformity in weight throughout the width is as already shown, brought about by an uniform air draft. The evenness of length depends upon the accurate working of the evener. Of course the evener cannot regulate the weight of sections in the width of the lap. It can only make the whole amount of cotton fed within a given time uniform. A thick place will have its corresponding thin place. With a sensitive evening device the actual amount fed in within any fixed time remains practically the same. This therefore insures that each yard of length will have in it the same amount of cotton, and the air draft must be depended upon to spread this amount uniformly over the cages.

It is very important that all parts of the evening mechanism be free from dirt, which quickly accumulates more extensively upon some types of eveners than upon others. If an almost instantaneous regulation of the speed of the evener feed roll can be had, good results are assured.

An attachment is applied to the eveners, whereby the evener plates can be moved nearer to or farther away from the evener roll, thus permitting the thickness of the lap to be regulated very closely. The setting device is commonly a thumbscrew upon a thread of fine pitch. It is shown at g^4 in Fig. 23. Of course this regulation is only possible within limits, any greater change in the amount fed being dependent upon another source soon to be mentioned.

The evener is sometimes applied to the automatic feed of an opener. The evener plates and roll work at the point where the cotton is fed to the first beater, and the part whose speed is changed, is the feed roll and ascending spiked feeding lattice. Of course it is obvious that in no case should the feeding of the cotton to any of the machines by the one tending be neglected. The evener cannot make compensation for the thickness of a whole lap. So four laps must always be fed on intermediates and finishers, one never being allowed to run out; and on an opener the hopper should be well filled.

To summarize, the factors influencing uniformity of the lap may be said to be (1) an uniform speed, which depends upon: *a*, the care of the attendant, *b*, the sensitiveness of the evener device; (2) a regular air draft of proper strength.

Equally as important a consideration as cleanliness and uniformity is avoidance of any injury to the fibre. The action of all the preparatory machines is harsh and severe, and there is undoubtedly danger of injury. This danger is, of course, at the place where the beater does its work. The principal cause of injury to the fibre is crushing by the beater. The distance between the feed rolls and the beater should be sufficient to allow the beater to strike the projecting sheet of cotton without crushing the fibres, and not large enough to allow a large amount to protrude. The

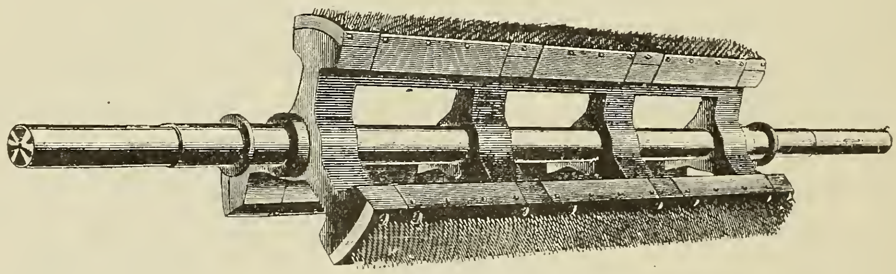


FIG. 28.

effect of a close setting is evident; that of a wide one is to allow the cotton to be curled up into what are called "cat tails." The distance depends upon two points, (1) the length of the staple, and (2) the amount being passed through the machine. The action of the beater should be to pull the cotton away from the sheet evenly throughout the whole 40 inches width of the machine. The blow struck is very forcible, therefore the blades must not be sharp enough to cut the fibres, nor so dull that they will rub the cotton without detaching it. Beaters with two and three arms are largely used, both being very popular. Theoretically, the three-armed beater would give a more forcible blow at shorter intervals than the two-armed. Practical considerations make it advisable to run the three-armed beater more slowly, which reduces its theoretical advantage. As a matter of fact, both types give good results in detaching and cleaning the cotton.

A third type is shown in Fig. 28. This beater has inclined teeth upon it and is called a "carding beater." It is sometimes applied to the finisher lapper. It tends to comb the cotton a little, lightening to some extent the duty of the card. Its cleaning power is undoubtedly less than that of the bladed beater, but it is quite popular on the cleaner cottons. Still another type shown in Fig. 9 is used in openers, especially on the short-stapled dirty cottons. Its size and striking parts offer very good cleaning power for short, strong cotton. It is never used except at the opener.

The arrangement of the machines is largely a matter of convenience, and one mainly decided by the mill architect. It is important that the finisher lappers be near the carding room to which the laps are taken. The openers must also be near the place for storing the bales of cotton. These points often necessitate the placing of some machines on one floor and others on another, as previously mentioned.

INTRODUCTION TO CALCULATIONS

DRAFT.

There are some words and expressions which are used throughout the processes of cotton spinning in a technical sense. While their meaning can be traced to the ordinary significations of the words, yet in many cases this connection is not evident. The first term of this sort is "draft." The word is used in connection with every machine from the bale breaker to the spinning frame, and its meaning ought to be understood at the very beginning. In its broadest general sense, draft means a drawing out. On the bale breaker, it will be remembered, the large lumps of cotton were drawn out. The machine is therefore said to have introduced draft. On the breaker lapper a large mass of cotton is drawn out into a thin lap. On the intermediate and finisher lappers, four laps are drawn out into one which is of nearly the same weight per yard as one of those fed. It is clear, then, that in each of these machines there is what is technically termed draft. This must be clearly distinguished from the same word which has been used previously to mean a current of air. Draft in the sense now being discussed is always produced by causing the delivering roll of the machine to revolve faster than the feeding roll.

It is customary to say that a machine has a certain amount of draft, *e.g.*, a bale breaker has a draft of 24, a lapper has a draft of 4.24, etc. By these numerical expressions is meant the number of times that any given length of cotton fed to the machine is increased by the time that it is delivered. If a machine is said to have a draft of four, the amount of cotton in one yard of the strand of cotton, in whatever form it may be, would be so drawn out while passing through the machine, that its length would be four yards when delivered. Or considering the matter from the point of view of weight per yard, it may be said, that if one yard of the strand fed weighed 40 ounces, and a draft of four were given, one yard of the strand produced would weigh only one fourth as much, or ten ounces.

We may then technically define draft (1) as the number of times that a given length is increased while passing through any machine, or (2) as the number of times that the weight of a given length is decreased.

It is obvious that in order to produce laps of given weight per yard, as has been pointed out to be necessary, some means must be adopted for calculating the draft of every machine, and for giving any machine a definite amount of draft. This brings us to the point of entering upon a discussion of some arithmetical calculations.

There are in connection with cotton machinery arithmetical operations which are essential to the production of good work. Careful calculations must be made if speed and economy in reaching results are desired. In actual mill work hitherto there has been much "rule of thumb" calculation, which has been merely "guess work," or a dependence upon the results of long experience. But by application of a few, not always difficult, mathematical processes, results can quickly and accurately be reached.

These calculations have to do with the speeds at which different parts of the various machines run, and the weights and lengths of the strands of cotton fed to and delivered by them. Before devoting attention to the calculations required on the machines already described, it will be advantageous to lay down some general definitions and rules which will guide us through all the later mathematical work.

DEFINITIONS

I. Speed.

(*a*) The "speed" of an organ of any machine is the number of revolutions or vibrations, or traverses made by it in a unit of time. The unit of time usually taken is one minute; and all speeds hereafter mentioned will be on that basis unless otherwise specified.

(*b*) "Surface speed" is the distance through which a point on the surface of an organ passes in a unit of time. In this case the unit of time is commonly one minute, and the units of distance are feet and inches.

II. PULLEYS.

A pulley is a wheel used to receive or transmit power, when the power passes from one pulley to another by the medium of belts or bands.

NOTE.—Belts made in rope form are almost invariably called bands.

Names for Pulleys.

(1) Driving pulleys are those which transmit power.

(2) Driven pulleys receive power from driving pulleys. Two belts are seldom connected with the same pulley, so that in any train of pulleys the number will be even ; for every driving there will be a driven pulley.

III. GEARS.

A gear is a toothed wheel used to transmit or receive power.

(*a*) Spur gears are those whose teeth have their edges perpendicular to the radii.

(*b*) Bevel gears are those the edges of whose teeth are angularly disposed to the radii.

(*c*) Pinion is the name applied to a small gear working into a larger one.

(*d*) Worm is a sort of screw used to revolve a gear.

NOTE 1.—The expressions "driver" and "driven" apply with the same meaning to gears as to pulleys.

NOTE 2.—Since gears mesh one with another without the intervention of belts, the number in a train may be even or odd.

In the case of a train of three or more gears meshing one with another, each gear between the first and the last, both receives and transmits power; hence it is both a driving and a driven gear. Such a gear is called an "intermediate" or a "carrier."

FUNDAMENTAL RULES

I. TO FIND THE SPEED OF A DRIVEN PULLEY.

The necessary data are the diameters of the driving and the driven pulleys, and the speed of the driving pulley.

(*a*) When the train consists of two pulleys only.

Derivation of Rule.

Pulleys are connected by endless belts. If a pulley having a circumference of 10 inches makes 100 revolutions a minute, 100 times 10 inches of belt pass over any point on its suface in one minute. The same number of inches of belt also passes over any point on the driven pulley. Since the driven pulley is driven by contact with the belt, if its circumference is 8 inches, it will make as many revolutions per minute as 8 is contained times in 100 times 10, or 125 revolutions.

In order to understand the principle just shown, it is necessary to consider the circumference of the pulley. The circumference of any circle is 3.1416 $\times$ its diameter, and in the instance above cited, one circumference is divided by the other, consequently, the number 3.1416 cancels out in the arithmetical operation; and may be neglected as shown in the example below.

From the above demonstration the following rule may be derived:

Rule.—To find the speed of a driven pulley, multiply the speed of the driving pulley by its diameter, and divide this result by the diameter of the driven pulley. The quotient will be the speed of the driven pulley.

Example 1. Diameter of driving pulley, 12 inches
" " driven " 25 "
Speed of driving pulley, 142 revolutions.
Speed of driven pulley $= \frac{12 \times 142}{25} = 68.16$

If the circumferences had been used as the reasoning used in deriving the rule necessitates, the operation would be written as follows :

$$\frac{12 \times 3.1416 \times 142}{25 \times 3.1416} = 68.16$$

For practical work we therefore disregard the circumference and use the diameters only.

(*b*) When the driven pulley is the last of a train of pulleys. The rule for this can best be derived from an example. Let it be assumed that there are in the train the following pulleys:

8″ pulley driving to 12″ pulley
15″ " " " 13″ "
6″ " " " 5″ "

Speed of first driving pulley has been found by counting to be 184 revolutions.

By applying the rule already given, the speed of the 12″ pulley will be found as follows:

Example 1. $\frac{8 \times 184}{12} = \frac{368}{3} = 122\frac{2}{3}$ revolutions.

Since the first driven pulley is on the same shaft as the second driving pulley, the speed of the 15″ pulley in the example is $122\frac{2}{3}$ in.

Proceeding now with the example:

Example 2. $\frac{368 \times 15}{3 \times 13} = \frac{1840}{13} = 141\frac{7}{13}$ revolutions.

Speed of second driven pulley.

Proceeding further:

Example 3. $\frac{1840}{13} \times \frac{6}{5} = \frac{2208}{13} = 169\frac{11}{13}$ revolutions.

Speed of last driven pulley.

Answer, $169\frac{11}{13}$ revolutions.

If the operations just performed are examined it will be found that the diameters of the driving pulleys have been used as multipliers, always occurring in the numerator of the fraction. Likewise the diameters of the driven pulleys have always been used in the denominators. The speed of the first driver is used as a multiplier. The whole example may be performed therefore in one operation as follows:

Example 4. $\frac{184 \times 8 \times 15 \times 6}{12 \times 13 \times 5} = \frac{2208}{13} = 169\frac{11}{13}$ as above.

We may now derive a rule.

Rule.—To find speed of a driven pulley at the end of a long train, multiply the diameters of the driving pulleys together, and that product by the speed of the first driving pulley. Divide this product by the product of the diameters of the driven pulleys. The quotient obtained will be the speed of the last pulley of the train.

NOTE.—The rule is applicable to a train of pulleys of any length. The work should be done in one example of cancellation.

The rules above derived apply as well to toothed gears, except that instead of circumferences or diameters, the number of teeth in the gears is used. In applying these rules to gears, intermediates fall out of the calculation. Their nature, as before mentioned, makes them both drivers and drivens, hence in the arithmetical operation they cancel out—

Example.—A 74-toothed gear runs at a speed of 52. It meshes with a 94-toothed gear, the 94 with a 48, the 48 with a 21 and the 21 with a 26. Find the speed of the last or 26-toothed gear.

The example in full would be written as follows :

$$\frac{52 \times 74 \times 94 \times 48 \times 21}{94 \times 48 \times 21 \times 26} = 148 \text{ revolutions.}$$

Answer, 148 revolutions.

In actual practice the example would be written as follows :

$$\frac{52 \times 74}{26} = 148 \text{ revolutions.}$$

Answer, 148 revolutions.

II. Surface Speed.

To find the surface speed of a pulley, roll or cylindrical surface of any sort, multiply the speed by the circumference.

Example. Speed of pulley, 100.
Diameter, 14″.

$$\text{Surface speed} = \frac{100 \times 14 \times 22}{7} = 4400 \text{ inches per minute.}$$

The surface speed of any pulley or roll which comes at the end of a train of pulleys or gears, of which the speed of the first only, and the sizes of the others are known, may of course be found by one operation only. It is simply necessary to introduce into the numerator the circumference of the pulley or roll in question.

Referring to example 4 above. The surface speed of the last pulley would be found as follows :

$$\frac{184 \times 8 \times 15 \times 6 \times 5 \times 22}{12 \times 13 \times 5 \qquad \times 7} = 2717\tfrac{33}{91} \text{ inches per minute.}$$

III. Draft.

Rule 1.—To find the draft of any machine divide the surface speed of the delivering roll by the surface speed of the feeding roll.

This is the fundamental rule which will always apply. Modifications of it which are at times simpler to use in actual practice may well be given. It is often inconvenient to perform the calculation of finding the actual surface speeds of both feeding and delivering rolls of a machine when only the draft is desired. Since it is actually only the relation between these surface speeds which is necessary a useful rule may be made.

Rule 2.—Consider that the gear or pulley on the end of the feeding roll drives the rest of the machine, and consider that its speed is one. By following the train of gears or pulleys from this roll to the delivering roll, the surface speed of the delivering roll may be found. This result will be the surface speed of that roll for the time required by the feeding roll to make one revolution. To find the draft it is only necessary to divide this surface speed as found, by the surface speed of the feeding roll for the same length of time, namely, for the time required by it to make one revolution. Evidently in that time its surface speed will be one times its circumference. By using as the unit of time the time required by the feeding roll to make one revolution instead of the usual unit of one minute, the work is often much simplified.

The rules for speeds and draft as given apply throughout all the processes of cotton spinning. They all refer to machines. Many other rules and mathematical calculations are necessary at different stages. They will be given at their proper place. It is now our intention to apply the rules already laid down to the machinery in a picker room.

We shall devote our attention to the calculations on a finisher lapper which are essentially the same as those on the preceding machines. A description of the manner of driving the various parts is however necessary at the outset. By reference to any one of the views of lappers it will be seen that there is at the top of the machine a countershaft which is connected by a belt with the beater shaft. The beater revolves at a speed of about 1,500 turns a minute, and from it all the other parts of the machine receive their power. The various views shown give some little idea of the driving mechanism, but Fig. 29, which is a top view of all the driving parts of a finisher lapper, may best be referred to for the description.

The beater belt and the pulley which it drives on the beater shaft are shown at the right. Beside the pulley just mentioned is one connected by the belt shown to a pulley on the fan shaft at the bottom of the machine. On the opposite side is a second pulley connected by the calender belt to a much larger one near the front of the machine. The 24-inch pulley on which the belt is in Fig. 29 is loose upon the shaft, but has beside it fast upon the same shaft another pulley of the same size.

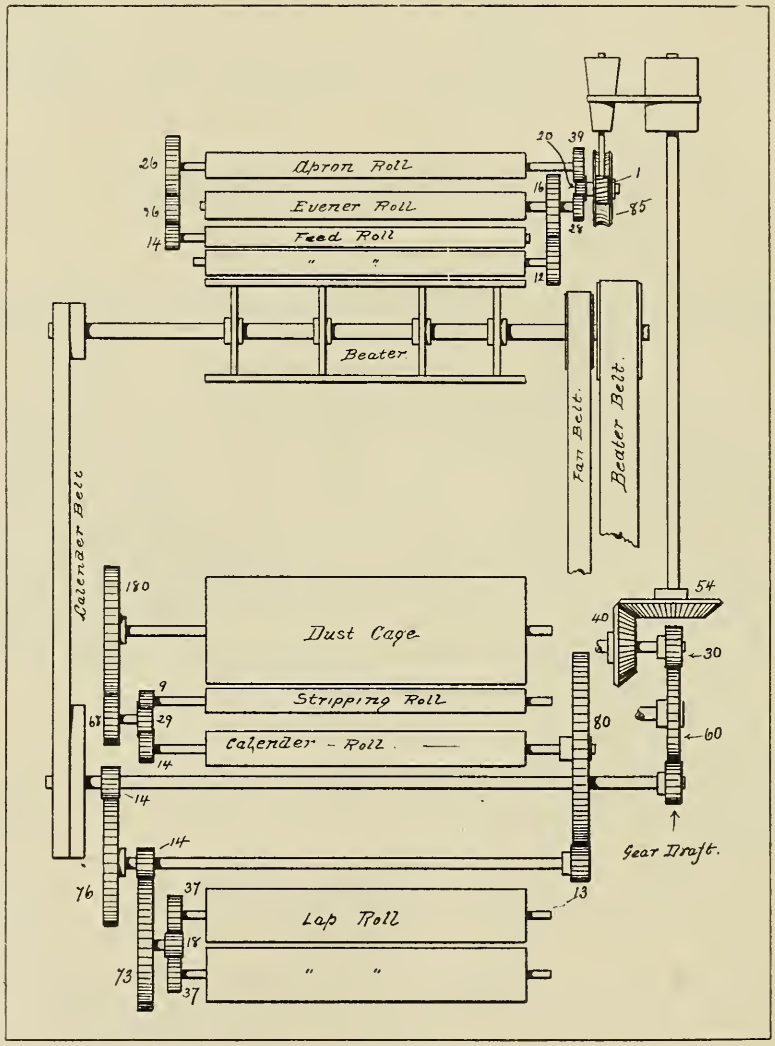


Fig. 29.

The pulley on the beater shaft is twice as wide as the belt so that the belt may be easily shifted from the fast to the loose pulley above mentioned, thus stopping all parts except the beater and fan. On the same shaft with the 20-inch fast pulley is a small spur gear with 14-teeth meshing with one with 76 teeth. On the shaft with this a 14-toothed pinion meshes with a gear having 73 teeth. On the stud with this a pinion with 18-teeth drives two 37-toothed gears, each of which is on the end of one of the large calender rolls on which the lap rests while it is being formed. The driving of the calender rolls, the dust cages, and the stripping rolls is quite easily seen in the figure. It may, however, be mentioned that there is no direct connection between the 80-toothed gear and the lap pulley shaft, the gear being upon the shaft of the calender roll.

The feeding parts get their power through the train of gearing starting with the gear marked draft gear on the end of the lap pulley shaft. There probably is no difficulty in tracing the connection from this point to the side shaft on which may be seen a cylindrical drum connected by a belt with a conical pulley. At the end of its shaft is what is called a single worm, one revolution of which turns the worm wheel with which it meshes forward one tooth. The 85-toothed worm wheel has on the same stud with itself a pinion with 20 teeth, meshing with a gear with 28 teeth and with another having 39 teeth. The 28 gear is on the same shaft with the evener roll, a gear on which drives the lower feed roll. The 39 gear is on the roll around which the lattice feed apon runs, and from gearing starting at the other end of this roll the top feed roll gets its power.

The gearing on all lappers is not exactly as described, but the arrangement shown is sufficiently typical to convey a general idea of lapper gearing. In the calculations which follow the sizes of the gears shown in the figure will be used. We shall also assume that a 20-toothed gear is being used as a draft gear, and that the speed of the beater is 1,500 revolutions per minute. The following sizes are not shown in the drawing:

Diameter of pulley on beater shaft	4½	inches
" " " connected with above	24	"
" " large evener drum	10	"
" " conical drum at middle point	3¼	"
" " feed roll	2⅛	"
" " lap roll	9	"
" " fan driving pulley	6	"
" " pulley on fan shaft	7	"

CALCULATIONS.

