The Bottom Rolls are made of steel, in sections, which are jointed into one continuous roll for the entire length of the frame, each roll having one boss for each delivery, and having necks for bearings between each boss. These bottom rolls are fluted, that is, grooves are cut lengthwise in each section of the roll over which the sliver passes, in order that a firm grip may be obtained on the cotton as it passes through the set of drawing rolls, and by this means prevent the cotton from slipping. The grooves are not cut perfectly wedge shaped, being somewhat narrower at the bottom than at the top, neither do the flutes end in knife edges, but are made blunt. A bottom roll consists of four principal parts, viz: the fluted section for drafting; the bearings for positioning the roll; the square neck and the squared recess, the square neck of one fitting into the recess of another roll, thus making a continuous roll. A fluted bottom roll, made in one piece, has only two parts, i. e., the fluted section and bearing, and since the rolls are similar in other respects, a description of one roll will answer for the others. The fluted section occupies the space between the stands on the frame, except for a distance of an inch to an inch and a half next to the inside of each stand. This fluted portion, which is made by having flutes cut lengthwise on it, constitutes the largest diameter as well as the greater part of the roll, and is the portion which in conjunction with its top roll operates on the cotton. Different sizes of bottom fluted rolls are used in the frame, the diameters of which vary from $\frac{7}{8}$ of an inch to $1\frac{3}{4}$ inches, the general diameter used being from $\frac{7}{8}$ of an inch to $1\frac{1}{2}$ inches, the smaller sizes being used for the later processes. The bottom rolls, besides being of different diameters, also contain either more or less flutes on the same size roll, thus giving different pitched rolls. The pitch, i. e., the number of flutes on a roll varies, according to its position in the frame, the coarser spaced flutes being used at the back of the machine through which the heaviest bulk of cotton is passed.

Fluted rolls when spoken of as hard or soft, refer to the temper given to the metal of the rolls. The metal, as mentioned before, for making bottom rolls is steel and in some instances, the rolls are case hardened over the entire length, while in other instances only the bearings are case hardened. The flutes on a case hardened roll are necessarily hard and brittle and consequently when any foreign substance comes in contact with any of them, such as iron or steel, instead of yielding, a piece is chipped out of the flutes, making that part of the roll very difficult to get smooth again, owing to the hardness of the metal. A hardened fluted roll is also apt to injure the top leather roll by making channels, or cutting the leather covering of the top rolls in case a very light sliver with heavy weighted rolls is being run, and which results in extra cost for covering. A soft fluted roll, while it may be more easily nicked or dented, does not chip as easily as a hardened roll and a nick when made, may be easily taken out by using a flute file, which is specially constructed for that purpose. The edges on the teeth of the flutes are not made as sharp as on the hardened flutes and consequently the top leather roll is not as liable to be damaged by them. A mistake of having the flutes too soft will prove as bad as having them too hard.

The bearings of the bottom rolls are subject to a great deal of wear due to friction, and consequently they are case hardened so that they will not wear away as quickly as if they were as soft as the flutes. The bearings represent the smallest diameter of the roll and are the parts which wear away very quickly if a roll is not properly adjusted and regularly attended to in the matter of oiling, cleaning, etc. The small space between the flutes of the roll and the bearings is smooth and is turned down so that the diameter is about the same as that of the bottom of the spaces in the fluted portion. When a roll, made up of sections is used, the squared end of each of the rolls is case hardened and is shaped so as to make a driving fit into the squared recess of the previous section of roll into which it fits. Each section, except the end section of a jointed roll, has one end squared and the other end recessed, and one of the end sections has a squared portion at one end, and smooth at the other, while the opposite end section has a recessed portion at one end, and the other end smooth.

The bottom rolls are fluted on the surface over which the cotton passes, in order that they may obtain a good bite on the cotton as it passes between them and their corresponding top rolls, so that slippage will not occur. The flutes also serve the purpose of driving the top roll more positively than would be the case provided the bottom roll was smooth, because of the increased friction between them. As a matter of fact it is impracticable to run the top roll if the bottom roll is smooth. The flutes on the bottom roll are unevenly spaced, as in this manner the leather top rolls are less liable to be channeled by them. The bearings of the rolls are for the purpose of positioning the rolls in the frame and also to steady them at different points throughout their lengths. If some means were not provided to support the fluted rolls at regular and frequent intervals along their lengths, the rolls would bend, due to the weight upon them, and cause trouble, and it is for the purpose of preventing these bends, that the bearings are made use of. The bearings are placed in stands on the frame, and generally these stands are provided with brass bushings, in order to have as little friction as possible between the bearing and its bushing. The bearings should be kept well oiled, and as is frequently done, a piece of tallow or grease is placed on top of the roll in each stand. The stands on the frame are made large enough to also accommodate the top rolls. The bushings for the different rolls are separate, each being bolted to the stand individually, which allows individual setting of the rolls for any length of staple.

The Top Rolls also demand a careful consideration, as correct drawing is dependent upon them to a considerable degree and any deficiency in their proper working will be readily seen in the drawn sliver. Top rolls are made in short lengths, one for each delivery and rest in open bearings on the bottom rolls, being weighted down with weight stirrups, one on each end. The surfaces of all top drawing rolls are divided into two classes, that is, rigid surfaces and yielding surfaces. An example of the rigid surface is seen in the metallic rolls, while the leather covered top roll is the best example of a yielding surface.