1. Speed of dust cage =

$$\frac{1500 \times 9 \times 14 \times 13 \times 14 \times 68}{2 \times 24 \times 76 \times 80 \times 29 \times 180} = 1.535 \text{ rev. per min.}$$

2. Speed of fan =

$$\frac{1500 \times 6}{7} = 1285.7 \text{ rev. per min.}$$

3. Speed of lap roll =

$$\frac{1500 \times 9 \times 14 \times 14 \times 18}{2 \times 24 \times 76 \times 73 \times 37} = 4.83 \text{ rev. per min.}$$

4. Surface speed of lap roll equals above result times the circumference = 4.83 x 9 x 3.1416 = 136.56 inches per minute.

5. Speed of feed roll =

$$\frac{1500 \times 9 \times 20 \times 40 \times 10 \times 4 \times 1 \times 20 \times 16}{2 \times 24 \times 30 \times 54 \times 13 \times 85 \times 28 \times 12} = 4.78 \text{ rev. per min.}$$

This example led us through the evener drums, whose diameters we treat in the same manner as the number of teeth in gears, considering that the belt is at the middle point. The single worm on the cone shaft is the same as a gear having one tooth, except that it gives continuous instead of intermittent motion. The gear 60 is of course a carrier and need not be considered.

6. Surface speed of feed roll =

$$\frac{4.78 \times 17 \times 3.1416}{8} = 31.91 \text{ inches per minute.}$$

7. Draft.

Reference has already been made to the draft gear which, as its name implies, is changed to regulate the draft. A glance at Fig. 29 will show that the draft gear is a driving gear in the train that drives the feed roll. Evidently a larger draft gear would increase the number of yards of cotton fed into the machine within a given time, while the amount delivered remains the same. Therefore by the use of a larger draft gear the draft would be decreased, and vice versa.

(*a*) Draft of the machine could be found by applying rule 1 under draft. So, by dividing the result of No. 4 by the result of No. 6, the draft of the machine could be found. Hence draft equals

$$\frac{136.56}{31.91} = 4.28$$

(*b*) If we apply rule 2 under draft, the operation will be as follows:

Draft=

$$\frac{12 \times 28 \times 85 \times 13 \times 54 \times 30 \times 14 \times 18 \times 9 \times 8}{16 \times 20 \times 1 \times 4 \times 10 \times 40 \times 20 \times 76 \times 73 \times 37 \times 17} = 4.28$$

NOTE.—If the calculations for draft only is to be made, the latter method is by far the simpler.

8. Calculations relating to weight of lap and draft.

(*a*) Finding the draft required to produce a lap of a certain weight per yard, when the weight per yard of one of the laps fed is known.

Rule.—Multiply the weight per yard of one of the laps fed by the number fed, which is usually four, and divide this product by the weight per yard of the lap to be delivered.

(*b*) Finding the weight per yard of the lap fed, knowing the draft and the weight per yard of the lap delivered.

Rule.—Weight per yard of lap fed equals weight per yard of lap delivered times draft, divided by the number of laps fed.

(*c*) Finding the weight per yard of lap delivered, knowing the weight per yard of the lap fed and the draft.

Rule.—Weight per yard of lap delivered equals weight per yard of laps fed times the number fed, divided by the draft.

There is always considerable waste on lappers. The absolute amoun depends upon the cleanliness of the cotton. The per cent. of waste, whatever it may be, must be allowed for in the calculations for draft. In calculations (*a*) and (*c*) the deduction should be made from the weight of the lap fed, and in calculation (*b*) the result will be a certain per cent. less than the true answer.

A good way in which to determine the actual per cent. that ought to be deducted in any particular case is as follows: Weigh accurately a number of laps, e. g. 16, which are to be fed to the machine. Empty the machine of all the cotton in it, and feed in the laps weighed. Then weigh carefully all the laps produced. The difference in weight between the cotton fed and that produced will of course be the amount of waste. This difference divided by the weight of the cotton fed will give the per cent. of waste. The per cent. of waste on openers is about 6, on intermediate lappers about 3, and on finishers about 2.

9. Production.

The production of all lappers is very large. It can be computed in a manner similar to the one which will be outlined later in connection with other machines. A simple and convenient method is as follows: Determine the actual time required to produce a lap, either by computation or by actual timing, the latter method being the simpler; add to this two minutes to allow for removing the lap and restarting the machine The weight of a lap can of course be found by multiplying the length by the weight of one yard or by weighing the lap. In actual practice the laps should be weighed, in order to see that the proper weight per yard is being preserved. If the weight of a lap and the time required to produce it are known it is surely an easy matter to determine the production in pounds for any length of time desired.

Laps are usually not far from 48 yards in length, and they weigh anywhere between 24 and 48 pounds. About ten minutes are required to produce and doff a lap; consequently the production of a lapper varies between 8,000 and 17,000 pounds for a week of 60 hours.

10. Length of lap produced.

As previously mentioned there is applied to finisher, and sometimes to intermediate and breaker lappers, a device for stopping the machine after a lap of a certain length has been delivered. By changing one of the gears in the train controlling the movement of a knock-off lever, the length of the lap can easily be regulated. Fig. 29a shows in section and outline the lap end of a finisher lapper with all the gearing connections needed to compute the length of a lap. The calender rolls, lap rolls and lap will easily be recognized. The full and dotted circles represent gears, the dotted ones being on the opposite side of the machine. The working of the knock-off motion is as follows: A single-toothed worm on lowest calender roll drives a worm wheel on a side shaft. At the other end of the side shaft is a pinion, capable of being changed and known as the side-shaft change gear. This pinion meshes with the knock-off wheel which is shown in the figure to have 48 teeth. When the knock-off wheel has made one complete revolution, a pin upon it, not shown in the drawing, releases a lever, which during the time that the machine is running supports what is called a drop shaft. Upon that shaft, which is indicated in the drawing, is a pinion which drives both the calender rolls and the lap rolls. When the lever supporting the drop shaft is released, the pinion falls away from the gears which it has been driving.

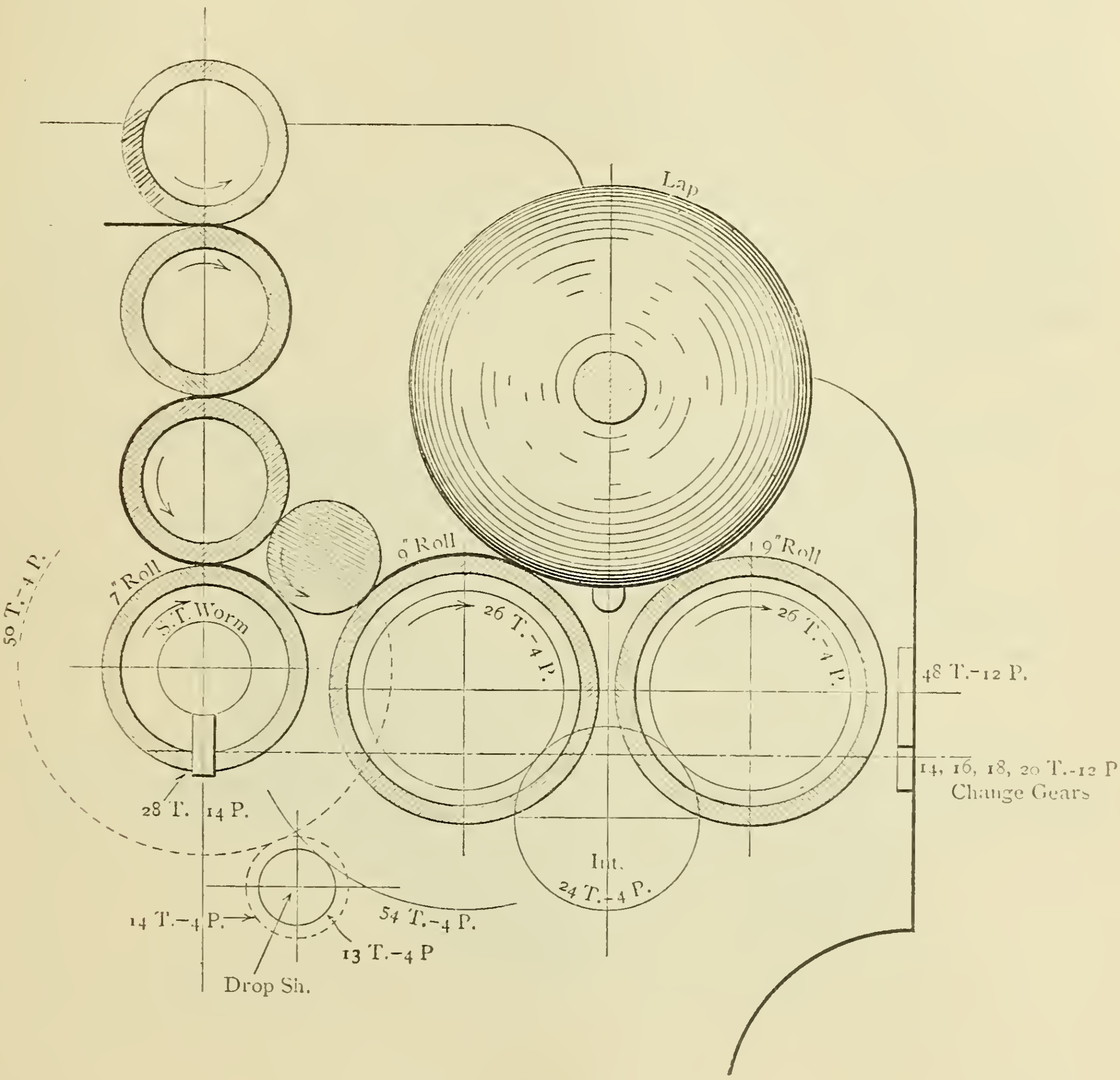


FIG. 29A.

They consequently stop, and no more cotton is delivered. At the same time a lever connected with the knock-off lever and extending along the side of the machine is so actuated as to throw out of gear a clutch on the end of the feed roll, thus preventing any more cotton from being fed to the machine. After the lap is removed the knock-off lever can be put back into position, and all the other parts restored to their normal condition.

The above brief description will enable us to proceed to compute the length of a lap. To do this it is necessary only to determine the surface speed of the lap rolls for the length of time required by the 48-toothed knock-off wheel to make one complete revolution. We shall therefore consider that the knock-off wheel makes one revolution and that it is driving all the rest of the mechanism. By considering the knock-off wheel the first driver, we can find the result obtained by dividing the product of the driving gears by the product of the driven gears from the knock-off wheel to the gear on the lap roll inclusive. The result will be the speed of the lap roll. The surface speed in inches and then in yards may readily be found therefrom.

Example.—Find the length of a lap if the change gear in use has 18 teeth.

Surface speed of lap roll for one revolution of knock-off wheel =

$$\frac{1 \times 48 \times 28 \times 50 \times 13 \times 9 \times 3.1416}{18 \times 1 \times 14 \times 54} = 1815.146 \text{ inches.}$$

Yards in length of lap =

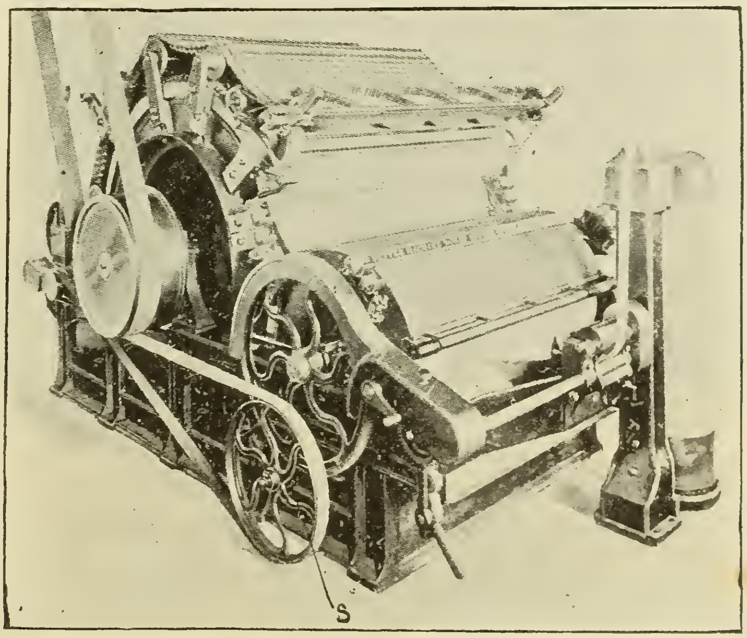
$$\frac{1815.146}{36} = 50.42$$

NOTE.—Cotton while being rolled up is likely to stretch about 4 per cent., so that the length of a lap is about 4 per cent. more than the calculation shows. The above result, corrected on the assumption of 4 per cent. stretch, could be 52.43 yards.

CHAPTER IV

CARDING

The fibres in a lap produced by a finisher picker need considerable further treatment before they can be spun into yarn. If a lap be examined it will be found still to contain many impurities clinging tightly and loosely as well, to the matted and tangled fibres. The impurities



PETTEE REVOLVING FLAT CARD.

consist mainly of pieces of broken seeds and leaves, sticks, immature seeds, called "motes," tightly rolled balls of fibre called "neps," and considerable light dust. The action of the preceding machines has in no case except where the carding beater was used been one of combing;

consequently the crossed and tangled condition of the fibres is natural. Moreover the fibres are by no means equal in length; short, immature ones are mixed indiscriminately with the long, ripe fibres.

The machine which undertakes the treatment of such a mass of cotton is technically termed a "carding engine" or "carding machine," colloquially a "card." While carding primarily means a combing process, the functions of a modern card are more than that, yet the combing or untangling operation is still pre-eminent.

Briefly the objects to be attained by a modern card in their order of performance are :

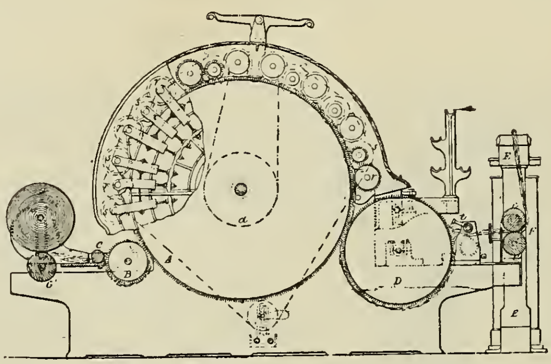


FIG. 30.

(1) Removal of the heavier foreign substances, as motes, broken seeds and leaf.

(2) Straightening of masses of tangled fibres, accompanied by

(3) Removal of short fibres, neps and light dust.

(4) The drawing out of the lap into a thin web.

(5) The forming of this web into a rope-like strand, called a "sliver."

(6) Coiling of the "sliver" in a cylindrical can.

Three types of cards have been employed in cotton mills. The intrinsic differences are in what is called the carding surface.

The "roller card," shown in Fig. 30, performs its carding with the help of pairs of rollers, known as "workers" and "strippers." This type of card is now used only in the manufacture of wool, worsted and waste yarn.

The "stationary flat card," or "Wellman card," is shown in Fig. 31. Its name describes its carding surface, which is made up of flat strips

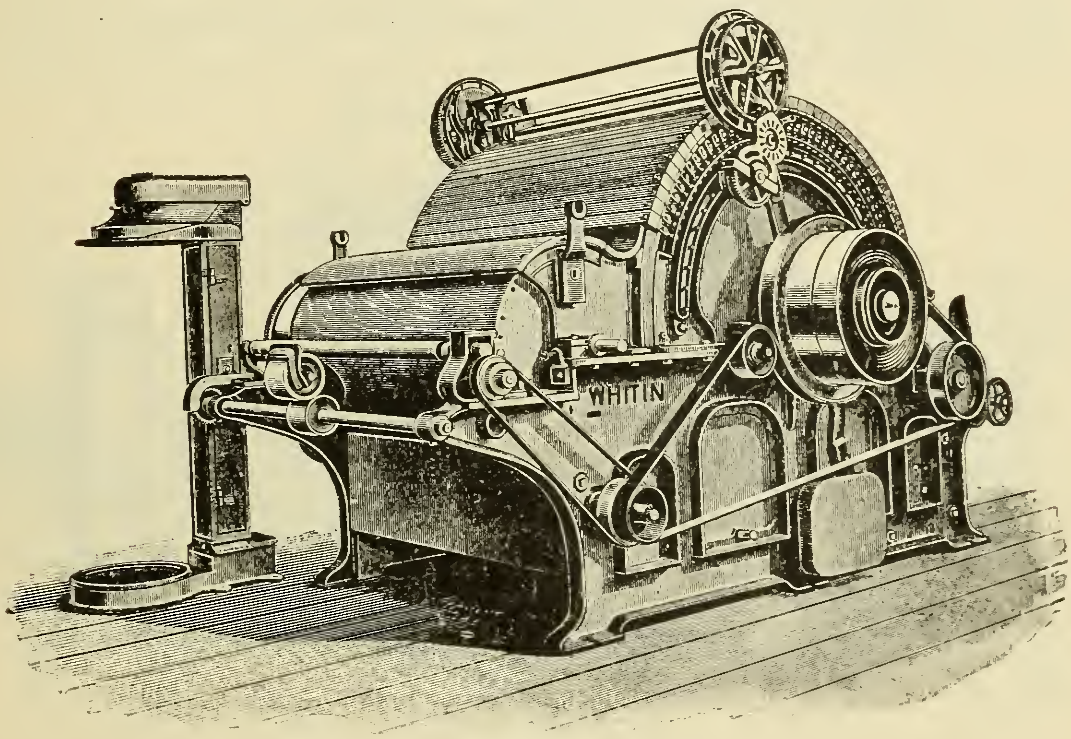


Fig. 31.

which remain stationary. The name stationary flat distinguishes this type from the third and most common type, the "revolving flat."

The Wellman card is an American invention which has now given place almost entirely to the English type, the "revolving flat." Several practical advantages, not the least being increased production and economy of work, have led to its adoption. It seems therefore advisable to devote the following discussion to the revolving flat card.

There are several makes of this kind of card. They resemble each other closely, differing only in the devices for adjusting various parts common to all makes, and in the manner in which the different parts are constructed. They all perform the same work pretty satisfactorily, the nearest approach to perfection being claimed by many different builders.

Reference to Figs. 31 and 32 may be made in connection with the description which follows.

The "lap" having end of an iron or wooden lap stick protruding from either end is placed at the back of the machine, and is made to rest upon a corrugated wooden roller called a "lap roll," B, in Fig. 33. B is given a positive motion in the direction of the arrow by means of a train of gears hereinafter shown. The contact between A and B unrolls the

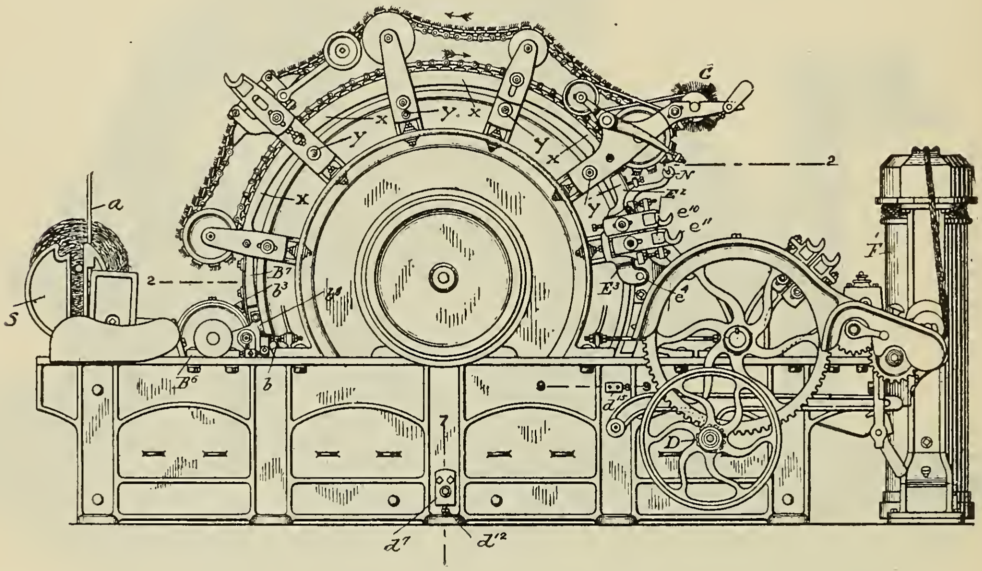


Fig. 32.

lap, which is prevented from being carried forward bodily by the contact of the protruding lap rod with the slotted uprights on each side of the card. One is shown at S in Fig. 32.

As the lap is unrolled, the sheet of cotton is led along a smooth plate called a feed plate. This plate with the contiguous feeding parts is shown in Fig. 33, and in detail in Fig. 34.

One end of the plate is dished out, so to speak, taking the curve of a roll called the feed roll which fits into it. Between the roll and the plate the cotton is passed. A firm grip is exerted by the roll owing to two weights which press upon it. One of these can be seen in Fig. 32.

The roll itself is corrugated throughout its length, which equals the width of the machine. It is positively driven by gearing at a speed varying from three-quarters of a turn to four turns per minute.

Referring again to Fig. 34 it will be seen that the feed roll pushes the end of the lap within the action of saw teeth on the surface of a cylinder B^2 called the "licker-in." This organ revolves at a speed of about 400 turns per minute. The great speed and the shape of the teeth enable it to remove fibres from the end of the lap.

The licker-in is a hollow cylindrical shell about 9 inches in diameter. Spiral grooves are cut in its periphery, and into these saw teeth are fitted.

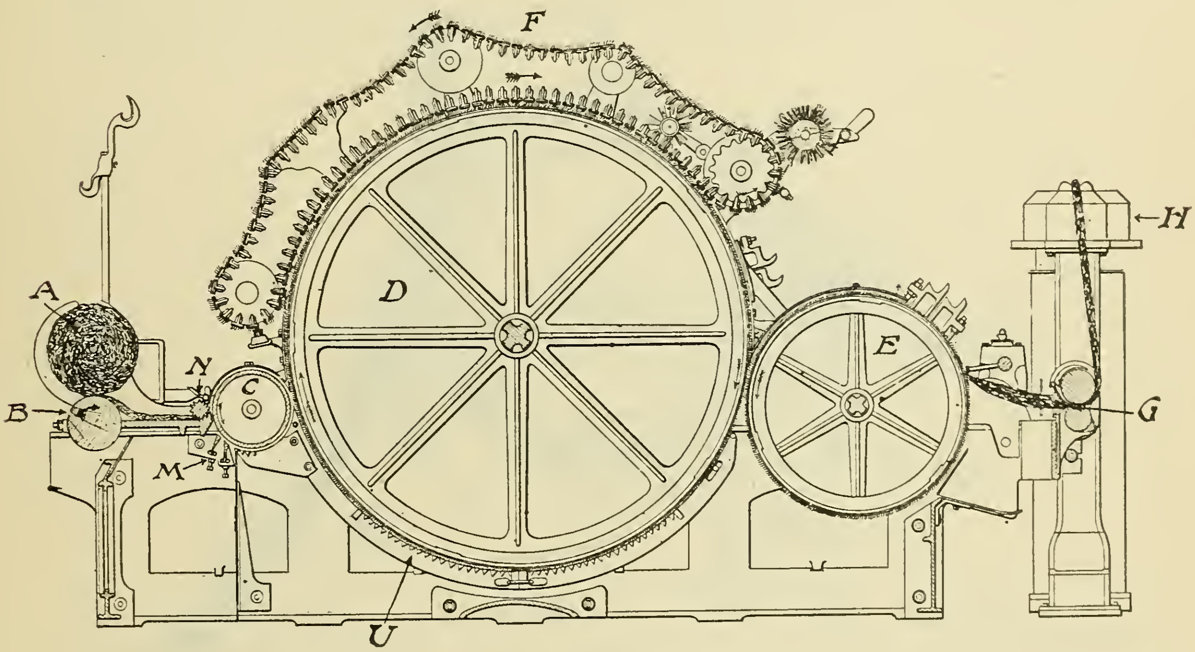


FIG. 33.

The pitch of the spiral grooves is 1 inch, and usually eight are cut. The distance apart of the rows is therefore one-eighth of an inch. The saw teeth are made in a continuous roll, being drawn into the grooves by the revolution of the licker-in, and being suitably fastened at the ends. The teeth will therefore not follow each other in straight lines, but each tooth will be a slight distance at one side of the preceding one. There is hence offered to the lap, as it is fed, an unbroken line of points, so that the probability of striking all parts of the lap equally is almost certain. The saw teeth pass through the end of the lap, and after exerting a combing action detach the fibres that have been released from the grip of the feed roll. The fibres are held by the licker-in in all sorts of positions, but never in large lumps. Since the number of teeth passing the feed plate while an inch of lap is being fed is many hundred thousand, and since the fibres are scarcely more numerous, and are detached, not singly, but in groups of a few clinging together, it follows that many of the teeth on the licker-in will be bare. It never requires cleaning.

The fibres which are detached from the lap by the licker-in teeth are carried around beneath it. Placed near the surface of the licker-in, a short distance from the point where the cotton is detached from the lap, are two

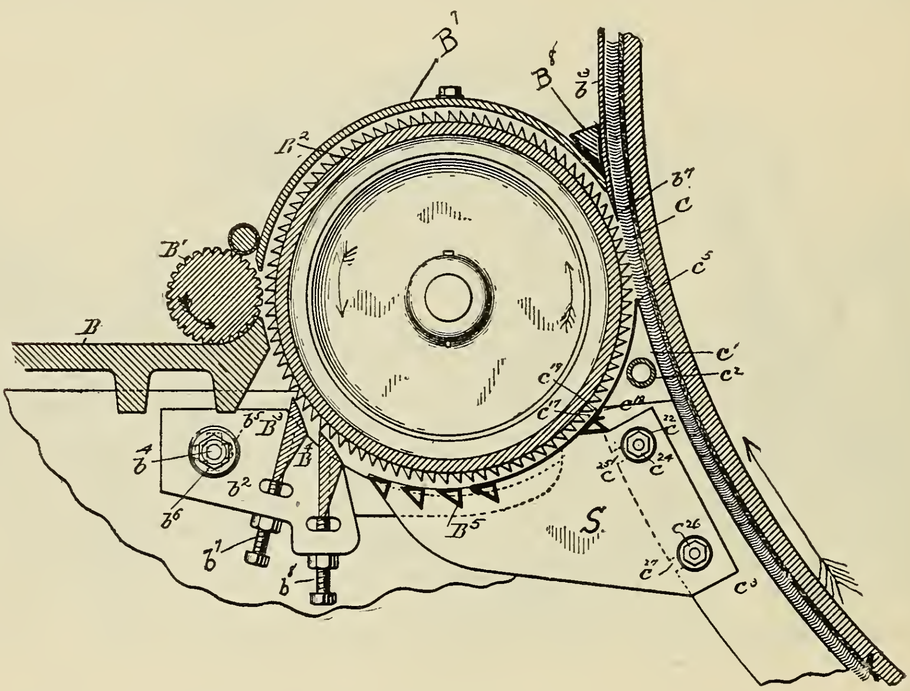


FIG. 34.

transverse peculiarly shaped bars, sharp on the top edge, known as mote knives. The shape and position of these knives are shown at B^3 and B^4 in Fig. 34. Their duty is to aid in the removal of the heavier impurities which still remain in the lap. Motes, dirt, pieces of leaf, which do not cling tightly to the fibre or the licker-in teeth, are by the centrifugal force of the licker-in thrown away from its surface. As they strike the sharp edge of the mote knives, they are deflected and fall down through the spaces to the floor. As the space between the edges of the knives and the licker-in teeth is very small, leaf, broken seed, etc., which do cling to the fibre, being longer than the space, are scraped off by the knives, and fall between them. It is at this point, therefore, that the majority of the heavy impurities in the lap are removed. Some long fibres loosely held are thrown through the interstices, but their number is very small.

Placed directly in front of the mote knives in a curve conforming to the surface of the licker-in, is a tin arrangement called a "screen or under casing." In it are small spaces between the grids B^5 through which short loose fibres may be thrown on to the floor beneath. It is set very near the licker-in surface, and has the duty, first, of preventing fibres from being thrown away from the licker-in and becoming waste; and, second, of allowing shorter fibres and dust to be cast out.

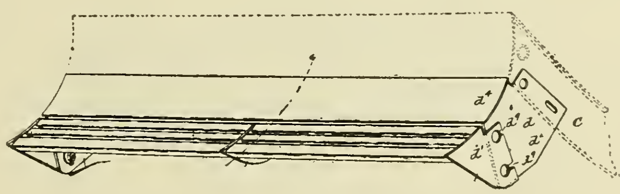


FIG. 35.

This licker-in screen is bolted at c^{24} and c^{26} to a similar one C^3 under the main cylinder. A view in perspective of the screen is shown at Fig. 35.

B^7, Fig. 34, is a cover over the licker-in. B^6 is a small rod covered with flannel, called a clearer roll, and is used to collect fly which may come through the space between B^1 and B^7. B^8 is a wedge-shaped piece of wood covered with flannel and is also a clearer.

The cotton which clings to the licker-in teeth is carried through 180° and then entirely removed by the action of the teeth on the cylinder. The "cylinder" is a large cylindrical shell about 50 inches in diameter. It is commonly cast in one piece, sometimes in two and bolted together. It is strengthened by longitudinal and transverse ribs, and has fitted into its ends eight armed spiders, to be seen in Fig. 33. Through these a cast-iron shaft is placed; the means used for holding it firmly to the spiders differ in different makes of machines. In all cases it is securely fastened so as to be unable to become loose. The surface of the cylinder is smoothly planed and ground, and the whole cylinder is carefully and accurately balanced. Rows of holes are bored through the surface. Into them wooden plugs are driven. To the plugs is tacked the covering, which is known as "clothing." It consists of a long narrow strip or "fillet" about 2 inches in width, made of some closely woven fabric or india rubber, and contains short wire teeth, bent as shown in Fig. 34. The fillets, so called, are wound on the cylinder surface spirally, completely covering it.

The inclination of these teeth when on the cylinder, and their relation to the teeth on the licker-in, are shown in Fig. 34; their action will be easily understood. The cylinder has a speed of about 165 turns per minute. Owing to its large diameter, its surface speed is about 2,100 feet per minute. The licker-in has a surface speed of only about 1,000 feet per minute. In addition to the difference in surface speed, it will be noticed as indicated by the arrows in Fig. 34, that the cylinder teeth approach those on the licker-in at the back. It is obvious, then, that the licker-in teeth offer no resistance to the removal of all the fibres upon them. The cylinder strips the licker-in entirely, taking to itself the fibres in the same condition, tangled or straight, in which they lay upon the licker-in. As the cylinder revolves, it carries the cotton towards the top and front of the machine, past the part where the process of carding in its true sense is performed.

The carding surface consists of a series of flat strips, having a ⊥ shaped cross section, and carrying on their flat side wire teeth similar to those on the cylinder with their angle of inclination in the opposite direction. These flats, so called, are as long as the width of the machine, and are supported at either end on a smooth surface shaped to the arc of a circle and technically known as a "bend." This is fastened to the fixed frame of the machine, but is made adjustable for a purpose to be described later. The ends of the flats are attached to endless chains. The chains revolve very slowly in the direction shown in Figs. 32 and 33, and move the flats from the back to the front of the machine. The shape of a flat and its relation to the cylinder are shown at Fig. 36. It will be seen that one side of the flat approaches nearer to the cylinder than the other. This is made possible by having the bearing surface of the flat and the wire surface not parallel. The side of the flat which comes nearer to the cylinder is technically called the "heel," and the other side is the "toe." The reason for this will be referred to again.

The action of the flats has been said to be that of combing. Tangled masses of fibres on the cylinder, owing to the short space between the cylinder and the flat, come in contact with the flat teeth and are untangled. This is possible on account of the relative speed of the cylinder and flats, and the inclination of the teeth on both. Short fibres and neps either become imbedded at once in the cylinder teeth or are held so loosely that the flats catch them, and, as they are thrown forcibly by the revolution of the cylinder, they cling tightly in the teeth of the flats. From both

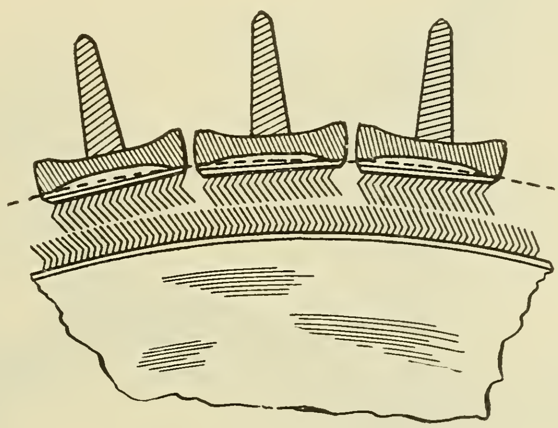


FIG. 36.

the cylinder and the flats the short fibres are later removed as waste. The heel and toe arrangement on the individual flats is so that the cotton, as it approaches each flat, may be drawn down gradually into the thin place between the cylinder and the flat, rather than be thrust into it immediately. The theory that the fibres stand a little away from the cylinder surface, while passing from one flat to another, underlies this arrangement. The flats surround nearly half of the cylinder; the number used is about 110, of which 48 are working at a time, while the remainder are passing over the top of the machine from front to back.

Between the last working flat and the organ E in Fig. 33, called a "doffer," is fitted a plate known as the front knife plate. Its object is to prevent drafts of air from blowing across the cylinder. It acts therefore as a tight cover extending from one side of the machine to the other. This plate is adjustable and is set very close to the cylinder surface. The passage of any drafts of air across the cylinder surface would tend to disturb the straightened fibres and make unevenness. The plate in question succeeds very well in preventing them.

The cotton carried around by the cylinder is laid upon what is called the "doffer." The doffer is a cylindrical shell about 24 or 27 inches in diameter, and is constructed similarly to the cylinder. Its surface is covered with teeth like those on the cylinder, but somewhat finer. The

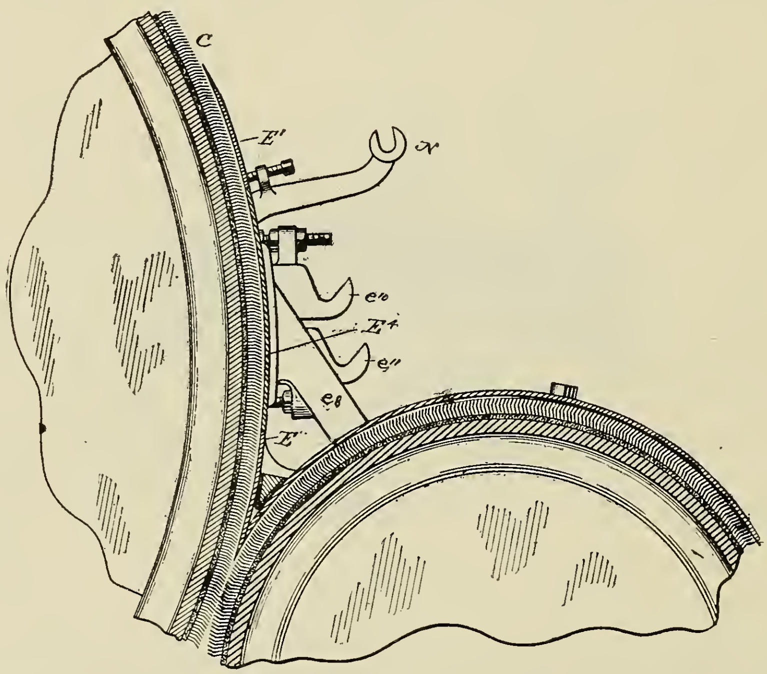


FIG. 49.

inclination of the teeth is exactly like that of the ones on the cylinder. At the point where the two organs are nearly in contact, however, since the points are not corresponding points on the two cylinders, the teeth are opposed to each other. The doffer revolves very slowly in the opposite direction to that of the cylinder, with a surface speed of about 60 feet a minute. This speed and the relation between the doffer's teeth and those on the cylinder, allow the swiftly revolving cylinder to deposit its cotton on the doffer. There is therefore cotton on the cylinder even while it passes from the point of nearness to the doffer around to the licker-in. Underneath the cylinder between these two points is placed a tin screen or under-casing, similar to the one under the licker-in. This was incidentally referred to before; it can be clearly seen at C^3 in Fig. 37, and at U in Fig. 33. It has the same function as the licker-in screen and its proper adjustment has much influence upon the amount of waste.

Owing to its slow speed, the doffer receives the cotton in a sheet thicker than the one on the cylinder, if there be one on the cylinder at all. It is very likely, of course, that there is no continuous sheet on the cylinder, but that there are many bare places. On the doffer, however, there is a thin sheet. This is carried around on the underside of the

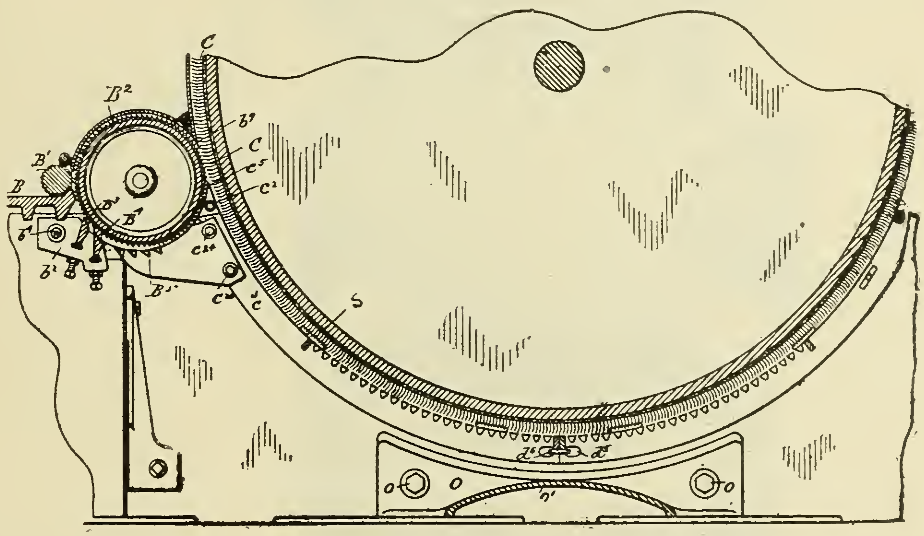


FIG. 37.

doffer towards the front of the machine. Here it is stripped off by a swiftly oscillating comb called the "doffer comb." This comb is only a few thousandths of an inch distant from the doffer, and makes about 1,100 vibrations per minute. It removes the cotton effectually in the form of a very thin web (see Fig. 38). The shape of the doffer comb can be partly seen in this Fig. 38. It is a flat strip with serrations on its lower edge; five short bars support it on a shaft which receives a reciprocating motion.

The web is next passed through a trumpet shown at G, Fig. 33, and at G, Fig. 38. A detailed view of this trumpet is shown in Fig. 39. When the cotton is first started through the card, it has to be trained by hand into a thin strand and pushed through the trumpet hole. Thereafter the cohesion of the fibres is sufficient to prevent the web from breaking as it passes from the doffer.

After emerging from the trumpet hole the cotton is in a thin rope-like strand, but the elasticity of the cotton tends to cause it to expand. To

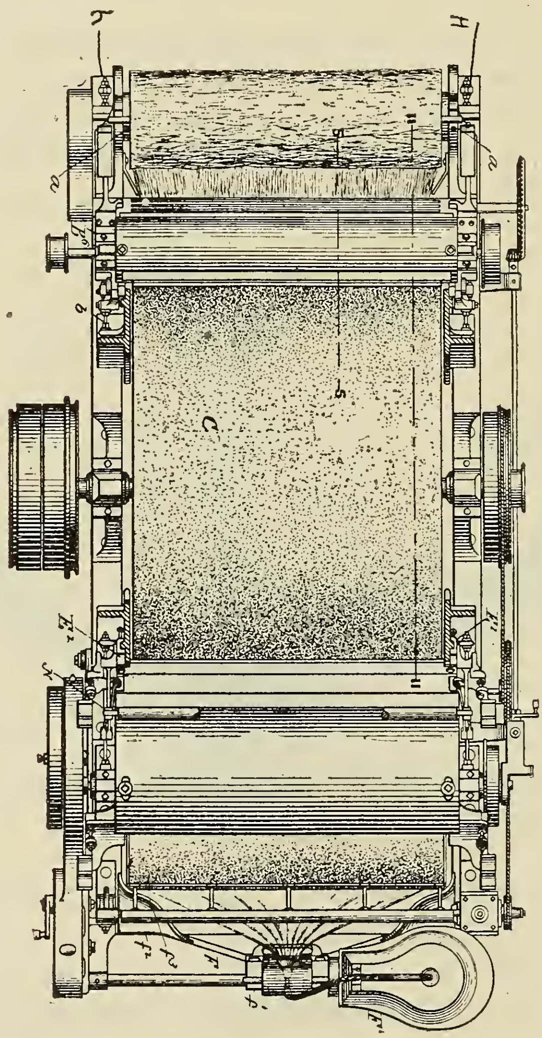


FIG. 38.