Leather Covered Top Rolls.—A study of the conditions of the sliver during drawing discloses a very important reason for using top rolls having a yielding or cushioning surface, and that is the unequal distribution of the fibres in a cross section of the sliver from the card or comber. If the film, which emerges from the front roll, is more particularly noticed, the several slivers may be seen to be more or less distinct in the film. This condition is due to the fact that the slivers are approximately round in section when they enter the drawing frame, and it will be seen that whenever there is a difference in the quantity of fibres through any section of the sliver, the degree to which the rolls can either hold the fibres or pull them is seriously affected. This will be the case considerably more with rolls that have non-yielding or rigid surfaces, which have the effect of increasing the tendency for the drawing to be irregular in those parts where the drawing rolls are unable to hold or pull the fibres with sufficient power.

The aim of covering drawing rolls with a yielding body, besides providing a smooth surface possessing good pulling properties, which is the generally accredited reason, is also to provide a yielding surface which will instantly adapt itself to whatever variations there may be in the quantity of the fibres presented at any part of their surface. Such a condition is certainly necessary in order that the rolls may exert an equally effective pull on the whole surface of the sliver, no matter how much said sliver may vary in point of thickness. Rolls which are not provided with a yielding surface, cannot deal with such variations, as by their action the edges of the sliver are not gripped, owing to the diminishing thickness at these points with an excessive thickness at the centre and the inflexibility of the rolls. If the top roll is provided with a moderately yielding surface, while the lower roll remains rigid, the upper one will slightly adapt itself to the sliver, a feature which would produce a better pull on the sliver toward its edges, where the falling off in the thickness is most noticeable.

There are several different types of leather covered top rolls in general use at the present time, viz: the fast boss or solid roll, the loose boss or shell roll, and the loose end roll. By the boss of a roll we refer to the part which is covered.

A solid top or fast boss roll is made by covering a solid piece of iron roll first with felted woolen cloth and afterwards with leather. This style may also be called a one-piece roll. An illustration of a solid roll is given in Fig. 154, which is a cross section through the covering, showing the iron roll in full lines. *A* indicates the cast iron roll which has to be covered, and *B* indicates both the felted woolen covering which is placed on the boss of the iron roll and the leather or outside covering which is drawn on over the felt covering. These kinds of top rolls are generally supplied by the makers, unless otherwise specified.

A shell or loose boss roll is constructed, as its name indicates, by having an outer cast iron shell, which is the length of the fluted portion of the bottom roll, covered first with a single thickness of woolen cloth and then with leather, in the same manner as in the case of the solid top roll. This shell of the roll fits over a spindle or arbor of special shape, and

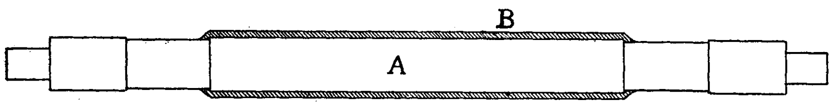


Fig. 154.

it is upon this spindle that the shell rotates, the spindle remaining stationary.

This style of roll is shown in Fig. 155, which is a cross section through the shell and coverings, while the spindle or arbor is shown in full lines. *A* indicates the spindle or arbor on which the shell rotates, *B* the cast iron shell, and *C* both the felted cloth for covering the shell *B* and the leather covering which fits over the cloth covering.

Shell rolls can be used for all lines of top rolls, but the general practice is to use them for the front line only. The bearings of the roll are enclosed in such a manner as to make them almost dust proof. Only a small portion of the central spindle is in contact with the inner side of the boss or shell, and owing to the spindle having a slightly barreled form, the oil gravitates toward the middle of its length or that portion which is in contact with the shell, thereby keeping it lubricated without any tendency for the oil to get upon the leather covering of the roll. When oiled, the bearing will remain lubricated sufficiently to last two weeks. Another important feature of this type of roll is the

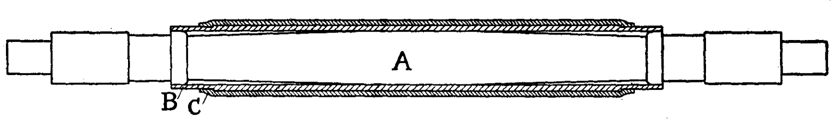


Fig. 155.

amount of freedom of movement which the boss possesses, and which enables the roll to adjust itself to the slightest variations in the quantity of material passing under it. This freedom of movement secures a better and more uniform pull on the fibres under operation, especially in the thin places, than would otherwise be the case if the rolls were rigid. This movement does not interfere with the action of the other boss when there are two on the same spindle, or a double boss as it is called. This shell double boss differs from the solid double boss, in that each boss may be detached separately, and if one is worn out, it is only necessary to have that particular one re-covered; the other one being again available when another boss of similar diameter is found. In this way considerable economy may be effected without deteriorating the quality of the work done.

In the fast boss type of top rolls there are several disadvantages as compared with the loose boss roll. An ordinary solid or fast boss leather top roll, besides having to overcome the friction set up in its bearings, also has to overcome the friction of the hooks on its arbor, owing to the fact that the whole roll rotates. In the loose boss or shell roll, both of these points of friction are absent and are replaced by the friction between the shell and spindle, but which is much less than that of the hooks and rolls. The weighted stirrups hang from the stationary spindle or arbor and hence there is no friction between them. By having less friction, the loose boss shell will therefore rotate more freely than a solid, or fast boss roll, which condition makes it a little more difficult for the two rolls to obtain a firm grip on the cotton, which is necessary in order to produce the required draft. The loose boss will therefore require more weighting, which might be said to be a disadvantage, because any extra weight will increase the wear on the leather covering. Referring again to the fast boss roll, we find that besides its additional friction surfaces, they are unprotected from the dust and cotton which is constantly attaching itself to them and thus interfering with their efficiency, besides increasing the amount of power required for driving them, requiring also more attention from the operative to keep them in good working condition. This extra work which is put on the rolls, must necessarily have a shortening effect upon the life of the leather.