FIG. 39.

counteract this tendency two calender rolls, the top one of considerable weight, are placed directly in front of the hole, and through them the cotton, now called a "sliver," passes. It is, of course, by them that it is pulled through the trumpet hole.

After leaving the calender roll, the sliver is drawn up as shown in

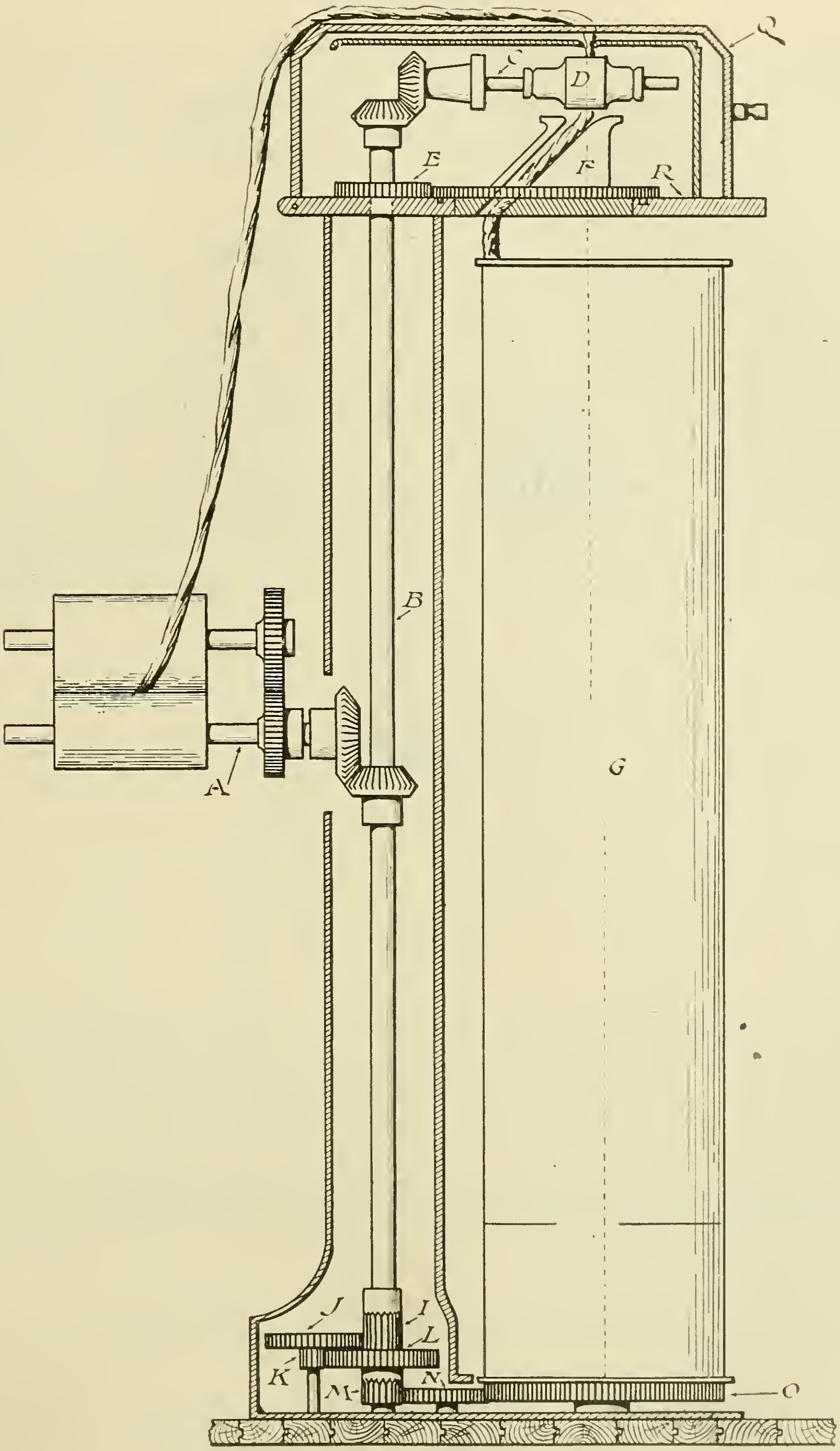


FIG. 40.

Figs. 32 and 33, to a devise known as a "coiler." Through a trumpet hole in the top of this and between two small calender rolls is the next course taken, after which, by means of the coiler itself, the strand is laid very compactly in a can.

The coiler and its connections are shown in Fig. 40. An upright shaft B is driven from the shaft on the card frame carrying the lower calender above mentioned. Near the top of B a pinion E meshes with a rack formed on the coiler plate F. The coiler plate is supported by the framework R of the coiler itself, and by the revolution of E is made to revolve. Through it is an oblique hole, for the passage of the sliver, which has previously come through a pair of calender rolls D. The sliver leaves the disc and enters the can at the edge, and the coil therefore does not fill the whole area of the can. The can itself is made to revolve in

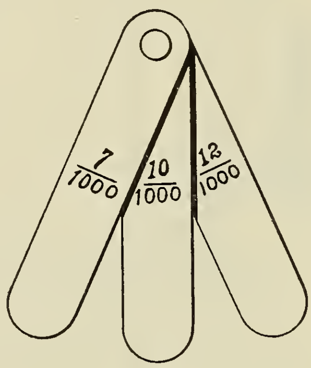


FIG. 41.

the opposite direction from the coiler plate. It rests upon a disc O having a rack formed on it. By the train of gearing I J K L M N, the disc revolves. Since the centre of the can is not directly beneath the centre of the coiler plate, the coils are laid in a can in such a way as to utilize about all of the available space, and yet so that when the sliver is later drawn from the can, there is likely to be no damage caused. Cans may be tightly filled without injury to the cotton. After the card has run a short time the can appears to be full, but by the continuous delivery of more the mass is forced down so that many times as much cotton as one naturally supposes may be got into a can.

The foregoing is a brief description of the passage of the cotton through a card with some discussion of the working of the various parts. Some of the organs require further treatment. It will therefore be the aim of this work next to describe the adjustable parts, and to show the manner in which the adjustments are made on one style of machine. Other styles may be referred to from time to time, and some of the illustrations show various arrangements peculiar to special makes of cards.

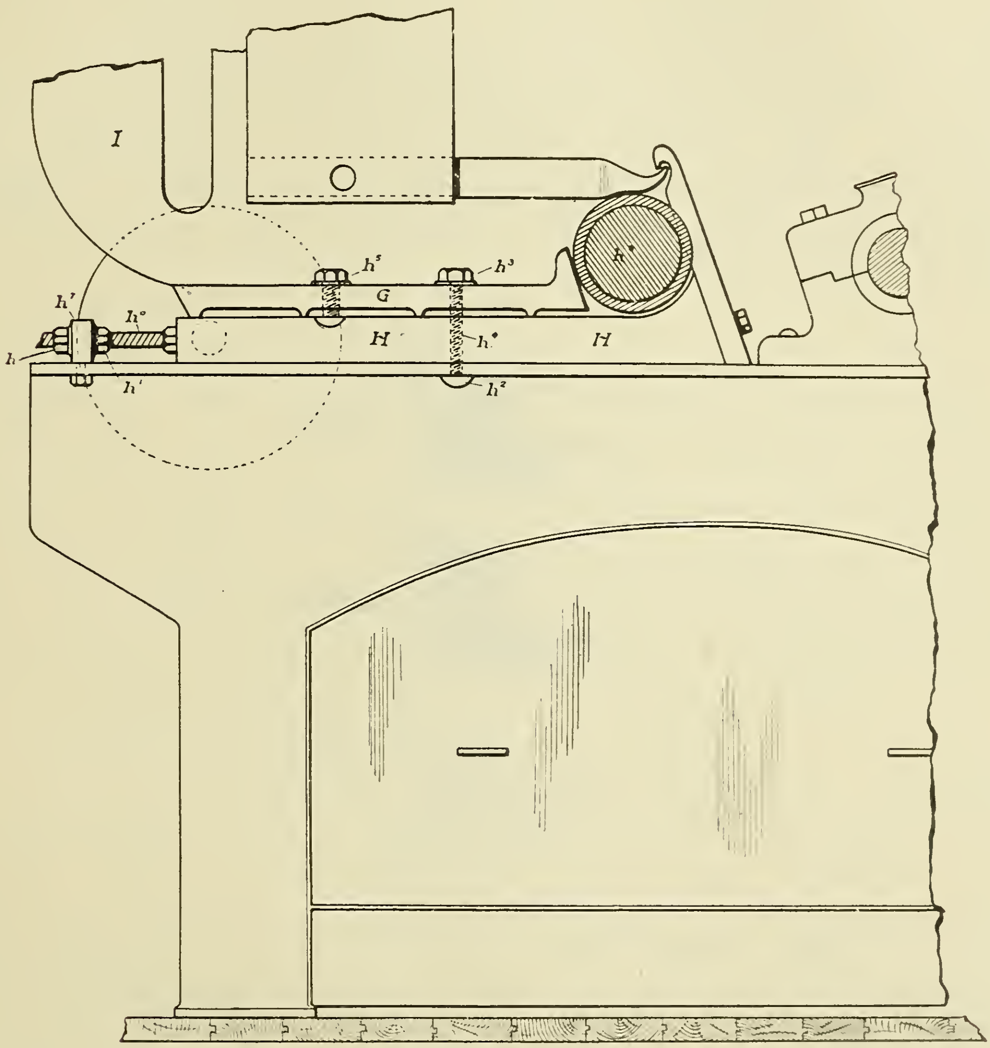


FIG. 42.

The feed plate is always made adjustable. It is set so that its furthermost forward point is a certain distance from the licker-in teeth. The distance cannot be said to be an invariable one. Conditions such as length of staple, thickness of the lap feed, and the speed of the feed roll, are the important factors. If the distance between the plate and the licker-in teeth is between twelve and fifteen-thousandths of an inch, good results can generally be gotten. The exact setting must be obtained by experiment, in which the factors mentioned above play a very important part. It is of the greatest importance that, whatever the setting decided upon may be, the two parts in question be the same distance from each other throughout the whole width of the machine. The parts are made adjustable at both sides of the machine, and by means of thin steel strips or gauges, made of definite thicknesses, any desired distance between them can be obtained. The thin gauge, a view of which is shown in Fig. 41, of the required thickness is slipped between the two parts to be adjusted and must fit with the same degree of tightness at every point, before the parts are fastened in place.

FIG. 43.

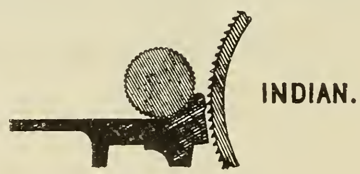


FIG. 44.

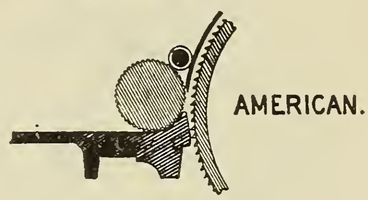
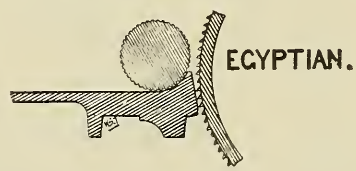


FIG. 45.



The setting screws for the feed plate are shown in Fig. 38, at H, and more clearly in Fig. 42, to which reference may be made. H is the feed plate bolted to the frame of the card by the bolt h^4 which passes through a slot in H and one in the casting G, which is intregal with the lap-stands I. G is bolted to the feed plate at h^5. Attached to the rear end of the feed plate is a screw having threaded upon it the two nuts h and h^1. By loosening h and tightening h^1 the feed plate may be pushed forward towards the licker-in, while an opposite turning of the two nuts will, of course, pull it away from the licker-in. It is important to make the turning of the nuts very slight, and to tighten one exactly as much as the other is loosened.

The shape of the forward part and nose of feed plates has been the cause of much discussion and experiment. The angle of inclination to the horizontal varies on different makes of cards. Some machine builders have decided to make a certain shape, and they adopt that shape for all classes of work and for all varieties of cotton. Theory, which has been carried out with the best practical results, advises the use of feed plates differently constructed for different classes of cotton. In the use of these different shapes, the length of the staple has been the deciding factor. Three types, adapted to very short, medium and long staples, are shown in Figs. 43, 44 and 45, respectively. It will be seen that between them the intrinsic difference is the distance between the gripping point and the point where the fibres will be detached. This distance should bear some close relation to the length of the fibre. If the distance be too great, the fibres will be detached in lump, a proceeding to be avoided as far as possible. Of course it is impossible to avoid this condition entirely. If all the fibres were presented to the licker-in in the direction of their length, ideal combing would be possible. But more of the fibres are probably in a tangled condition, lying in all directions. These are therefore removed bodily from the lap and the combing effect upon them is slight. Yet combing action at this point is very desirable, and every possible means is used to secure it. The use of a carding beater on the finisher lapper does undoubtedly aid to some extent in getting the fibres in a better condition in which to be fed to the licker-in.

Formerly two feed rolls were used, but the advantages of a feed plate over them are so great that it is now in universal use. Its chief advantage is that it prevents the cotton from being detached from the lap in tufts. With feed rolls, the distance from the point of contact to the point where the licker-in detached the cotton, was so great, that any combing action was not often possible. With the feed plate shaped as experience has taught it ought to be, the teeth of the licker-in pass through the end of the lap, do not detach the fibres in such large lumps as formerly, but exert a sort of combing action.

In Fig. 34 the mote knives B^3 and B^4 can be seen to be supported in slots in a bracket b^2. There is one of these brackets at each side of the machine. The lower edges of the knives rest upon the screws b^7 b^8, by adjusting which the knives can be set at any desired distance from the periphery of the licker-in. The bracket b^2 is attached to the licker-in box by means of a bolt b^4 passing through a horizontal slot in the downward hanging part of the licker-in box, and a vertical slot in the bracket. The bracket can therefore be moved in any direction, enabling the mote knives to be set at any desired angle. Experience has shown that a good setting for them is at a distance of about fifteen-thousandths of an inch from the licker-in. Here, too, the same factors mentioned in connection with the feed plate have much influence; the cleanliness of the cotton in use, however, is as important an one as any.

The licker-in screen is adjustable to the licker-in independently of the movement of the cylinder screen. The bolts c^{24} c^{26} in Fig. 34, are

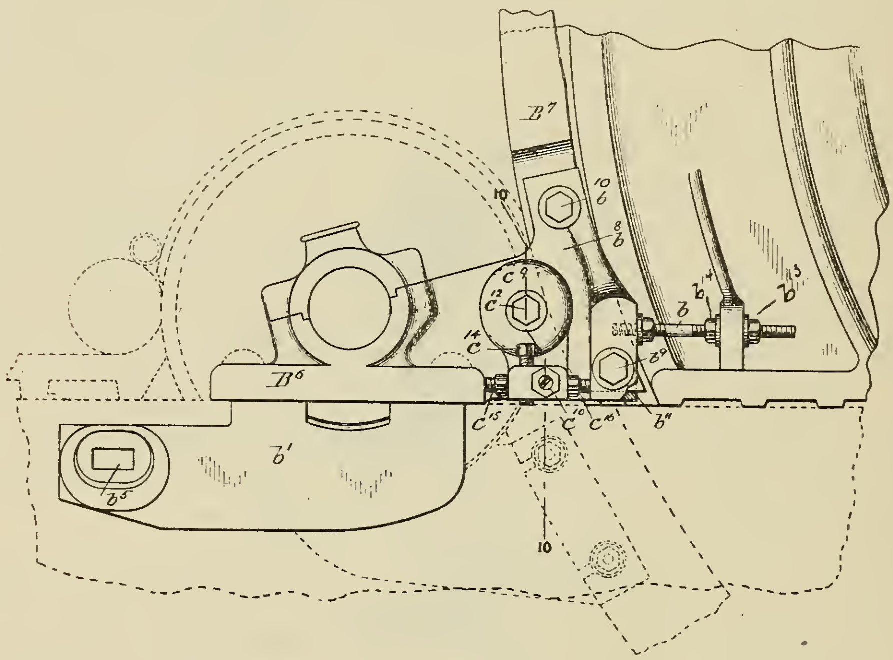


Fig. 46.

fitted in slots. By loosening them, the licker-in screen can be swung around, and set at any desired distance from the licker-in. A distance of .022 of an inch will generally give good results.

In Figs. 32 and 34 may be seen at b^3 a plate known as the "back knife plate." Its function is to prevent air drafts and to prevent the fibres from standing far away from the cylinder surface. The lower edge is sharp, like a knife, and reaches almost to the point where the cylinder strips the licker-in. It is made adjustable and is usually set at a distance of about .017 of an inch from the surface of the cylinder. In Fig. 46 the means for adjustment may be seen. The plate itself is not shown, but it will be readily understood that it is tightly bolted to the make-up piece B^7. B^7 is bolted to the portion b^8 of the licker-in box casting at b^9 b^{10}. By loosening b^9 b^{10}, B^7 may be swung around on B^{10} as a movable fulcrum, and set at the desired distance from the cylinder surface. Of course this adjustment must be made with the licker-in removed, in order that the gauge may be slipped between the plate and the cylinder. Moreover, an adjustment of this knife plate is scarcely ever necessary after it is once properly set.

The licker-in itself has to be set carefully at a fixed distance from the cylinder. A good setting is .010 of an inch. The means of adjust-

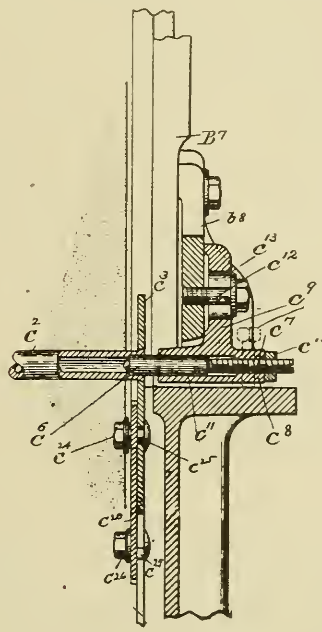


FIG. 47.

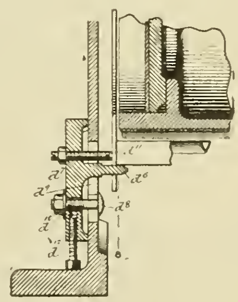


FIG 48.

ment may be clearly seen in Fig. 46. The screw b is attached to the front part of the licker-in box casting, and tightly secured by a lock-nut. The forward end of the screw passes through a portion of the fixed frame of the card. By turning the nuts b^{13} b^{14} the licker-in may be moved towards or away from the cylinder. It is important to notice at this point that by the adjustment of the licker-in, the surrounding parts are also moved. Therefore if these parts have once been accurately set, their relations to the fixed parts always remain the same. Those parts which move with the licker-in are the mote-knives, whose bracket is bolted to b^1 at b^5, the knife plate, attached to licker-in box as above described, and the undercasings, attached to the casting c^9, which in turn is bolted to the licker-in box casting at c^{12}.