In the facility with which the loose boss roll works there is an advantage which it has over the fast boss roll, that is, the prevention of the possibility of the top roll remaining stationary, if only for a moment while the bottom roll is still running. Provided this occurs, the slivers that are passing at that time between the rolls, are practically crushed and strained, and consequently weakened by the rubbing they receive, this being a feature which does not occur with loose boss or shell rolls. Oil is also more liable to get on the leather roll covering of the fast boss rolls, on account of the fact that they have to be oiled once a day, at least the front rolls, and that in oiling the bearings, the oil is very liable to drop on the rolls. The first cost of the fast boss rolls is less than the loose boss, but extra shells can be used on any spindle which has been used, as they are all made of a similar inside diameter, for the same diameter of roll. All shell rolls should be taken off about once a week and cleaned and oiled.

It will be seen from the points given that each style has its advantages and disadvantages, although the number of advantages of the loose boss exceed those of the fast, and that the same is very extensively used, but at the same time many prefer the fast boss, claiming in addition that a better draft is obtained and lighter weights can be used.

The loose end top roll differs from the regular fast boss roll by having a loose bush on either side of the roll as an end bearing, a specimen of this style of roll being shown in its top view in Fig. 156. The bushing *A*, as used on each end of these rolls, is constructed by boring out a small cylinder of metal so that it fits loosely on the neck or bearing

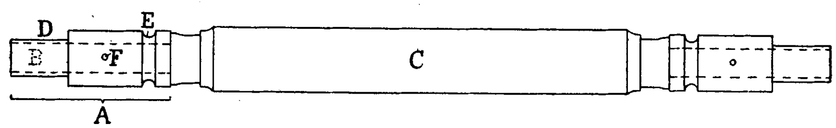


FIG. 156.

B of the top roll *C*. The bushing is filed flat on two opposite sides *D* at the end; so that it then fits into the stand on the frame, and thus the top rolls which are held by said bushes are fixed in their proper positions. A groove *E* is cut, on the bushing near the inner end, for holding the saddle hook as in turn is connected to a weight, in its proper position. The top side of the bushing is provided with an oil hole *F*, so that the bearings are easily lubricated. Care must be taken not to have the bushings fit the ends of the top rolls too tight or else they will retard the movement of the rolls and thus cause bad work. From the fact that in connection with the loose end top roll, the weights do not press directly on the revolving roll, less power is required to drive them, than the fast boss top rolls.

One of the most serious defects in connection with leather top rolls is the fact that the leather covering wears out so quickly and then of course the roll has to be re-covered. The leather wears more from channeling than any other cause. A channeled roll is made when the flutes of the bottom steel roll have sunk into the leather covering of the top roll until a crease or groove is made along the length of the leather of the top roll. Sometimes only three or four of these creases or grooves are made, but more generally the leather roll is creased around its entire surface, the distance apart of the grooves varying according to the number of flutes of the bottom steel roll. Channeled rolls may result from several different causes, any one of which always shows that the machine is not working in proper order. The channels may be caused by the frame being run with the weights on the rolls and no cotton being put through the machine, also by allowing the machine to stand too long without either removing the weights or turning the rolls slightly, again the trouble may have been caused by running with too heavy a weight on the top roll when operating on a light weight sliver, or by having the cotton fed to the rolls so that one end is raised more than the other, or it may be caused by having too much weight on one end of the roll so that it does not lie in a perfectly horizontal position. Channeled rolls should never be allowed to remain running when found, but should be taken out and either buffed down or sent away to be re-covered. If allowed to run in a channeled condition, they will produce uneven work.

The tendency for the top leather rolls to channel is decreased by making them of a slightly smaller diameter than the bottom steel roll. The reason for this is very plain, for it will be seen that if the top and bottom rolls were of the same diameter, the flutes of the bottom roll would always come in contact with the leather roll at the same point at every revolution of the bottom roll, that is, in case there was no slippage between the rolls, and by thus coming in contact at the same point every time the roll revolves, the flutes would be more apt to cause channeling than if the roll was made of a different diameter. In case the top roll was made of a larger diameter, it would likewise help to prevent channeling, but in order to permit a close setting of the bottom rolls, when required, the top rolls are usually made smaller.

A traverse motion is provided for traversing the slivers from one end to the other of the bosses of the drawing rolls, for the purpose of preventing grooves being worn in any particular portion of a roll, and at the same time utilize as nearly as possible the entire boss of the roll. In connection with this traverse motion, the slivers are held by guides placed at the back of each set of rolls, said guides being connected to each other by rods, all guides being moved to and fro behind the rolls by means of a cam and spring attachment to the connecting rod. The cam is on a slowly rotating shaft and thus imparts a slow traverse to the guides which thus slowly guide the slivers from one side of the boss of the roll to the other, the slivers still remaining in their relative positions to each other since they are moved in unison. A traverse motion is not used in connection with metallic rolls.

Varnishing and the Care of Rolls.—The top leather rolls before they are put into the drawing frame have to be varnished, and the frequency of re-varnishing them during the life of the leather depends on the kind of varnish used, the method of its application, the weight of sliver run, the speed of the frame, the amount of top roll weighting and the amount of care given the machine.

Under ordinary conditions top rolls should be cleaned and varnished about once a week, the varnish consisting of glue and a fine gritty paint, for preserving the leather and preventing it from becoming too smooth. The reason of this is that the grain of the leather wears away and gets broken, on account of the high speed at which the rolls revolve, and the heavy work they have to do, and when any roughness on the surface of these rolls causes licking, which in turn results in waste, light sliver and loss in production through stopping the machine to remove roller laps. The natural grain in the leather must thus be re-inforced by some sort of a drawing surface, the varnished surface being the one adopted for this purpose. Well varnished rolls must present a smooth, hard surface, which has dried without cracking and will not cause fibre or dust to adhere to it.