In Fig. 34, c^2 represents the end of a tube which extends across the screen from one side of the machine to the other. Its object is to strengthen the screen and to provide means for its adjustment as follows: Into each end of it is fitted a stud c^6 in Fig. 47. This stud passes through the casting c^9 and has a thread on its outer end to receive the lock nut c^{10}. It will thus be seen that the cylinder screen and consequently the licker-in screen, which is bolted to it, is supported at each side by the studs c^6. In the tube c^2 a shoulder is formed against which c^6 can seat itself. Any sidewise movement of the screen may be made by tightening or loosening the nut c^{10} and by screwing c^7 in the direction desired. The more important adjustment is, however, the bringing of the screen towards or away from the cylinder. Evidently this adjustment may be made by moving the casting c^9 through which c^6 passes. Means for moving said casting are shown in Fig. 47. By loosening c^{12} the casting c^9 will be made free to move. By screwing down c^{14} which passes through c^9 and rests against the frame work of the card, the casting, and hence the top edge of the under-casing, may be raised. A loosening of c^{14} will of course allow the screen to be lowered by its own weight. The screws c^{15} c^{16} serve to move the casting and screen forward or backward. A good setting for the screen in question is at a distance of about .022 of an inch from the cylinder.

In Fig. 37 it may be seen that the cylinder screen is in two parts, known as the "back screen" and the "front screen." Both sections have slots at d^5 into which fits the ear d^6, which extends inward from a casting on the outside of the frame (see Fig. 48 and Fig. 32). By loosening the nut on d^{10} which fastens said casting to the frame work of the card, and by raising or lowering d^{12}, which is threaded into the casting and rests against the bottom of the card frame, the bottom of both sections of the screen may be raised or lowered. Lateral adjustment of the front section to the cylinder may be made at d^{15} in Fig. 32. In Fig. 37 the four slots shown in the screen at S are to allow a gauge to be slipped between the cylinder wire and the screen.

Reference may next be made to the means employed for adjusting the flats. The question may already have occurred to the reader why it is necessary to furnish means for adjusting the various organs. The most important reason is, that after time the wire teeth upon the cylinder, doffer and flats become dull with use and require sharpening. Sharpening is done by means of emery which reduces the length of the teeth. In order that the organs may always bear the same relation to each other, some opportunity for changing their position is necessary. The cylinder is the organ to which others are adjusted.

It is important that the surface which supports the flats shall always be concentric with the cylinder. The supporting surface was previously referred to as "the bend" and may be seen at X in Fig. 32. Many methods of constructing this bend have been adopted, but they all depend upon the principle that perfect concentricity with the cylinder must always be retained without regard to the amount ground from the cylinder teeth, or from the flat teeth. The result is that the bend must in all cases be flexible. It is obvious that if the flats were supported on a rigid

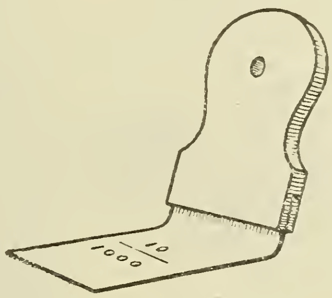


FIG. 50.

arch concentric with the cylinder, any lowering of said rigid arch to bring the flats nearer to the cylinder, would lower the centre of the arch so that it would not longer be concentric with the cylinder. The effect of this movement would be that the flats at the front and back would be farther from the cylinder surface than those at the top. Hence to make it possible for all the flats to be an equal distance from the cylinder, a bend which can be bent to conform to the cylinder surface must be used. We therefore have the expression "flexible bend."

The flexible bend seen in Fig. 32 is a common type and its manner of adjustment is a typical one. It may be seen to be adjustable at five points. The adjusting screws at the middle and the two end points are firmly attached to the bend itself, the other two act as supports. In adjusting this type of bend it is customary first to remove one flat from those which are not in action. The flats are then revolved manually by means of a wrench applied in a manner to be hereinafter shown until the space in the chain reaches the middle setting point. The lock nuts *y* are then all loosened. A gauge such as is shown in Fig. 50 is next put between the heel of one of the flats on one side of the space and the cylinder. By loosening one of the setting nuts and by tightening the other the same amount, the correct distance between the flat and the cylinder at this point can be gotten. The same process is repeated at the two points on each side of the middle one. Finally the two ends are adjusted, after which the nuts *y* are tightened, and the bend locked in place. There are of course two bends, one on each side of the machine; consequently each has

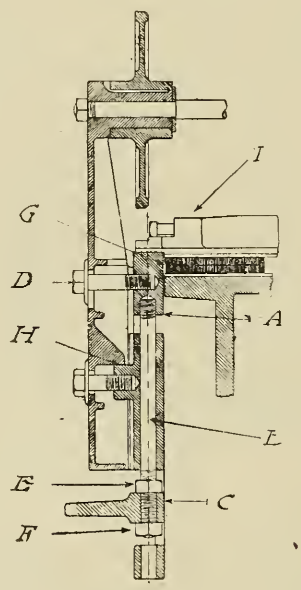


FIG. 51.

to be adjusted. A good setting distance is .010 of an inch; the amount being passed through the card has, however, a very important influence upon the axact setting.

At Fig. 51 the sectional view of one of the setting places for the bend is shown. A represents the flexible bend on which the end of the flat I rests. The stud B is secured to the bend, and passes through a portion of the fixed framework C. On B are threaded the adjusting nuts E and F. The bend is locked in position by a lock nut D. The very small space between the bend and the clothing on the flats and cylinder can be seen at G.

At Figs. 52, 53, is shown the kind of bend used by the American

Machine Company. E is the flexible conical bend upon whhic the end of the flat H rests. The flexible bend E bears upon a rigid conical bend D, which in turn is supported by the framework G. The inner side of E also rests against a part of G. The screw eye passes through the conical rigid bend D, and has threaded upon it the toothed nut C, and the index nut A. To adjust the flats, a setting key B with fluted teeth is inserted so as to mesh with C. By loosening A and turning B, the nut C may be pressed against D, moving it outward. The weight of the chain of flats

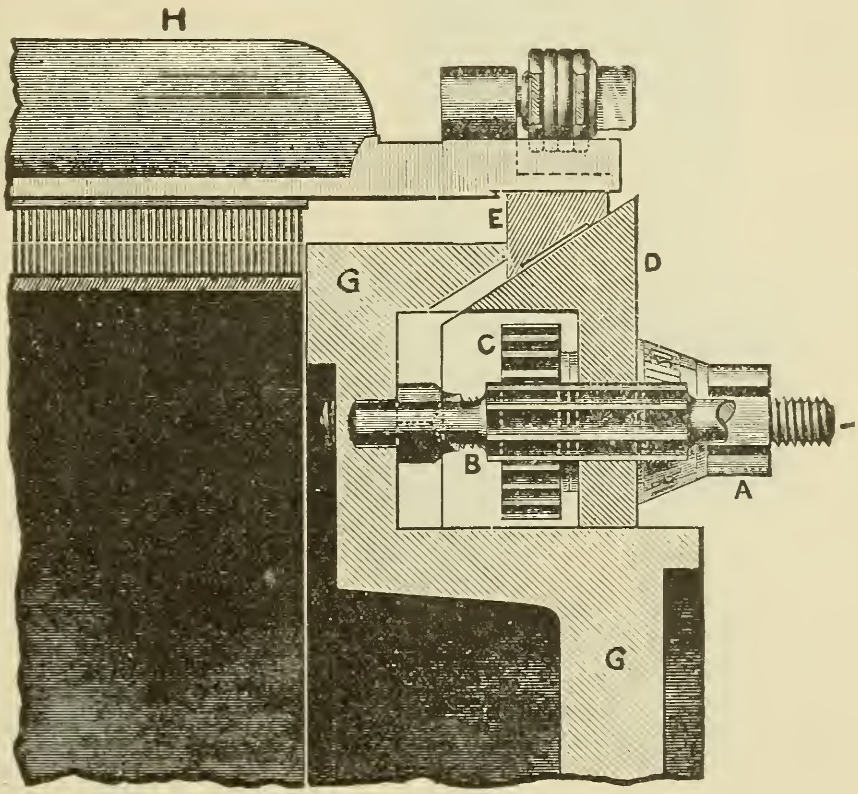


FIG. 52.

resting upon E forces it down and conforms it to a smaller arc. The divisions on A represent thousandths of an inch; hence by turning the nuts the distance of one division, the flats can be raised or lowered by that amount. In this case also there are five setting points on each side of the card.

On some makes of cards it is possible to adjust the cylinder centre. One appliance for making that adjustment is shown in Fig. 54, and will be readily understood therefrom.

As the front of the card is approached, the next part requiring adjustment is the front knife plate. This is really in three parts, as can be seen at Figs. 55 and 56 at E^1, E^4 and E. E and E^1 are both bolted to a make-up piece E^2, while E^4 is a hinged door, by opening which access may be had to the cylinder for the purpose of cleaning and grinding. The make-up piece E^2 in Fig. 55 is pivoted at e^4 to the casting E^3 which may slide in ways on the framework of the card. The plates E and E^1

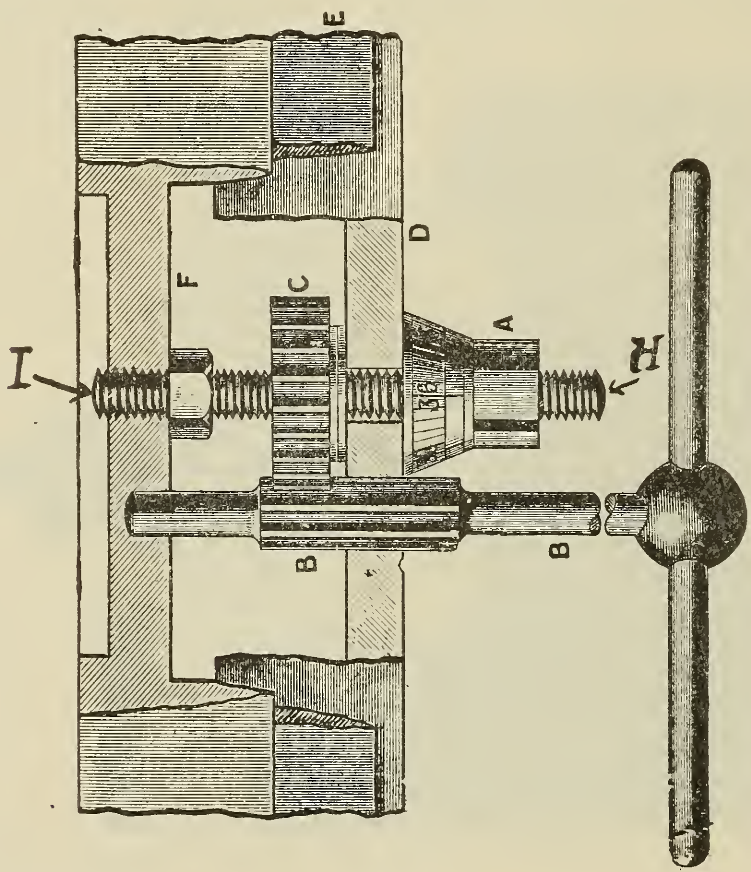


FIG. 53.

are jointly and separately adjustable. By means of the nuts e^1 and e^2 the casting E^3, and consequently the make-up piece and two knife plates, may all be moved towards or away from the cylinder. After each plate has been properly adjusted, they both may be moved together in this manner; at the same time the nuts e^1 and e^2 are the only means for adjusting the lower plate. This is commonly set about .017 of an inch from the cylinder.

The upper plate can be independently set and it regulates to a certain extent the amount of waste which may cling to and be removed by the flats. The nearer it is set to the cylinder, the smaller will be the amount of waste on the flats and *vice versa*. The method of adjusting it can be explained best by reference to Fig. 56. The positions of the plate are there shown, one being in dotted lines. Through the make-up piece E^2 is passed a screw e^6, the end of which rests against a casting E^3. Through an ear in the make-up piece is passed a second screw e^5, which also rests against the casting E^3. By loosening e^6 and tightening e^5 or *vice versa*, the plate may be brought towards or pushed away from the cylinder. Since the make-up piece is pivoted at e^4, a movement of E^1 in one direction will have the opposite effect in a very slight degree upon E.

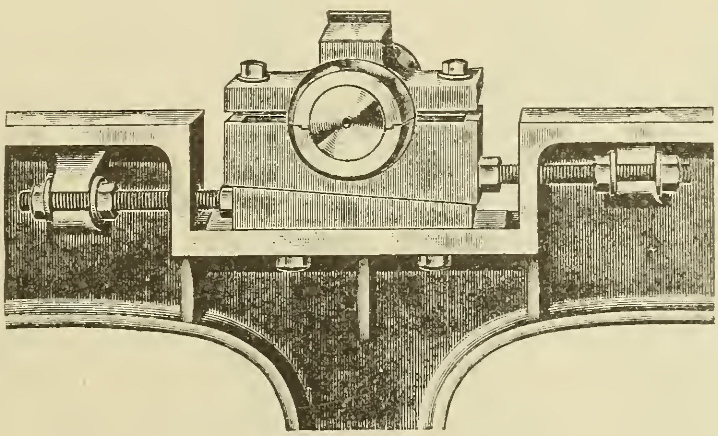


FIG. 54.

The doffer is adjusted to the cylinder by screws and nuts similar to those used for setting the licker-in. These may be seen in Fig. 32. Its distance from the cylinder should be about .007 of an inch. The doffer comb may be similarly adjusted to the doffer. Its distance should be about .009 of an inch.

The manner in which most of the parts of the card receive their power may be seen in the plan in Fig. 57. The cylinder receives its power from the line shaft. The licker-in is driven directly from the cylinder by a crossed belt. A pulley on the other end of the licker-in transmits to a pulley just beneath the doffer. On the shaft with this pulley, which can be clearly seen at D in Fig. 32 in dotted lines, is a small pinion meshing with a large gear wheel on the doffer shaft. The small pinion just mentioned is called the "doffer change gear." From the large gear on the doffer, power is transmitted by the train shown in Fig. 57 to the card calender rolls. Between the shaft of the lower calender roll and the coiler, the connection may be seen in Fig. 40. On the opposite end of the doffer shaft to the large doffer wheel, a bevel gear called the "doffer bevel" transmits power to what is called the "side shaft bevel." On the end of the side shaft near the feed roll a small bevel gear called the "draft change gear" drives a large "plate bevel" on the end of the feed roll. The lap roll receives its power from the other end of the feed roll by the train of gears shown.

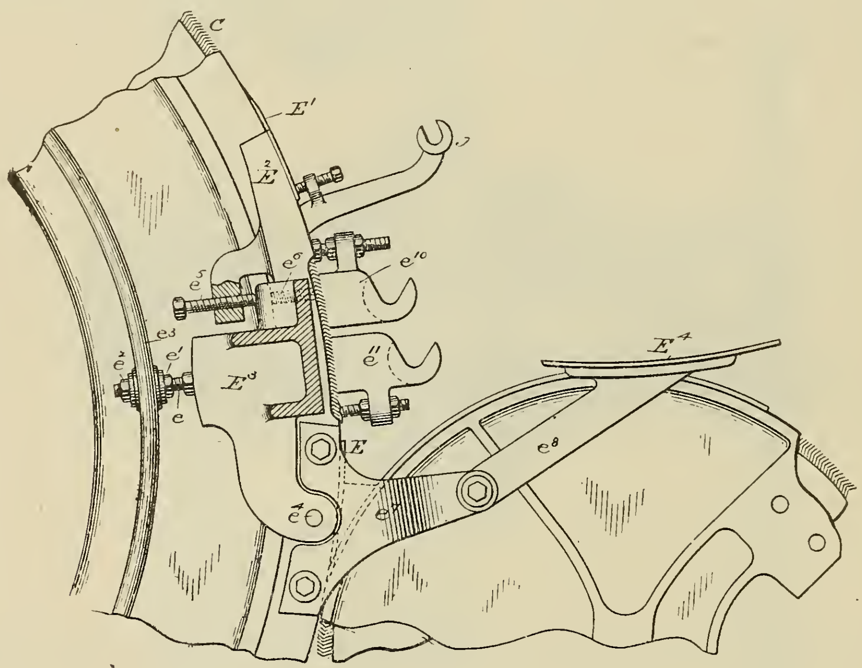


FIG. 55.

There are in all this driving mechanism two gears which can be and are changed. One, the draft gear, changes the relation between the surface speed of the delivering roll and the surface speed of the feeding roll, or in other words the draft. This gear is marked in the drawing, and the effect of changing it will readily be understood. If a draft gear be replaced by a larger one, evidently the feed roll and lap roll will run faster, while the speed of the delivering roll will remain the same. More cotton will be fed to the machine within the same length of time; hence less drawing will take place. The draft is therefore decreased by the substitution of a larger gear for the one in use. The opposite is of course true if a smaller gear be used. If a lap of the same weight per yard be used in both cases, with a large gear, the weight per yard of the sliver delivered by the card will be greater than if a smaller gear were used.

The other change gear, called the doffer change gear, is changed when it is desired to alter the production of the card without affecting the draft. A larger doffer change gear would increase the speed of all parts which this gear drives. Reference to the diagram of gearing and the

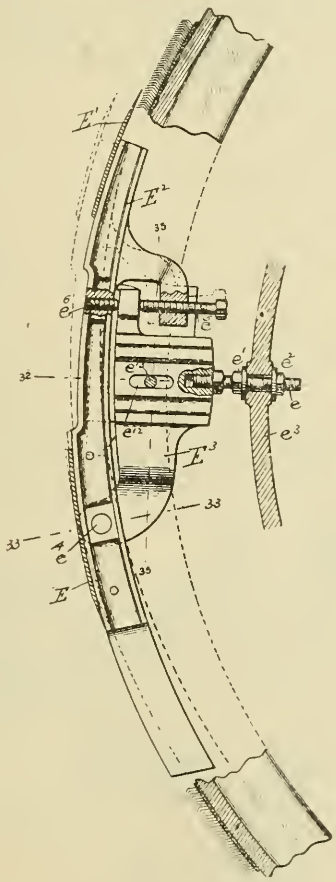
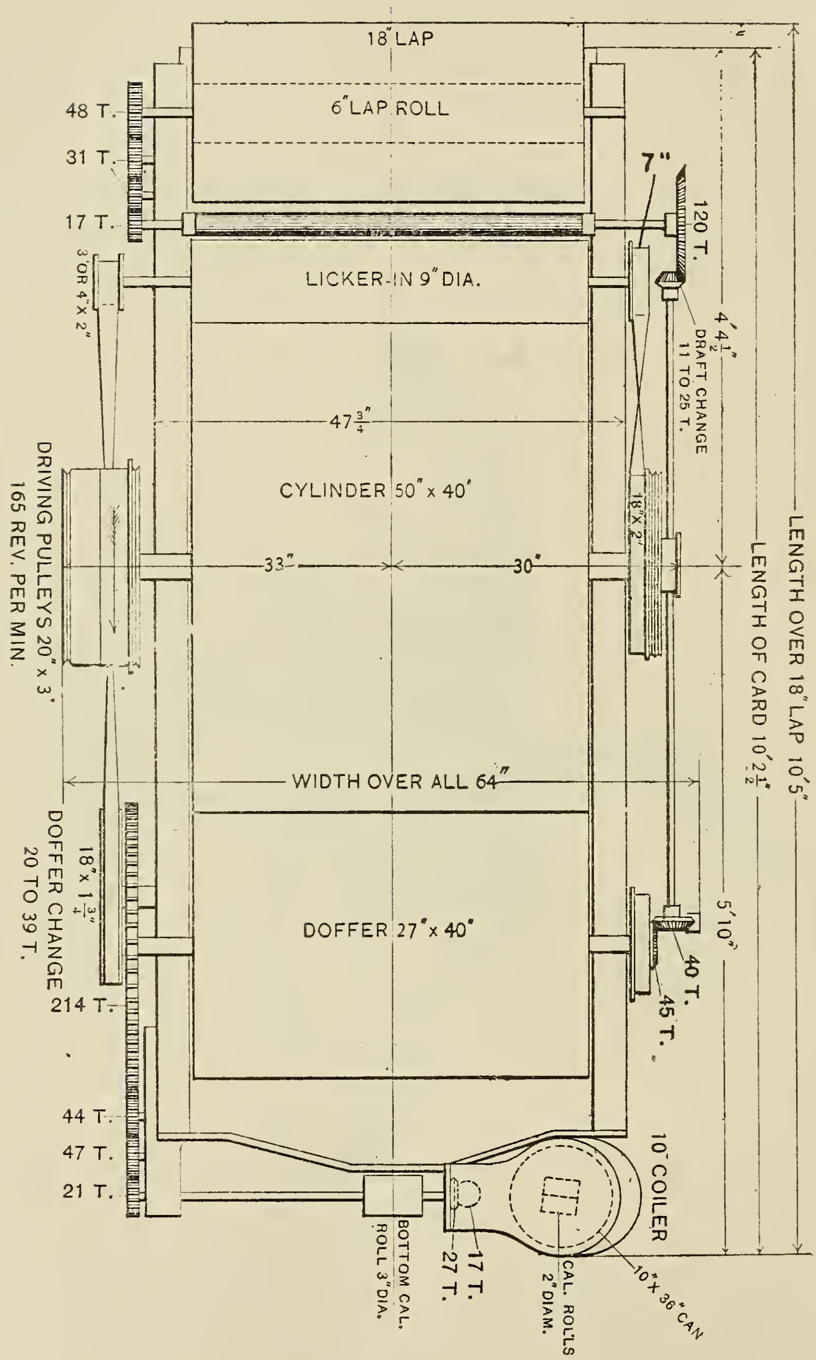


FIG. 56.

accompanying description will show that the doffer change wheel drives the delivering roll through a train of gears commencing with the large doffer wheel, and by another train running from the doffer back towards the feed roll, it drives the feeding parts. Consequently a larger gear would merely increase the speed of all these parts, thus feeding and delivering more yards of lap and sliver than a smaller gear would, while the weight per yard of the sliver delivered would not be changed.