Too much glue in the varnish, while giving the rolls the appearance of a highly polished surface, has a tendency to crack when dry; again too little glue will allow the varnish to wear off too quickly.

There are two classes of roll varnish, one of which is cooked, while the other is not cooked. Cooked varnishes, when applied to the rolls, produce a smoother surface and cause the roll to last longer than when they are painted with an uncooked varnish.

However, uncooked varnishes are used quite extensively for the rolls, but when an uncooked varnish will not work satisfactorily, a cooked varnish is prepared.

By a cooked varnish is meant that certain parts, or perhaps all, of the mixture, when prepared, are cooked for a certain length of time and allowed to cool before being applied to the rolls.

Four recipes for varnish are:

Recipe No. 1. 3 oz. glue, 1 oz. acetic acid, ½ tea-spoonful of oil of origanum, ½ tea-spoonful of brown sugar. Dissolve the glue in acetic acid, then add the other constituents and afterwards a color, like venetian red, chrome green, or lamp black.

Such colorings give the varnish body, saving it from cracking and thus preserving the life of the leather. The amount of color to be added to the mixture depends on circumstances. If you are drawing heavy, more body is needed to the varnish and more color will have to be added than when drawing light. Another reason for using a different amount of color is because certain machines require lighter varnish than others, so that all the way from ¾ of a tablespoonful to 2 tablespoonfuls may have to be used in connection with the preceding mixture. The addition of an extra amount of color will deaden the glossy appearance of the rolls, i. e., when dry, present a dull finish, which however is not a disadvantage, since the rolls will run just as well and last longer than a highly polished roll. In hot climates, or during hot weather, add ½ tea-spoonful of borax or a little ground charcoal and gum arabic to the preceding mixture. The gum arabic must be dissolved before being added to the already mixed varnish, which is readily accomplished by covering it with a spoonful of acetic acid or vinegar, this amount of acid being sufficient, since gum arabic when dissolved swells to five times its bulk. The oil of origanum is added to the mixture for the purpose of giving the roll varnish a smoothness, which, without it, the varnish would not possess. However, excellent results are also obtained without its use, but when the varnish is found to be rough, if oil of origanum is added it will tend to smoothen the varnish considerably.

Recipe No. 2. 1 pound best pulverized glue, 1 quart acetic acid, 1 quart water, ½ ounce oil of origanum or oil of cloves, ½ pound venetian red or any other suitable color. In place of 1 quart each acetic acid and water, 2 quarts good vinegar may be used.

Recipe No. 3. 7 oz. glue, 1 quart vinegar, 2 table-spoonfuls of gum tragacanth, 1 table-spoonful of borax, 1 tea-spoonful of brown sugar. Cook mixture about an hour and thicken it with lamp black and princess metallic.

Recipe No. 4. 2 quarts of ground glue, 1 ounce sal ammoniac, 2 tea-spoonfuls of sugar, 1 table-spoonful of dissolved gum tragacanth. Vinegar is used to dissolve the mixture, which when properly dissolved is ready for adding the color and then applying to the rolls.

The methods of putting the varnish on the rolls differ, some roll coverers using for this purpose a fine camel hair brush, about two inches wide, in the same manner as you would paint a stick, taking care to spread the varnish evenly over the surface of the leather, so that when it is dry it has a true, smooth surface. This method, with proper care, produces an evenly covered roll, but requires considerable time. Care should be taken to see that when varnishing with a brush the hairs do not fall out and become embedded in the varnish. Rolls are also varnished with a sponge, by first dipping the sponge into the varnish and applying it to the roll until the whole leather surface of the roll is covered with varnish. It should be put on so that when the leather portion of the roll is varnished an even coat is obtained without ridges or air holes. Care should be taken when varnishing rolls that no varnish is allowed to drop on the neck of the roll. Other roll coverers use a board, made slightly longer than the roll and about twice to three times as wide as the circumference of the roll. One side of the board is then covered with felted cloth, which in turn is secured tightly to the board by being tacked at the edges. The varnish is then, with a brush, put on the cloth, and the roll rolled over the surface of the cloth by placing the palm of each hand on either bushing of the roll and rolling the roll backward and forward over the varnish until the whole surface of the roll is evenly coated. This method performs the work quicker than the previous method, but if proper care is not taken the varnish will not spread evenly on the roll; again the cloth requires scouring after varnishing rolls, since otherwise it will stick to the board, becoming stiff and unfit for future use. Again the varnish may be applied to the rolls by the fingers, and rubbing the varnish well into the roll. This procedure, although requiring more time as compared to the other methods previously quoted, will produce an even and smooth surface, provided an experienced roll coverer does the work.

New rolls or rolls re-covered are given 2 or even 3 coats of varnish before being put into the frame, taking care to have one coat of varnish perfectly dry before the next coat is added. When dealing with rolls in use, i. e., when varnishing rolls to keep them in proper working condition, one coat of varnish, applied about once a week, will be sufficient when average counts of yarn are to be spun. Sometimes when fine counts of yarn are required to be spun the rolls are given 2 coats of varnish. Rolls must be perfectly dry before putting them back into their proper places in the drawing frame, since otherwise, as will be readily understood the cotton would adhere to them, making it almost impossible to operate the machine, besides rolls not perfectly dry will become fluted, the bottom rolls then having a good chance to impress their flutes upon the leather top rolls.

It is bad policy to have to grind off the grain of the leather in a newly covered roll in order to true the same up, and then varnish the roll to reproduce the grain that has been ground off, as it is a wrong principle. It will be better to devote more time and care to perfect covering of the rolls, instead of thus laying the foundation for loss to the mill, both, on account of bad work done, as well as shortening the life of the roll.