18" LAP
6" LAP ROLL
48 T.
31 T.
17 T.
7"
120 T.
3' OR 4" x 2"
LICKER-IN 9" DIA.
4' 4½"
DRAFT CHANGE
11 TO 25 T.
47¾"
CYLINDER 50" x 40'
18" x 2"
DRIVING PULLEYS 20" x 3'
165 REV. PER MIN.
33"
30"
LENGTH OVER 18" LAP 10' 5"
LENGTH OF CARD 10' 2½"
WIDTH OVER ALL 64"
18" x 1¾"
DOFFER CHANGE
20 TO 39 T.
DOFFER 27" x 40"
5' 10"
40 T.
45 T.
214 T.
44 T.
47 T.
21 T.
10" COILER
BOTTOM CAL.
ROLL 3" DIA.
17 T.
27 T.
CAL. ROLLS
2" DIAM.
10" x 36" CAN

FIG. 57.

To summarize we may say that an increase in the size of the draft gear decreases the draft, and an increase in the size of the doffer change

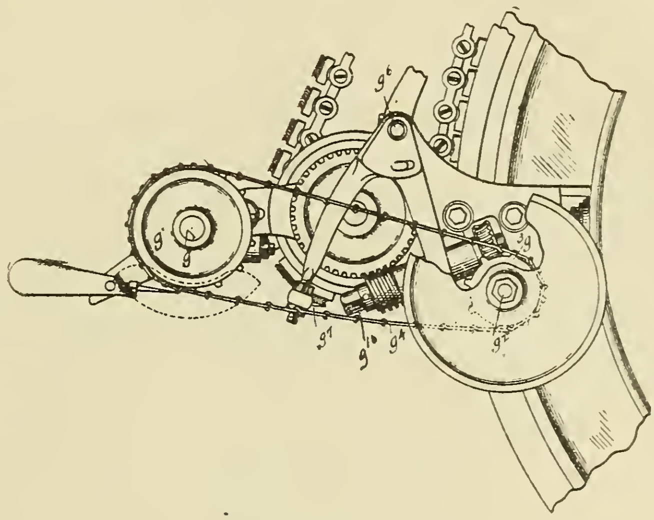


FIG. 58.

gear increases the number of yards produced in a given length of time, without affecting the draft.

In Figs. 58 and 59 the driving mechanism for the flats is shown.

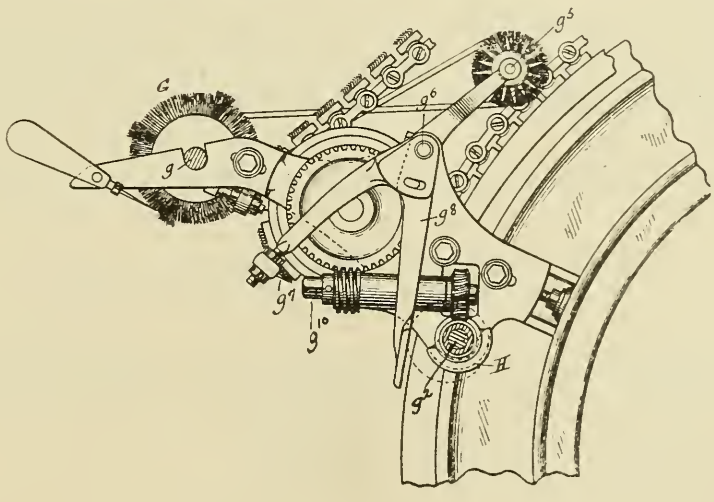


FIG. 59.

A pulley shown on the shaft g^2 is connected with a small pulley on the cylinder by a belt. Integral with this pulley is a worm which drives the worm wheel shown, on the shaft with which is the worm seen in the drawing. This in turn drives the larger worm wheel g^9. On the shaft with this are two sprocket wheels, one on each side of the machine. These engage with a chain of flats. In Fig. 59 on the shaft g^2 is seen a cam which gives an oscillating motion to the compound lever g^3, fulcrumed at g^6. A comb g^7 is attached to one end of the lever and stretches across the machine. It is set very near the teeth on the flat, and by its motion strips them of their waste. They are then further cleaned by the revolving spiral brush G, the driving of which is readily understood from Fig. 58. g^5 is a brush to clean fly from the bearing surface of the flats. g^{10} is a square end of the oblique shaft for the reception of a wrench by which the flats may be revolved manually. In order to turn them it is of course necessary to remove the pulley and worm on the shaft g^2.

CALCULATIONS

There are several calculations to be made on a card, of which those for drafts, draft-constant and production are the most important. All of any consequence whatever will be given, for perhaps through them a better understanding of the principles of all cotton spinning calculations may be obtained.

1.—To find the total draft on a card when all the gears including the draft change gear are known, use rule given in preceding chapter. An example in which the gears shown in Fig. 57, and a 20 draft gear are used, is given below.

Total draft equals

$$\frac{48 \times 120 \times 40 \times 214 \times 27 \times 2}{17 \times 20 \times 45 \times 21 \times 17 \times 6} = 81.24$$

The intermediate drafts which follow are found by considering as the feeding roll the first roll which touches the cotton, and as the delivering roll the last one which touches the cotton.

2.—Draft between lap roll and feed roll=

$$\frac{48 \times 9}{17 \times 4 \times 6} = 588$$

The diameter of the feed roll is 2¼ inches.

3.—Draft between feed roll and licker-in=

$$\frac{120 \times 40 \times 214 \times 18 \times 9 \times 4}{20 \times 45 \times 24 \times 4 \times 9}=856$$

In this case it is necessary, as in all others, to find the relation between the surface speed of the delivering roll and of the feeding roll. Here, however, to trace the connection between the two parts in question the way is less direct than before. It must be remembered, however, that it is possible to calculate the draft between any two points which are connected, no matter how round about the connection may be. It will be seen that some pulleys and the doffer change gear come into the above calculation.

4.—Draft between the licker-in and cylinder=

$$\frac{7 \times 50}{18 \times 9}=2.1605$$

5.—Draft between cylinder and doffer=

$$\frac{18 \times 4 \times 24 \times 27}{7 \times 18 \times 214 \times 50}=.0346$$

Note that in this case the draft is less than one, which of course means that one yard is not drawn out enough to be one yard; in other words, it is condensed into less than a yard. Any draft less than one therefore means a condensation.

6.—Draft between doffer and card calender rolls=

$$\frac{214 \times 3}{21 \times 27}=1.1322$$

7.—Draft between card calender rolls and calender rolls in coiler=

$$\frac{27 \times 2}{17 \times 3}=1.0588$$

8.—Total draft equals the product of all the intermediate drafts= 1.0588 x 856 x 2.1605 x .0346 x 1.1322 x 1.0588=81.24, which is the same as found above.

The examples above given show how the draft at all points on a card may be figured when all the gearing and the dimensions of the various parts are known. In actual practice it is customary for one to determine not so often the actual draft that a card is introducing, as, first, the draft which it is desirable to have it introduce into the cotton, and second, the necessary draft gear to produce the desired draft.

The necessary draft may be found in two ways.

1.—When the weight per yard of sliver which it is desired to produce, and also the weight per yard of lap to be used are known, divide the weight per yard of lap by the weight per yard of the sliver. Some modification of this rule must be made and practiced, since the card produces some waste. The amount varies somewhat on different cards, and can be accurately determined only by experiment. The waste is probably about 5 per cent. Therefore a deduction of 5 per cent. should be made from the weight per yard of the lap.

Example.—One desires to produce a 55 grain sliver from an 11 oz. lap.

11 oz. = 4812.5 grains.
.05

240.625 grains deduction for waste.

4812.5
240.625

4571.875 grains theoretical amount fed.

$4571.875 \div 55 = 83.12$ draft required.

2.—In the second place, if the weight per yard of the sliver alone be known, any draft between 70 and 120 may be determined upon, and from that the necessary weight per yard of the lap wanted may be found. About as good results may be gotten from the use of a high draft as from the use of a low one, but the limits of 70 and 120 are seldom, if ever, passed.

The necessary gear to produce any desired draft may be found by substituting the draft desired for the draft gear in the calculation for draft.

Example.—Find the draft gear required to produce a draft of 100 on a card having the gearing shown in Fig. 37. Calculation 1 was as follows:

$$\frac{48 \times 120 \times 40 \times 214 \times 27 \times 2}{17 \times \underset{\text{draft gear}}{\underset{\uparrow}{20}} \times 45 \times 21 \times 17 \times 6} = \text{draft.}$$

Substituting 100 in the place of the draft gear we have

$$\frac{48 \times 120 \times 40 \times 214 \times 27 \times 2}{17 \times 100 \times 45 \times 21 \times 17 \times 6} = 16.2$$

Answer, 16 teeth.

Since such a calculation is rather long, it has been found convenient to obtain a number which can always be used in finding the draft gear, when any change may be wanted after a card has once been started. This number always remains the same, so long as no gears except the draft gear are changed. It is called the "draft constant," and is found by carrying out the example for total draft with the omission of the draft gear. Since all the gears except the draft gears are not changed, the value of the calculation with the draft gear omitted will always be constant. In the case taken above the constant is as follows:

$$\frac{48 \times 120 \times 40 \times 214 \times 27 \times 2}{17 \times 45 \times 21 \times 17 \times 6} = 1624.83 \text{ draft constant.}$$

It will be seen that in the calculation the draft gear came in the denominator, hence the rest of the example for draft is divided by it. We may therefore derive the following simple formulæ for the use of the draft constant:

$$\text{Draft} = \frac{\text{draft constant}}{\text{draft gear}}$$

$$\text{Draft gear} = \frac{\text{draft constant}}{\text{draft}}$$

A second way of determining the necessary gear to produce a desired draft is by the use of proportion. This method can be used only when the draft which a certain gear produces and the draft desired are known. Since a larger gear produces a smaller draft, the proportion is an inverse one.

Example.—If a draft gear with 20 teeth produces a draft of 80, find the gear required to produce a draft of 90.

$$90 : 80 :: 20 : x$$

$$90\,x = 1600$$

Whence $x = 17.6$ Answer, 18 teeth.

Expressed in words, the rule is as follows:—

To find the necessary gear, multiply the draft in use by the gear in use, and divide this product by the draft wanted.

If the weight per yard of the lap be not changed, but only the weight per yard of the sliver produced, the draft gear needed may be found by proportion. Since, however, a larger draft gear increases the amount fed into the machine in a given length of time, while the number of yards delivered remains the same, each yard delivered must weigh more. The proportion is in this case a direct one.

Example.—Find the gear to produce a 60-grain sliver, if a 17 gear produces a 56-grain sliver, the same weight of lap being used in both cases.

$$56 : 60 :: 17 : x$$
$$56\,x = 1020$$

Whence $x = 18.2$ Answer, 18 teeth.

Expressed in words, the last rule is as follows:—

To find the desired gear, multiply the weight per yard of the sliver wanted by the gear in use, and divide this product by the weight per yard of the sliver being made. If the weight per yard of the lap is also to be changed, the two drafts must be found, and the first proportion may then be applied.

The production of a card is generally stated in pounds per day of 10 hours, or in pounds per week of 60 hours. Of course, the actual production of a card in inches is the surface speed of the coiler calender rolls for the length of time that the machine runs. It is customary and sufficiently accurate to compute the production as the surface speed of the doffer, and then to make an allowance for stopping and for waste. A card produces about 15% less than the theoretical production.

GRINDING AND STRIPPING

After a card has beeen running a little while the wire teeth on the cylinder, doffer and flats become so clogged up with short fibres, neps, etc., that it cannot do its work properly. It has therefore to be cleaned, and very often, too, about three times a day; even more often than that if the production is especially large. The operation of removing the waste from the card wire is called stripping. It is quickly and easily performed by means of a circular wire brush. The teeth on the brush are similar in shape to those on the cylinder except that they are longer and more coarsely set. The brush is placed in the brackets shown at e^{10} in Fig. 55, after the door has been opened. The brush, or stripping roll, as it is more commonly called, is so placed that its teeth, when it is made to revolve in the opposite direction from the cylinder, will strike the cylinder teeth at the back, *i. e.*, at the part where the knee is. The brackets are adjustable so that the teeth on the stripper may be made to enter the cylinder teeth any desired distance. This distance should be about two-thirds of the length of the cylinder tooth. If allowed to enter more deeply they may cause the waste to become more deeply imbedded, or they may injure the foundation of the clothing itself.

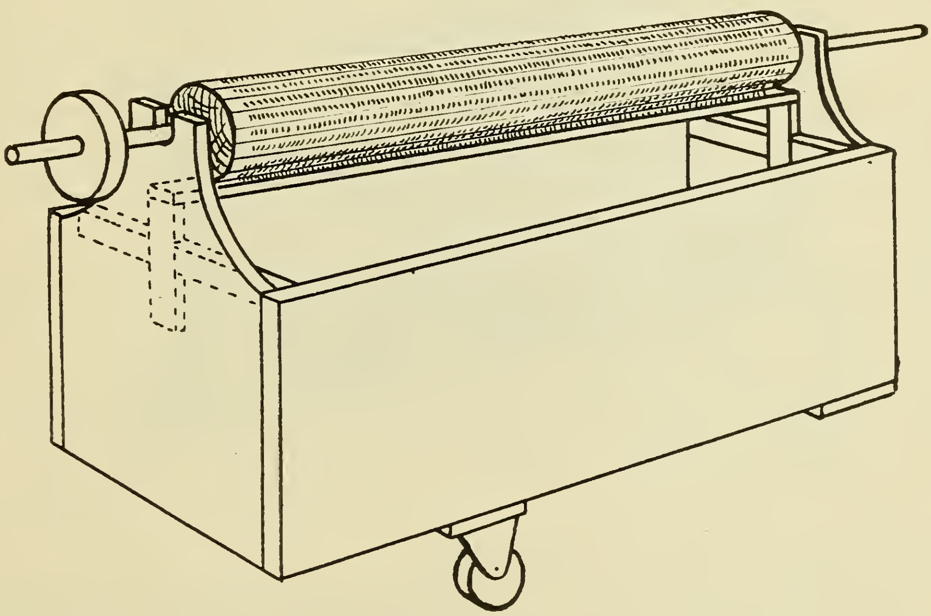


Fig. 60.

On the end of the stripping roll, at the side of the card carrying the driving pulleys, is placed a grooved pulley. This is connected by a crossed band with the large loose pulley on the main shaft of the card.

To perform the operation of stripping, the driving belt of the card is moved by hand from the fast to the loose pulley, and the card allowed to stop. At the same time the side shaft bevel is thrown out of gear with the doffer bevel by means of a handle at the side of the card provided for the purpose. In this manner the feed roll and lap roll are stopped. Another handle at the front of the card is also turned, to throw one of the gears in the train driving the coiler out of gear, thus stopping the coiler and card calender rolls. When the card has come to a standstill and the stripping roll has been placed in position and has been connected by a band with the loose pulley, the cylinder is slowly started by hand, while at the same time the stripping roll is revolving very fast. The difference in speed and the relative inclination of the teeth make it possible for the stripper to take all the cotton on the cylinder to itself. When all the waste has been removed, the stripping roll is quickly removed, care being taken not to allow it to stop moving before the cylinder does. To strip the doffer, a similar operation is gone through with; the stripping roll is placed in the brackets in the same manner as before, and is started up, stopped and removed just as previously described.

The stripping roll itself is cleaned on what is called a "stripping box." One is shown in Fig. 60. Directly beneath the stripping roll which is placed in the bearings shown, is a flat strip of wood covered with clothing like that on the stripping roll. The two sets of teeth engage with each other and by rapid movements of the stripping roll, first in one direction and then in the other, all the cotton is easily taken from the stripper.

The clothing on the flats is stripped automatically, as they reach the front of the card. An oscillating comb previously referred to in connection with Fig. 58, is set a very short distance from the edge of the flats, and by its upward and downward movement it pulls the waste away from the flats in strips. As the flats pass up over the top of the card they are further cleaned by the spiral brush seen in Fig. 59. The "strips," as the waste is called, is wound up on a stick, which gets its motion from frictional contact with the moving flats.

In addition to cleaning, the clothing on a card has to be ground. After about a month's wear the wire teeth become too dull to comb the cotton properly, but a little grinding with emery speedily brings them back into their right condition. Two types of rollers are used for grinding, one known as the dead roll, and the other called a traverse grinder. The traverse grinder is most commonly used on cylinders and doffers, and the long dead roll on the flats.

The operation of grinding is performed as follows: The card is first cleaned very carefully. The belts used to drive the licker-in, doffer and flats are removed, as well as the pulley and worm shown in Fig. 58. The doffer is then connected directly with the cylinder by a belt running from the pulley which had previously been used to drive the licker-in to a pulley on the doffer. This belt is an open belt, so that the doffer must revolve during grinding in the same direction as the cylinder, the reason of course being that the teeth on each are inclined in the same direction. The main driving belt is then changed for another which will cause the cylinder to revolve in a direction opposite to its normal one. The grinding roll is placed in the brackets provided for it, and has the grooved pulley on its end connected with a grooved pulley on the cylinder by an open belt. A second grinding roll is placed over the doffer and connected with the cylinder in a similar manner. After all the above named operations

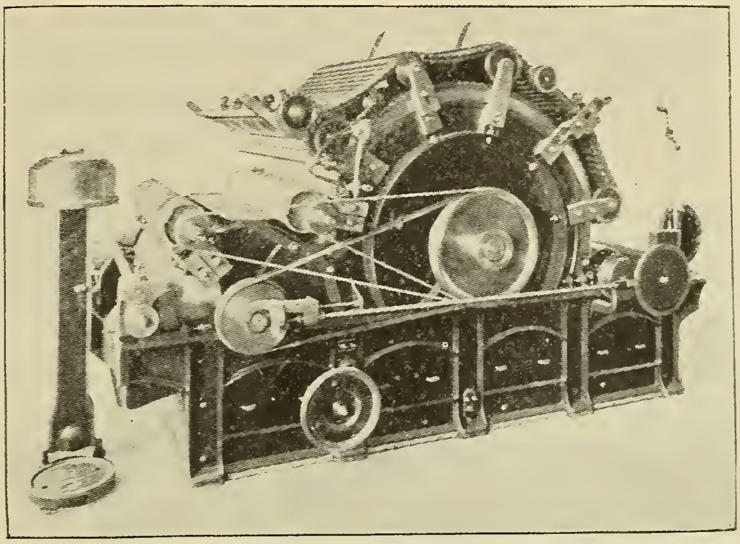


FIG. 61.

have been done, the brackets supporting the grinding rolls are adjusted and the grinding rolls set by means of a thin gauge as near to the cylinder and doffer as possible, without being allowed to touch. Each roll is then set a little nearer, being allowed to touch the wire very lightly. The closeness of the contact is determined by sound and some little practice is needed before the proper setting distance can be obtained. In no cases should the contact be close enough to allow sparks to fly, and it is a good general rule that light grinding at frequent intervals is much preferable to heavy grinding at longer intervals. Fig. 61 shows a card ready for grinding.

CHAPTER V

DRAWING

On especially high-class work, whose market price warrants the additional expense incurred, it is customary to use a process known as "combing." When combing is not used, the machine which follows the card is either a "railway head" or a "drawing frame." There are,

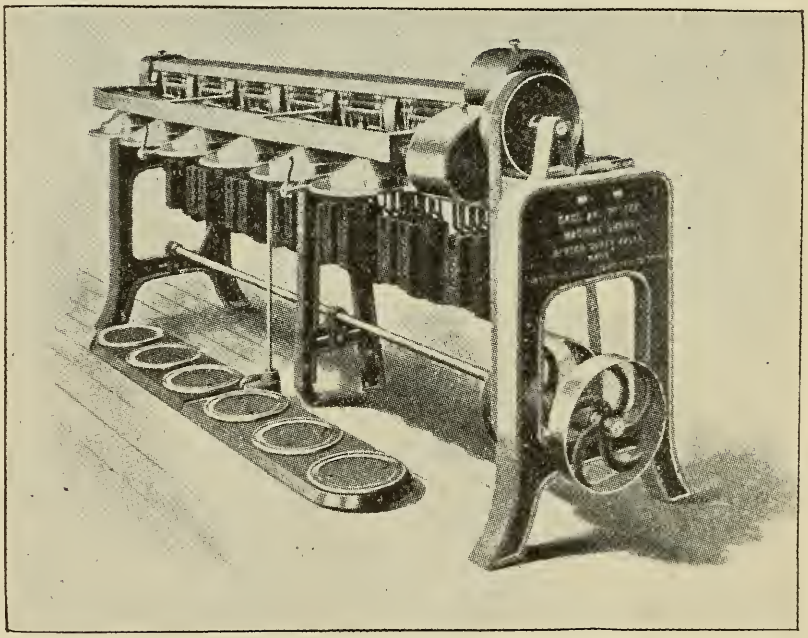


FIG. 62.

indeed, two systems in vogue, to which the names "American" and "English" have been given. In the former the railway head follows the card, and after it are used two sets of drawing frames, *i.e.*, two machines identical in construction and working, performing exactly the same process. In the latter, three sets of drawing frames are used with on railway heads. The modern railway head is practically a drawing frame with a certain characteristic device. It will be described after the theory and principles of the drawing, as well as a description of the drawing frame, have been given.

If the carding machine works properly, it should produce a sliver fairly free from neps, dirt, and all foreign matter, and with comparatively few short fibres remaining therein. The fibres themselves are not perfectly parallel. In fact, to one examining the web coming from a doffer, they will appear not to approximate that condition very nearly. They certainly are not tangled and matted, and even if some are crossed, they are in such a condition that a pulling upon them in the direction of their length will reduce them to parallel order. It is one duty of the drawing frame to perform this parallelization. The reason why parallelization is necessary needs little if any discussion, if the kind of thread to be produced be borne in mind. Cotton yarn, except in its debased use when mixed with wool to deceive the trusting public, should be strong, smooth, and as nearly cylindrical as possible. It is very evident that if many fibres may be got into a cross section, the strand will be stronger than if few were there. It is equally true that the greatest number can only be obtained when the fibres are parallel. A parallel arrangement is also obviously conducive to smoothness and cylindricality. Therefore, an attempt to make the fibres parallel is made at the drawing frame. When a comber is used before a drawing frame it usurps this function, and leaves the drawing frame only its second duty to perform, namely, that of producing a sliver more uniform in weight and diameter than the one fed to it.

The action and construction of a drawing frame are simple; its importance is very great. By it the cotton is brought to a condition in which the fibres lend themselves to the gradually reducing processes, which decrease the size of the strand from one nearly an inch in diameter to one of very great fineness. At this point, too, the last opportunity for correcting on a large scale the inequalities still existing in the sliver is given. Four sets of rollers perform the work of drawing. The four sets of rollers revolve at gradually accelerated speeds, the front rolls having a surface speed about six times as great as the back rolls. Six slivers are usually fed in together side by side, forming a rather heavy, wide strand. By the action of the back rolls this heavy strand is compressed and passed on to the second set of rolls. Since these go at a speed about 1.25 times that of the back roll, they draw the strand on, and of course reduce its thickness. At the same time the fibres are, by this very process of drawing, made gradually to approach parallel order. The exact action of the rolls demands a few words. In the first place, the rolls are sufficiently small to allow the distance from the centre of one set to the centre of the next to be nearly as short as the length of the fibres being worked. They are at the same time made as large as possible consistent with the above condition. Being adjustable, various sets may be fixed at any desired distance from the next one, which distance must always exceed the length of the fibres. Such a state of affairs shows that as every fibre passes from one set of rolls to the next, it occupies one of three general positions; first, it is held at one end by the back set of rolls, while its forward end is free from all action except that of the contiguous fibres upon it. They are being drawn forward by the second set of rollers; hence they slide away from the fibres still in the grip of the back rolls, and by this very sliding action they tend to straighten out the free end of every fibre held by the back rolls. The second position occupied by each fibre is one in which neither end is held. Fibres lying entirely between two sets of rolls have two influences acting upon them, one tending to hold them back, and another tending to draw them forward. The fibres held by the slowly revolving back rolls exert the retarding action, while those in the nip of the more swiftly moving second set exercise the onward pull. The effect of each is to straighten both ends of the free fibres. The third position is obviously that of being held in the grip of the second set, while the back ends of the fibres are free, and are acted upon by the retarding influence of the surrounding fibres. These three conditions recur between the second and third sets of rolls, and between the third set and the front rolls. The drawing between the third set and the front rolls exceeds that at all other points, the increase in draft being gradual. While the parallelizing effect has been described with reference to the two back sets, it is not as great there as between the forward sets. At first the strand made of six slivers combined is rather heavy, therefore in order to avoid rupture a small draft only is permissible. A typical arrangement of drafts is 1.25 between back and second, 1.75 between second and third, and 2.75 between third and front rolls. The principle of a small draft accompanying a heavy strand is carried through all the processes of cotton spinning.

One important element in the theory of drawing is the distance from centre to centre of the different sets of rollers. No rule for the exact setting can be laid down, but there are certain underlying principles which, coupled with experience and good judgment, must bring satisfactory results. The setting distance depends upon first, the length of staple, second, the amount of draft, third, the size of the strand, and fourth, the character of cotton used. With long staples the settings must be wider than with short staples. With high draft, all settings must be wider than with low or easy drafts. Thick slivers demand wide settings. The harsher and tougher the fibre, the wider the setting. These general principles apply to the four sets of rolls. The various sets are, however, not all put at the same distance apart. It is a good rule always to set the front and third set about $\frac{1}{16}$ or between that and $\frac{1}{8}$ of an inch further apart than the length of the staple; the third and next to the back set about $\frac{1}{8}$ or $\frac{3}{16}$, and the second and back $\frac{3}{16}$ or $\frac{1}{4}$ of an inch. The difference in the thickness of the strand at the different points is the main influence upon these relative settings. Although opportunity for the adjustment of the rolls is offered, yet if a change be made from long Sea Island cotton to very short American, it would be impossible to bring the rollers near enough together; in which case smaller rollers must be used. Such a great change is not likely often to occur in the same mill; it is mentioned here merely to show that small rolls accompany short staples and vice versa. The effect of too narrow setting would be breakage of the fibres. The short broken fibres would appear in the finished yarn as little bunches. Such yarn is said to be "cockled." With too wide settings the drawing would be uneven and the amount of waste would be increased.

The second function, evening, is a very important one; all important on the second and third frames, and on all when the comber is not used. It is made possible by feeding six slivers to each portion of the machine from which one sliver is to be delivered. It has been previously shown that drafts of 1.25, 1.75 and 2.75 are introduced, which give a total draft of about 6. The resulting sliver is therefore about the same weight per yard as each one fed. The principle involved is that of doubling, to which reference was made in connection with the feeding of four laps to an intermediate or to a finisher lapper. It is undeniably a fact that doubling, so called, does materially aid in producing an uniform strand. The probability is that heavy places will offset light places more often than two heavy places or two light places will come together. Even more important than this is the fact that whatever inequality may exist in any one sliver fed to the drawing frame, will be reduced at its first passage to an inequality only $\frac{1}{6}$ as great. This is, of course, due to the drawing out of six slivers without materially changing the weight per yard. By the second passage through a drawing frame the inequality is further reduced six times. It is then only $\frac{1}{36}$ as great as originally, and after leaving the third head, it is only $\frac{1}{216}$ of what it was at first. It will be seen, therefore, that three processes of drawing have much influence upon the evenness and weight and size of the strand of cotton.

In Fig. 62 the front of the drawing frame is shown. Places will be seen for the reception of six cans. Each can receives one drawn sliver, and the place where the sliver is delivered is called a "delivery." A group of deliveries constitutes what is called a "head." A head of six

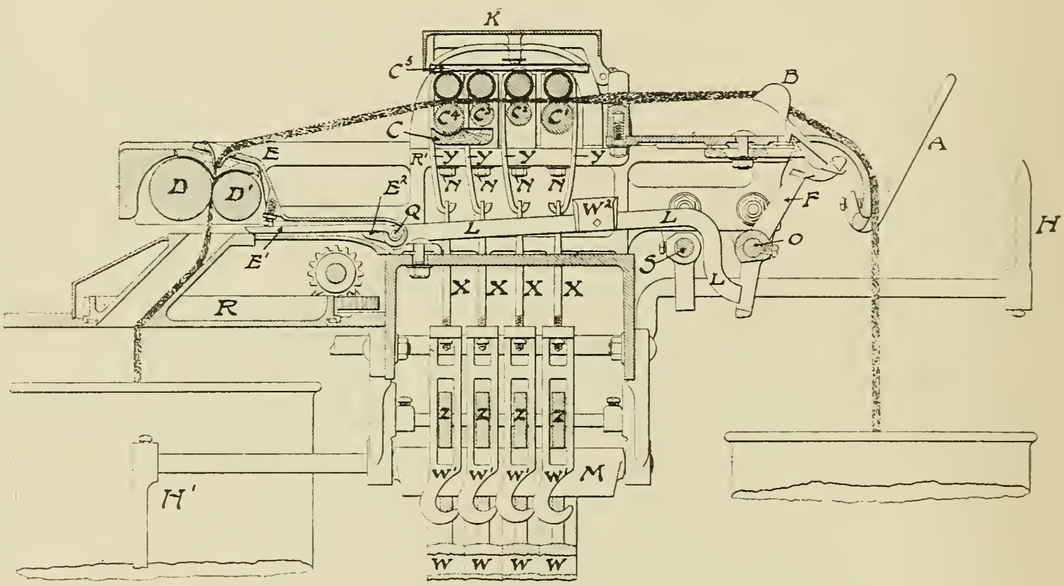


FIG. 63.

deliveries is shown. The sectional view in Fig. 63 may best be referred to in connection with the following description: The cans of sliver are placed at the back of the machine, six cans behind the portion from which one sliver is to be delivered. Each sliver is drawn out of its can through a guide shown at A. It then passes over a spoon-shaped lever B. Six of these spoon levers are placed side by side, and after passing them, the six slivers enter the back rolls together. After passing through the four sets of rolls the thin sheet is formed into a strand by the trumpet hole at E, then passes between two calender rolls, into a coiler, and is then coiled into a can as on the card.

The four bottom rolls are made of steel and fluted longitudinally on their "bosses." A view of the rollers is shown in Figs. 64, 65 and 66. In Fig. 64 the bosses of the bottom roll are seen at *b*. There are as many bosses as there are deliveries in the frame. "Necks" *n* are formed at intervals and upon these the roller revolves. These necks rest in brass steps in roller stands, an end view of which can be seen in Fig. 63. The bottom rolls appear to be continuous and to extend the entire length of the machine. Actually they are made in short sections, and fitted together by a square socket joint as shown in Fig. 66. The separate sections are driven together when the machine is erected, and when the rolls are removed later for periodic scouring, each lower roll is taken out in one

FIG. 64.

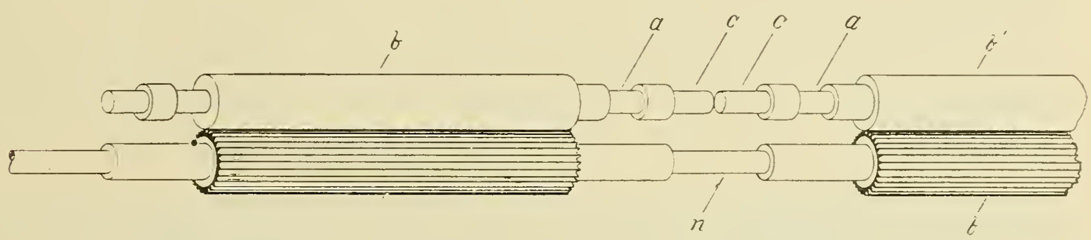
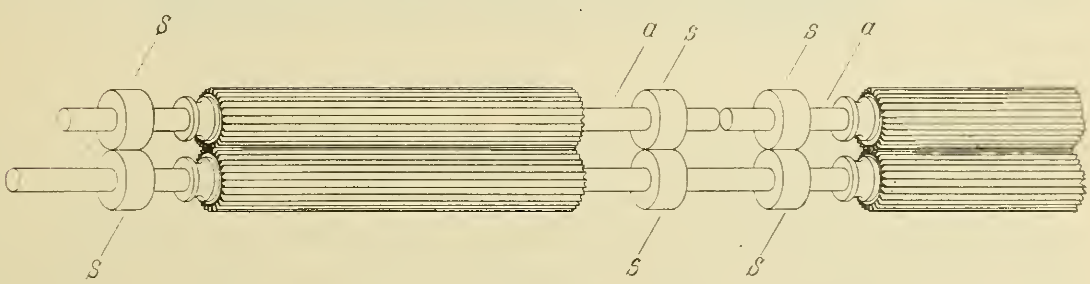


FIG. 65



continuous length. The various roller stands are bolted to the "roller beam" R by the bolts N (Fig. 63). By loosening N the stands may be moved to allow the distance between any two sets of rollers to be regulated.

The top rolls are short as shown in the drawing, and rest directly on top of the bottom roll. They are made of cast iron, and have their bosses covered with a carefully prepared woolen cloth, and that with thin smooth leather. Hooks *y* (Fig. 63) rest over the arbors of the top rolls (see Fig. 64) and have hanging from their lower end the stirrups *x* which in turn support the cast iron hooks W^1. Hanging from W^1 are the weights W. These can be plainly seen again in Fig. 63. Their function is to hold the top roll firmly in contact with the bosses of the bottom rolls. Since the top rolls receive their motion by friction only, the weights must be sufficiently heavy to insure a tight grip upon the cotton, and effectually to prevent slipping. The ends of the top rolls *c* (Fig. 64) rest against the upward extending sides of the roller stands, and are thereby prevented from slipping forward or backward.

There are in use three general types of top rolls, known as the "solid roll," the "shell roll" and the "metallic roll." The first two types are both leather rolls, and are undoubtedly most extensively used at present. The solid roll is the oldest type of all. It is made of cast iron and shaped as shown in Fig. 64. Its boss is covered with finely pitched circumferential grooves, which form a rough yet regular surface to which is glued a specially prepared cloth. The quality and character of the cloth vary from shoddy with a cotton face, to pure soft wool of fine quality. The quality and coarseness of the yarn desired, and the characteristics of the cotton used are the determining factors. In all

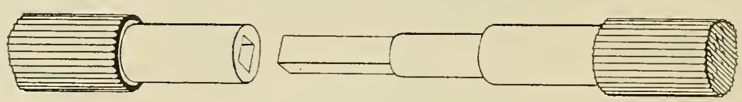


FIG. 66.

cases the cloth is carefully prepared and so skillfully put upon the roll, as to make a perfectly cylindrical surface. Over the cloth is pulled a cot of specially prepared smooth calf-skin. The leather fits very closely over the cloth, and the two together furnish a cushion surface to the cotton when it passes between the rolls.

The shell roll resembles the solid roll in general appearance when on the machine, but is somewhat differently constructed. Instead of having the cloth and leather applied directly to the solid cast iron spindle of the roll, it is supplied with a cylindrical shell or loose boss. The covering of cloth and leather is applied to the shell which slips over the spindle of the roll, and is held in place by small springs. When the machine is running, the loose boss revolves around the roll spindle. The weights are hung as on the solid roll, resting upon the spindle. They are necessarily somewhat heavier, however, to prevent slipping. This type of roll has become very popular, especially as a front roll. Its good features are decreased friction, owing to the fact that only the bosses, and not the whole roll itself, revolves, and facility for lubrication. Rings or strips of flannel are fastened inside the shell to the roller spindle. These carry oil for a long time, consequently obviating the necessity of frequent oiling. The argument urged against the shell roll is its tendency to slip. This disadvantage has been almost entirely overcome, however. Fig. 67 shows a section of the shell roll. The loose boss B fits over the spindle A of the roll S and is held in place by the sleeve C, which is slipped over the end of the spindle and secured in position by the engagement of a small spring with the groove C¹. The pieces of flannel for carrying oil are shown at *f*. The hooks which support the weights hang from the arbors *a*.

The metallic roll is made of steel with a fluted boss (see Fig. 65). When this type of roll is used, the top and bottom rolls have bosses exactly alike. The flutes are deeper than those on the ordinary steel bottom rolls, and the pitch of the flutes, owing to the difference in the thickness of the strand of cotton, decreases on each succeeding set of rolls

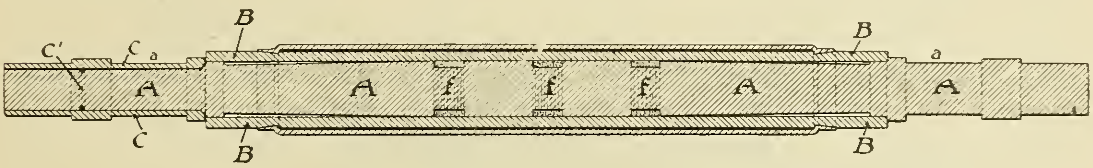


FIG. 67.

from the back to the front. The flutes of the top and bottom rolls mesh with each other after the fashion of spur gears; too deep contact is prevented by the collars shown at *s* in Fig. 65. Weights are applied to the arbors *a;* they must be only sufficiently heavy to maintain a grip between the teeth of each roll. It will therefore be seen that metallic rolls are positively driven like gears; no slipping is possible, and crushing of the fibre is prevented by having the teeth mesh not too deeply. Their introduction has not been universal owing to the existing skepticism in regard to their not injuring the fibres. As a matter of fact they are actually giving very good results on the stronger fibres. Slippage of leather rolls is an influential factor in producing uneven yarn; hence the aim has been to secure a type of roll absolutely free from that fault. The expenditure for re-covering leather rolls, considerable in itself, is entirely done away with, and is by no means overbalanced by the additional first cost of metallic rolls.

Since the four sets of rolls do most of the very important work of drawing, too much care cannot be given to keeping them in proper condition. Bottom and top rolls need considerable attention. Leather top rolls in time require re-covering, how often depends upon the roughness of their usage, the speed of the machine, the weight of the strand, and the quality of the cotton. To keep them smooth and to preserve their life, they are commonly covered with varnish, composed of glue, acetic acid, usually a green or red coloring matter, and oil of cloves, or a similar ingredient. A leather roll which is not perfectly cylindrical will invariably produce uneven sliver. Whenever such unevenness is made on the machine, the flutes on the bottom roll are almost always the cause. While the machine is running, however, there is little chance for them to damage the leather. No two successive pairs of flutes are the same distance apart. The difference in pitch of the flutes on a bottom roll is not discernible with the naked eye; it nevertheless exists, and effectually prevents the flutes from striking the same part of the top roll very often. On the other hand, when the machine is standing with heavy weights pressing firmly on the top rolls, ridges will be formed wherever the flutes come in contact with the leather. To prevent such injury a device partially seen in Fig. 63 proves useful. Through slots in the hooks W^1 extend slats Z. Beneath them is a cam M, operated by a handle H^1. By turning H^1, M may be made to press against the slats Z, which in turn raise the hooks W^1 and consequently the weights W. The rods X simply pass through the holes in the hooks W^1. Hence when raised, the hooks W^1 slide upward away from the sustaining nuts. The pressure of the weights is thereby removed from the top rolls. This device should be actuated whenever the machine is to be stopped for any length of time. The defects to be found in bottom rolls and metallic rolls may usually be remedied by periodic scouring. The flutes occasionally become rough, sharp or clogged up. At fixed intervals, two or three times a year, all bottom rolls and metallic rolls should be removed and scoured with whiting and oil. A mixture of these ingredients rubbed lengthwise of the flutes with pieces of card clothing does an immense amount of good. Aside from ordinary wear and tear the above are the most important points needing attention.