Rolls, like any other important factor in any machine, must be kept clean. The flutes of the bottom rolls collect dirt readily and if not watched and kept clean will soon become sticky, a feature which in turn will cause licking and consequently laps. For this reason these fluted bottom rolls, as soon as becoming dirty and unfit for perfect work, must be taken out of the frame and scoured first with pumice stone, then with oil and afterwards with whiting. In some instances the scouring with oil is omitted. While the bottom rolls are out of the machine, and this previously to scouring them, the flutes must be carefully gone over and any rough or knocked places seen must be smoothed either with a special flute file or rubbed down lightly with fine emery cloth before the scouring is commenced. While the rolls, for the purpose of scouring them are out of the machine, it is a good plan to then clean the boxes the rolls run in, as well as any other portions of the machine in general.

A peculiar type of drawing rolls has recently been brought out, being to a certain extent a

Combination of Rigid and Yielding Surface Rolls.—The object in view is to provide drawing rolls by which a positive and reliable hold upon the fibres is obtained. The accompanying illustrations, Figs. 157, 158 and 159 are end views of three forms of the new drawing rolls.

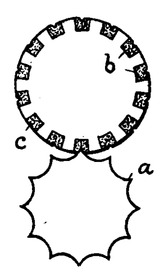


FIG. 157.

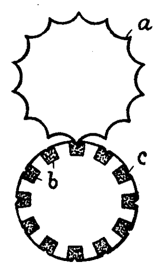


FIG. 158.

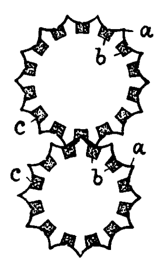


FIG. 159.

With reference to these illustrations it will be seen that either one of the rolls (see Figs. 157, 158, respectively), or both rolls (see Fig, 159), are provided with flutes *a* and cushion strips *b*, which latter are bedded at regular intervals in the surface of the rolls and are provided with central longitudinal grooves *c* in their exposed surfaces. The flutes *a* form sharp edges where adjacent ones intersect, and these edges are adapted to mesh with the grooves *c* of the elastic cushion strips *b*, thus securing a firm grip on the fibres to be drawn.

Metallic Drawing Rolls constitute the other general types of top rolls used in connection with the drawing frame. In their general construction the metallic rolls are somewhat similar to a common bottom steel roll, only that the flutes on both metallic rolls are evenly spaced, whereas on the common steel bottom roll, as was mentioned, said flutes are unevenly spaced. Another point of difference in the two types of rolls is that the flutes are spaced farther apart in the metallic rolls, the pitch thus being coarser. The reason for spacing the flutes in both metallic rolls evenly apart, is the fact that the two have to mesh together in a similar manner as a pair of spur gears. However the teeth or flutes of one do not sink as far into the grooves of the other as a regular gear, from the fact that the cotton sliver has to pass between them, and when, unless said sliver was fed in a very large bulk, the fibres would be very liable to be cut or strained from the pressure of contact of the rolls, which action would in turn weaken the sliver and render metallic rolls useless.

The rolls are prevented from meshing together too deeply by having each roll provided with circular collars, one at each end of each roll, so that when the rolls are placed in contact in the frame, the collars on the top roll rest on the respective collars of the bottom roll and thus allow the flutes to enter the grooves only a certain distance and revolve in that position. From this fact it will be seen that the diameter of these collars is a very important point and in fact is one of the most important parts of the rolls, for on the proper diameter of the collars depends the successful working of the rolls. If the collar is ground to a smaller diameter than is called for, the flutes will mesh too deeply and consequently cut or injure the fibres; again if the collars are not ground small enough, the flutes then will not mesh deeply enough, and owing to the fact that the revolutions of the top roll are dependent upon its meshing with the bottom roll, it is very apt to slip some of the flutes and thus break the sliver, if not at the same time injure the rolls.

Metallic bottom rolls as used in one frame have different diameters, and also contain a different number of flutes on a roll of the same diameter, or, as it is said, they have a different size fluting or pitch. The pitch of the flutes of the top roll should always correspond with the pitch of the flutes of its bottom roll. The back roll is made with the coarsest flutes, the flutes becoming finer in the succeeding rolls on the frame. Three different spacings of flutes, i. e., their pitches, are made, which are 16, 24, and 32 respectively. By these numbers, i. e., the pitches of the rolls, is meant the number of flutes and spaces on the roll per one inch of its diameter. This will then indicate that the 16 pitch rolls refer to the back rolls, 24 pitch to the middle rolls and 32 pitch to the front rolls. 16, 24 and 32, as quoted, do not indicate the total number of flutes on any of the rolls, but only the number of flutes and spaces on a roll per one inch of diameter and when consequently a 16 pitch roll, $1\frac{1}{2}$ inch diameter, will contain $16 + (16 \div 2 =) 8 = 24$ flutes and grooves on the roll. The same pitch roll, but of a diameter of $1\frac{1}{8}$ inch $= 16 + (16 \div 8 =) 2 = 18$ flutes and grooves on the roll. A 24 pitch roll, $1\frac{1}{4}$ inch diameter $= 24 + (24 \div 4 =) 6 = 30$ flutes and grooves on the roll. A 32 pitch roll $1\frac{1}{4}$ inch diameter $= 32 + (32 \div 4 =) 8 = 40$ flutes and grooves on the roll.