A drawing frame produces considerable fly, consisting of short fibres which the card has failed to remove. To catch these and to prevent their re-entering the cotton, top and bottom clearers C^5 and C, Fig. 63, are provided. C^5 is an endless band of flannel stretched over rods held in the hinged cover K. C consists of a piece of wood covered on the top with flannel, and held in contact with the bottom rolls by small weights hung by cords of leather over the front bottom roll.

To insure the feeding of the full number of slivers to the machine at all times, and to prevent excessive loss in time of breakage, stop motions are applied. There are two general types of stop motions, the mechanical and the electrical, yet the details of the particular ones under each general type differ considerably. The mechanical stop motion is usually applied at three places, stopping the machine if a sliver break while passing from the can to the back rolls, or while passing from the front rolls to the

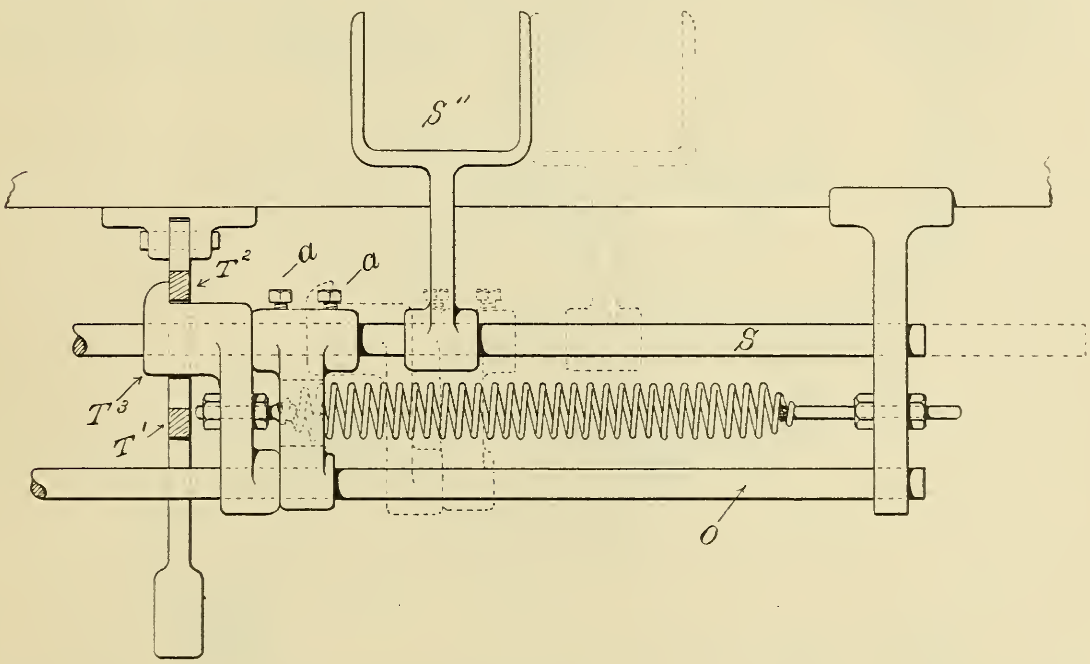


FIG. 68.

coiler, and when the cans receiving the drawn sliver have been filled. By reference to Figs. 63, 68, 69 and 70, one style of mechanical stop motion may be explained. The spoon levers, over one of which each sliver passes, are unevenly balanced and supported on a knife edge as shown in Fig. 63. The tension of the onward moving sliver holds the lever in the position shown in the figure, keeping the notched tail-piece away from the moving feeler bar F. F is fastened to the shaft O, which is given an oscillating motion in a manner easily understood from Fig. 69. To the rod O, which carries the feeler, not shown in Fig. 69, is fastened the casting S^1 pivoted at S^2 to a forked lever S^3. The fork of S^3 fits about a pin S^6 on the gear S^4. S^4 gets its revolution from the roller gearing. As S^4 revolves, the fork S^3 receives an oscillating motion which is communicated to O, the inertia of the feelers and their attachments being sufficient to prevent the knuckle joint at S^2 from bending. The lower part of S^3 can be seen to be formed into a finger which rests against the

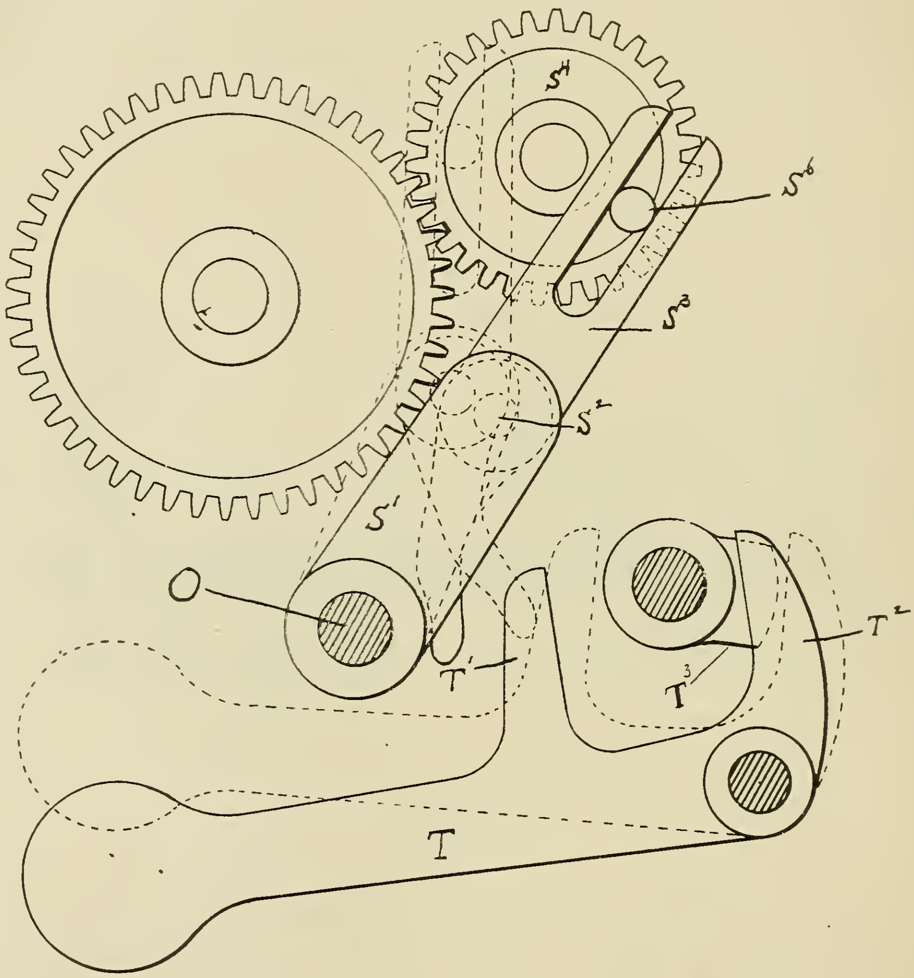


Fig. 69.

projection T^1 on the weighted lever T. The upward extending projection T^2 of the weighted lever engages as shown in Fig. 68, with a catch on the casting T^3. T^3 may slide along on the rod S, being fitted loosely therein. It is also penetrated by the shaft O. (The same letters represent the same parts in each drawing.) The casting V is screwed to the shipper rod S by the set screws *a a* and has a forked end fitted around the shaft O. Whenever S moves, V may move along O. Further along the rod S is the belt fork S^{11} which is used to move the belt from the fast to the loose pulley or vice versa, to stop or start the machine. Suitably attached to the slipper rod is the handle H shown in Fig. 63. Continually pulling against the casting T^3 is the spiral spring attached at the opposite end to a bracket bolted to the machine frame. When the machine is running, the parts occupy the position shown in Fig. 68. The belt is on the fast pulley, T^3 is held in position by the projection T^2 of the weighted lever. The action of this mechanism is as follows: When a sliver breaks at the back of the machine, the heavy tail-piece of the spoon lever falls into the course of the oscillating feeler bar F. The shape of

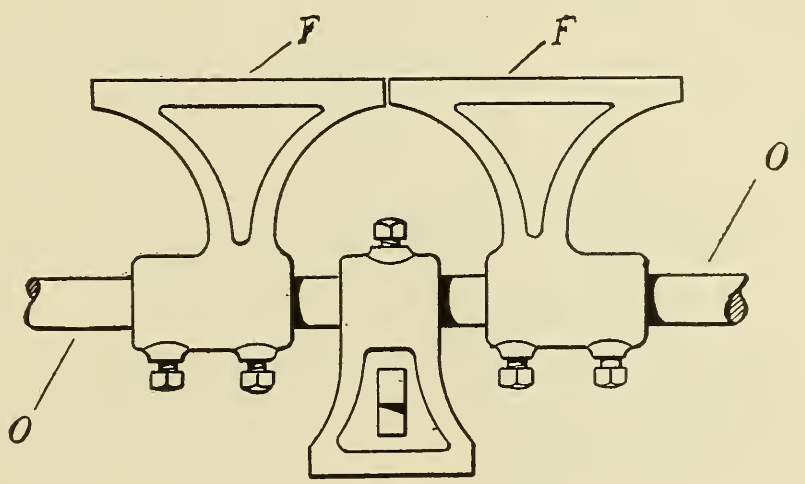


FIG. 70.

the parts is such that the parts engage one with the other. Thereby the backward movement of F is arrested and consequently O is stopped. The fork S^3 continues to move, however, and as S^1 remains stationary, the lever S^3 moves around the pivot S^2. Consequently the finger which forms the lower end of S^3 is pushed forward against T^1, as shown in dotted lines in Fig 69. T^2 then releases the catch on T^3. The spiral spring exerts its pull on T^3, which, as it moves to the right (Fig. 68), presses against V and moves the shipper rod S, transferring the belt from the fast to the loose pulley; when the parts would occupy the positions shown in dotted lines. When the machine is again started, the movement of V slides T^3 along far enough to engage it with T^2. The machine may of course be stopped or started without disturbing

T^3, when T^3 is in the position shown by the full lines in Fig. 68. The front stop motion for a breakage between the front roll and coiler is actuated by the trumpet E, Fig. 63. E may be seen to be loosely pivoted at Q on which is also pivoted the plate E^1 and the weighted lever L. When a sliver is passing through the trumpet hole in E, the tension presses the head of the screw in E down against the plate E^1. E^1 rests against E^2, which is a part of the weighted lever L fulcrumed at Q. The weighted end of L is thereby raised. When a sliver breaks at the front, the tension is destroyed, and the weight w^2 causes the tail of L to fall. The tail-piece of L then comes in contact with another feeler bar attached to the

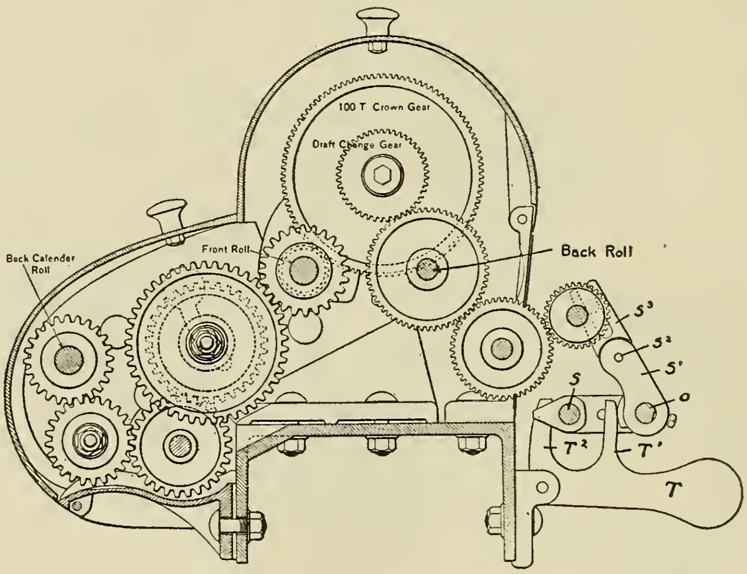


FIG. 72.

oscillating shaft O, shown in the detached drawing Fig. 70, O's motion is arrested, and the machine stopped as before. When the cams at the front are full of sliver, the coiler plate R is raised by the upper pressure of the cotton beneath it. As it rises it raises E, removing the pressure from E. The end of L then falls with the result noted above.

By reference to Figs. 63, 71 and 72, the driving mechanism of the drawing frame may be seen. The main shaft is near the floor, and extends lengthwise of the machine; when three heads are arranged zig-zag, one main shaft may serve to drive them all. On the spindle of the front roll is a fast pulley C and a loose pulley B. A narrow belt connects with the pulley A on the main shaft. The back roll receives its power from a train of gears starting with a small pinion on the front roll. The change gear for draft is indicated, and will be seen to drive the back roll. A larger gear therefore increases the speed of the back roll, consequently decreasing the draft. This will be recalled to be the identical effect

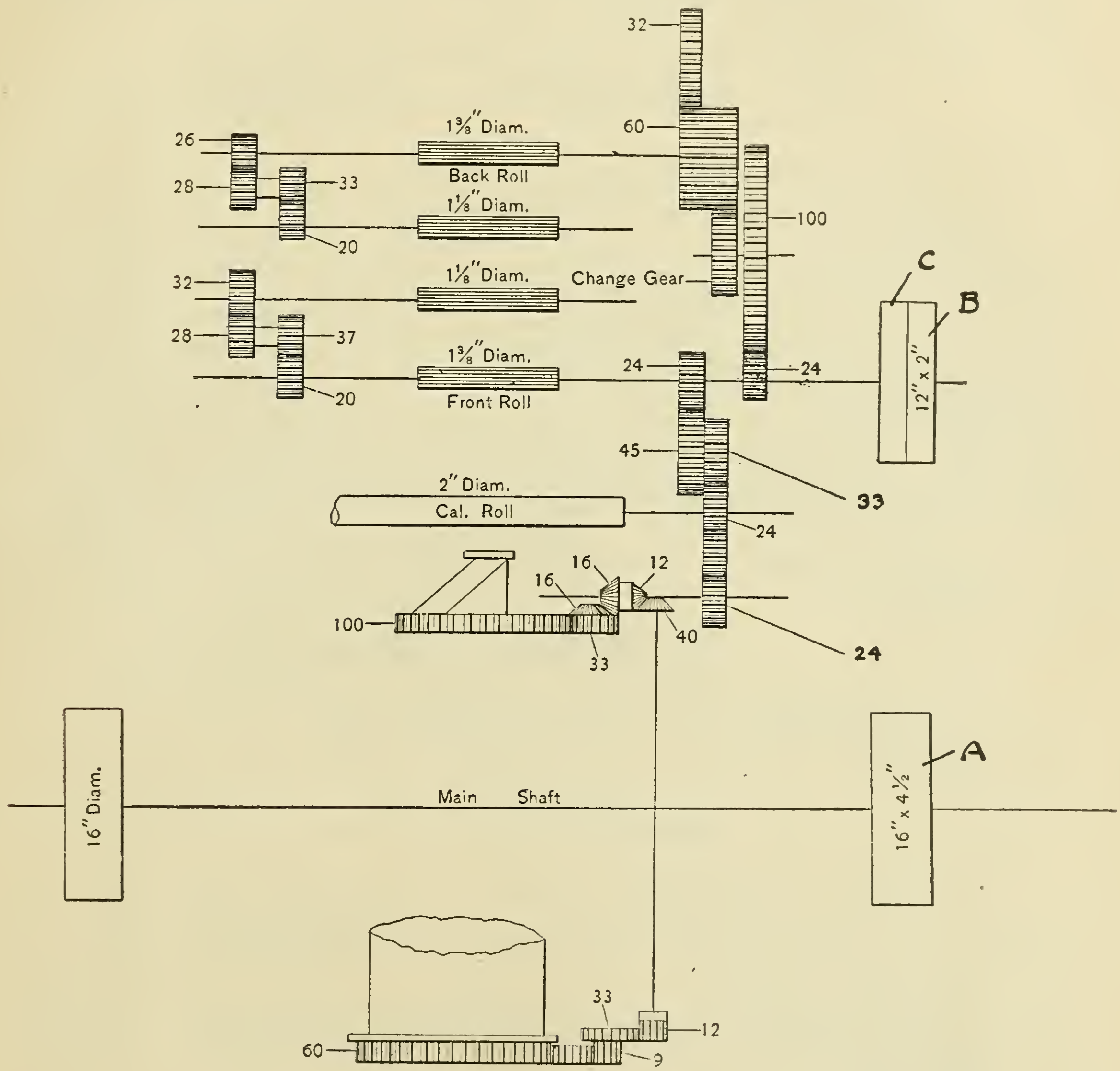


FIG. 71.

produced in changing the draft gear on a card. The next to the back and the next to the front rolls are driven from the back and front, respectively, as shown. The calender rolls and the coiler receive their power from the front roll.

CALCULATIONS

I. Calculations Relating to Draft.

A. Total draft is found in the manner previously described.

Example:—Gears used are taken from Fig. 71. The draft change gear is assumed to have 47 teeth.

$$\frac{60 \times 100 \times 24 \times 33 \times 2 \times 8}{47 \times 24 \times 45 \times 24 \times 11} \quad 5.67 \text{ total draft.}$$

B. Intermediate Drafts.

1. Draft between back rolls and second set.

Example:—

$$\frac{26 \times 23 \times 9 \times 8}{28 \times 20 \times 8 \times 11} \quad 1.25$$

2. Draft between second and third sets.

Example:—

$$\frac{29 \times 28 \times 60 \times 100 \times 20 \times 28 \times 11 \times 8}{33 \times 26 \times 47 \times 24 \times 37 \times 32 \times 8 \times 11} \quad 1.64$$

3. Draft between third set and front rolls.

Example:—

$$\frac{32 \times 37 \times 11 \times 8}{28 \times 20 \times 8 \times 9} \quad 2.58$$

4. Draft between front rolls and calender rolls.

Example:—

$$\frac{24 \times 33 \times 2 \times 8}{45 \times 24 \times 11} \quad 1.07$$

5. Product of intermediate drafts.

$$1.25 \times 1.64 \times 2.58 \times 1.07 \quad 5.66 \text{ total draft.}$$

C. Draft Constant.

1. Rule for draft constant previously given applies here.

Example:—

$$\frac{60 \times 100 \times 24 \times 33 \times 2 \times 8}{24 \times 45 \times 24 \times 11} \quad 266.667 \text{ draft constant.}$$

2. Draft gear $= \dfrac{\text{Draft Constant}}{\text{Draft.}}$

D. Weights per yard in their relations to draft.

1. Weight per yard of one sliver fed to the machine equals weight per yard of sliver delivered times draft, divided by the number of ends fed to a delivery.

2. Weight per yard of sliver delivered equals weight per yard of one sliver fed times number fed, divided by draft.

3. Draft equals weight per yard of sliver fed times number fed, divided by weight per yard of sliver delivered.

II. Calculations Relating to Production.

A. Theoretical Production.

Production is found just as on a card. It has become quite customary to compute the production from the surface speed of the front rolls. Since there is some draft between the front rolls and the calender rolls, a result obtained by this method is of course too small. But because a deduction for waste and stoppages must be made anyway, it is perhaps sufficiently accurate to calculate the production from the front rolls. The true theoretical production must be computed from the surface speed of the calender rolls, and is so computed here.

Let d = diameter of calender roll.
" s = speed of calender roll.
" w = weight per yard of sliver delivered.

Then production per delivery in pounds per 10 hours =

$$\frac{s \times d \times 3.1416 \times 60 \times 10 \times w}{36 \times 7000}$$
$$= s \times d \times w \times .00748$$

B. Actual Production.

The actual production is somewhat less than the theoretical owing to the necessary stoppages for oiling, cleaning, breakage of ends, etc. An allowance to cover all stoppages as well as loss by wasteshould be made. About 15 per cent. deduction from the theoretical production will give approximately correct results. Much of course depends upon the efficiency of the tenders, so that 20 per cent. deduction is often more nearly right. Generally speaking, we may say that one delivery of a drawing frame may be supplied by one card; yet conditions such as relative weights of slivers produced, and the speeds of the two machines have their effect.

LIST OF ILLUSTRATIONS