When a roll contains 16 pitch flutes, the collars are ground down so that they are 0.07 of an inch smaller in diameter than the outside diameter of the flutes, which then allows the flutes of that roll to enter 0.035 of an inch into the grooves of the bottom roll and vice versa. When the collars of the bottom roll are also ground 0.07 of an inch smaller than the outside diameter of the flutes, the flutes of the rolls are allowed to enter 0.035 of an inch farther into the grooves, thus making the total depth of mesh of the flutes of both rolls 0.07 of an inch. The collars on each roll of 24 pitch rolls are ground down 0.06 of an inch smaller than the outside diameter of the flutes, thus making the total depth of mesh for both rolls 0.06 of an inch. The collars on the 32 pitch rolls are ground down 0.044 of an inch smaller than the outside diameter of the flutes, and when in this case the flutes have a total mesh of 0.044 of an inch. The pitch of the roll, independent of its diameter, indicates the amount to be ground off its collars, thus a 16 pitch roll, $1\frac{1}{2}$ inch diameter, has its collars ground down 0.07 of an inch smaller than the outside diameter of the flutes, a 16 pitch roll, $1\frac{1}{4}$ inch or any other diameter, calling for the same amount of grinding off of its collars. The object of having different amounts ground off of the collars for the different pitch flutes is for the purpose of making each different pitch of flutes on the rolls of the same diameter deliver the same length of sliver when the rolls are given the same number of revolutions. The slivers on emerging from the front rolls are crimpy, owing to the meshing of the rolls.

In order to illustrate the manner in which the top and bottom rolls mesh into each other, two illustrations are given, of which Fig. 160 is a partial section of the top and bottom rolls, also showing the outlines of the two collars as placed on the rolls. Fig. 161 is a perspective view of the rolls, showing collars in pure rolling contact, but so adjusted as to separate the flutes while permitting them to interlock as shown in Fig. 160. Both illustrations will readily explain themselves by means of letters of reference, of which *A* indicates the bottom roll, *B* the top roll, *C* the collar on the bottom roll, *D* the collar on the top roll, *E* the flutes and *F* the grooves on both rolls.

Among the advantages claimed for the use of metallic drawing rolls several may be considered. The chief point in manufacturing at the present time is to get off as large a production as possible and at the same time have it up to the standard in quality. Production may be increased by speeding up the machine and increasing the weight of material under operation, but a limit has been found where it is not

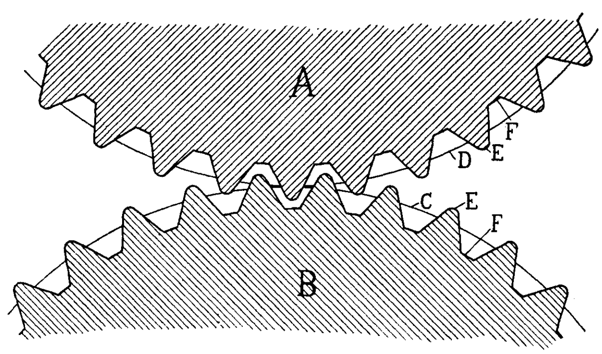


FIG. 160.

advisable to overstep, as experience has shown that the life of the machine is shortened and the product obtained of an inferior nature. The production may also be increased by increasing the diameters of the rolls and keep the speed the same, but the limit has also been found for these diameters, owing to the distances between the pairs of rolls and which must be maintained, thus setting a limit for them.

On a given diameter of metallic rolls, the flutes and grooves produce a periphery to this roll equal to that of a smooth roll having a larger

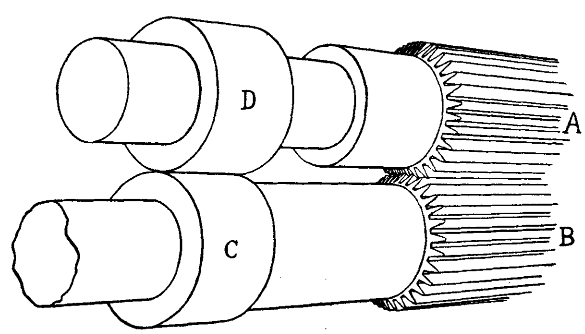


FIG. 161.

diameter, thus if the diameter of the metallic roll is made as large as that of the largest smooth roll, it will deliver a larger amount of sliver than the smooth periphery roll, owing to its flutes and grooves, and hence an increased production is obtained. From this fact, it will be seen that to figure the delivery of the front roll, its equivalent of a larger diameter roll must be found and used in the calculation.

The bite of the rolls is positive, as is also the drive of the top roll, from the meshing of its flutes with those of its bottom roll, a feature which prevents the possibility of any slipping between the pair of rolls. This fact also enables the rolls to remain perfectly in contact with less weighting, thus reducing power required to rotate them.

Metallic rolls require little attention after once installed, the cost of maintaining them in working condition being practically nothing.

The draft of metallic rolls is different from that of the leather covered rolls, for which reason the number of teeth in some of the gears in the machine have to be changed in case of changing the latter from leather top rolls to metallic rolls. Equivalent diameters in place of actual diameters of the rolls must also be used in connection with calculations for metallic rolls as previously mentioned, the following equivalents being those to be used in order to figure the drafts and production correctly:

1	inch diameter roll,	32 pitch,	to be figured as	$\frac{8}{6}$	inch	diameter	roll.
$1\frac{1}{8}$	" " "	32	" " "	$\frac{9}{6}$	"	"	"
$1\frac{1}{4}$	" " "	32	" " "	$\frac{10}{6}$	"	"	"
$1\frac{3}{8}$	" " "	32	" " "	$\frac{11}{6}$	"	"	"
$1\frac{1}{2}$	" " "	32	" " "	$\frac{12}{6}$	"	"	"

24 pitch is figured same as 32 pitch.

$1\frac{1}{8}$	inch diameter roll,	16 pitch,	to be figured as	$\frac{10}{6}$	inch	diameter	roll.
$1\frac{1}{4}$	" " "	16	" " "	$\frac{11}{6}$	"	"	"
$1\frac{3}{8}$	" " "	16	" " "	$\frac{12}{6}$	"	"	"
$1\frac{1}{2}$	" " "	16	" " "	$\frac{13}{6}$	"	"	"

Besides allowing for metallic rolls the equivalents given for obtaining the main draft, we must also add an extra percentage of draft in order to obtain the actual draft, the percentage usually allowed for this extra draft, in connection with average counts of yarn, being about 10%. The same has for its cause the action of the flutes when pushing the sliver into their respective grooves on their mate roll, a feature which cannot help but impart an additional stretch to the sliver.

When using metallic rolls, care must be taken that the flutes are kept clean, for if they become clogged with lint or dirt they will more or less cut the fibres. Never allow the rolls to rust or become rough or nicked.

Setting Drawing Rolls.—The setting of the bottom rolls of a drawing frame in their proper relation to each other requires a great deal of care and also a study of the cotton under operation. The first point to be considered is the length of the staple, after this the bulk of cotton or weight per yard of the sliver we are going to run through the machine.

If short stapled cottons are to be used, they will require short distances between the bites of the different rolls, and as the staple increases in length these distances must be increased correspondingly. In case a heavy card or comber sliver is being used, the distances that the bites are set from each other must be farther than when a lighter sliver is under operation. Again if the draft of the machine is comparatively small, and we are using a light sliver, the settings may be less than if the opposite were the case. After ascertaining the length of staple to be run through the machine, the rolls may be set in their proper relation to each other and as in the case with the sliver and ribbon lap machines they should be set a little further apart than the length of the staple, the amount of excess varying with the character of the staple that we are dealing with. For example, harsh, tough fibres which require a larger draft to place them in parallel order, can easily have the rolls set further apart, while the finer qualities of staple which are easily reduced, do not require so much space. If one machine is speeded higher than another with other conditions the same, the rolls in that case would require a wider setting. The setting of the rolls is also influenced by the character of the sliver to be drawn; for instance, if a combed sliver is fed to the back of the machine the work of parallelization has already been performed and all that is necessary is to produce an even sliver, which considerably lessens the work to be done by the drawing frame, from the mere fact that in this case the fibres slide easily over each other when subjected to a draft. As a basis to work on, we have a general rule to go by, which is: Set the bite of the second roll, in the first process of drawing, from the bite of the front roll a distance equal to the length of the staple under operation, plus one eighth of an inch, and add one eighth of an inch to this distance between the bites of the second and third rolls, and again one eighth of an inch over this distance between the bites of the third and last rolls. For example, say we are dealing with $1\frac{1}{4}$ inch staple, then we would set the bite of the second roll from the front roll, a distance of $1\frac{3}{8}$ inches; between the second and third rolls the distance would be $1\frac{1}{2}$ inches, and between the third and last rolls $1\frac{5}{8}$ inches. This rule for setting also applies to the second process of drawing, while in the last process, instead of adding one eighth of an inch, we substitute in its place one sixteenth of an inch. In special cases, the rule is sometimes varied and one sixteenth of an inch is added between the front and second pairs of rolls and between the second and third, while one eighth of an inch is added between the third and last pairs of rolls.

These distances having been obtained, we proceed with the mechanical part of setting the rolls as follows: Loosen all the studs which hold the gears and all the nuts holding the cap bars in which the rolls rest, so that the rolls may be capable of movement in either a forward or backward direction, the front roll of course remaining unaltered. Next set the second roll to the front roll the required distance, using a gauge first at one end of the roll and then at the other, in order to bring them parallel. The gauge as used for adjusting the rolls is either made of wood, brass or iron, of the required thickness, which then is passed between the rolls. Tighten the cap bars at these points, and then set the next roll in the same manner, using the correct distance as previously determined, and lastly set the fourth roll to the third, using in this instance also the proper distance. It is always better to go over all the settings with the gauge again to see that everything is all right and then set your gears. One of the reasons for setting the bites of the rolls a distance greater than the average length of staple involves the principle of parallelizing the fibres. By having the distance greater than the length of the staple at some time during its passage, every fibre is free from the grip of the rolls and is only held by its surrounding fibres, in fact there are only two other conditions which the fibres are in during their passage through the rolls, one being that they are gripped by a pair of slowly revolving rolls and the other is that they are gripped by a faster revolving pair. The fibres which are gripped by the faster pair of rolls exert a pull on the free fibres to a greater or less extent, due to the fact that all of the fibres are tangled among each other to a considerable degree, and during this pull, the fibres slide a little over each other and thus the back ends of the gripped fibres are straightened by the friction between the free fibres and also the front ends of the free fibres are similarly straightened. At the same time, the free fibres are exerting a pull on the fibres which are gripped by the back roll, due to the friction between them, which is caused by the back roll delivering the fibres slower than the next roll in front, and this in turn straightens the back ends of the free fibres and the front ends of the gripped fibres. Thus it will be seen that every fibre at the same time when it is not gripped by one or the other pairs of rolls is practically pulled in both directions at the same time and the friction between the other surrounding fibres is just enough to exert a slight pull and in this manner straighten them, so that it is very necessary to have the fibres perfectly free at some time between each pair of rolls in order to get the full benefit of the draft, i. e., parallelization of the fibres. As was shown, the fibres are also straightened when gripped by the rolls, and as they retain this straight position by contact with the surrounding fibres, when they leave the front pair of rolls, they are necessarily in a more or less parallel condition.

Another reason for setting the rolls at a greater distance than the length of the staple under operation, is that if both pairs of rolls held the same fibre at each end it would be broken. However this setting of the rolls apart, over the length of its staple, must not be too great. One of the objects of drawing is to stretch the curl out of the fibres. When stretching takes place, there is always some slipping among the fibres, and if the gripping points of the rolls where the pull is exerted, were too far apart, friction between fibres would be less, and consequently the slippage would be excessive, and the amount of stretch to the fibres thus reduced.

The reason for spacing the rolls at different distances on the same machine is due to the fact that a larger bulk or heavier weight per yard of cotton is fed up between the back rolls, because the draft has not had a chance to draw it down, and hence it requires a greater distance between the rolls than when a lighter weight of cotton per yard is dealt with, as is the case at the other rolls of the same machine, so that this is why the widest settings are used between the back set of rolls of a frame and the distance gradually lessened towards the front pair of rolls.

The diameters of the drawing rolls, being of different sizes, also demand a consideration as to their use. In some cases all of the diameters of the rolls are alike, but generally that of the second roll is smaller than those of the other three, which are the same. This is for the purpose of being able to set this roll closer to the other rolls, if necessary, because it often happens that different lengths of staple are used, and when in case of dealing with a short staple and the second roll was not made smaller, the setting then could not be made close enough. In other cases the frame is made with the front roll larger and the second roll smaller than the two back rolls. A large diameter front roll helps to prevent licking of the cotton and also the production is larger, due to the increased surface speed. Knowing that the diameters are different in different machines, it is always best to measure the diameters of the rolls before starting to gauge them for setting. This should be done particularly if two machines of different makes have to be set for the same length of staple and quality of cotton. This is necessary, because it is generally the practice to set one frame with a certain gauge, and then set the next frame to the same gauge. Large front rolls are generally restricted to the longer stapled cottons.

The most often used arrangement in regard to the diameter of the drawing frame rolls is to have the bottom front roll $1\frac{3}{8}$ inches in diameter, and the other three rolls $1\frac{1}{8}$ inches in diameter. For Egyptian cotton, the front roll may be $1\frac{3}{8}$ inches in diameter, the second roll $1\frac{1}{4}$ inches, and the last two rolls $1\frac{3}{8}$ inches, while for Sea Island cotton, the front roll is generally $1\frac{1}{2}$ inches in diameter, the second roll $1\frac{1}{4}$ inches, and the last two rolls $1\frac{3}{8}$ inches in diameter. In order to explain the arrangements of the rolls, more particularly, two illustrations have been prepared, and of which Fig. 162 is a diagram of a set of rolls, showing the first mentioned arrangement and the proper settings of the rolls from each other when working a $1\frac{1}{4}$ inch staple. Fig. 163 shows the last arrangement with the proper settings for a $1\frac{1}{2}$ inch staple.

The different systems should be compared if one is purchasing drawing frames, and the diameters of the rolls should be considered in connection with the range of the lengths of staple to be used, because very often, as was previously mentioned, different cottons and staples have to be run on the same frame at different times, and when the diameters of the rolls should be such as to meet the needs of the staple to be worked.

On machines where metallic drawing rolls are used they should be set a slight distance farther apart than when leather top rolls are used, the reason for this being that the metallic rolls have a more positive bite and begin to grip the fibres before leather top rolls do. The distance generally allowed is a little less than $\frac{1}{32}$ of an inch in addition to the distance which would be allowed for leather rolls.

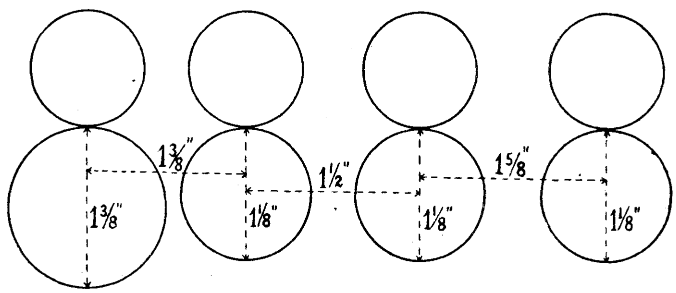


Fig. 162.

Weighting of Top Rolls.—As has already been pointed out, there is a considerable amount of cotton put through the drawing frame at the same time, and if the top rolls are not held down firmly in contact with the bottom steel rolls, the top rolls will slip, because under ordinary circumstances they are not heavy enough to properly grip the cotton which it has to pass through the machine. The most convenient method and the one generally used on the drawing frame to keep the

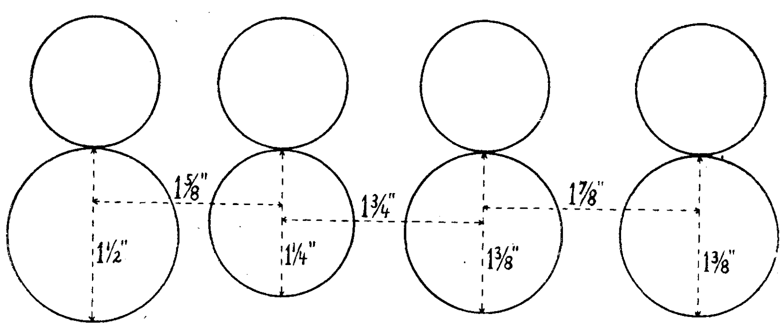


Fig. 163.

rolls from slipping, is to weight them. This is accomplished by suspending a weight or weights on each end of the rolls, or as is occasionally done, one long, heavy weight is made to answer the purpose of weighting both ends of the roll. Weighting in this manner is known as dead weighting, and is the one most generally adopted in this country, other systems being known respectively as self weighting and lever weighting. Self weighting, for the reason stated before, is practically never used on the drawing frame, because it depends entirely on its own weight for gripping contact with the bottom roll. The lever weighting arrangement makes use of a weight on the end of a lever, the other end of said lever being used as a fulcrum.

The question often arises as to whether dead weights or lever weights should be used in the drawing frame, the subject having called forth many opinions from different mill men. The dead weights, when used, hold the top rolls firmly and uniformly down on the bottom roll, while in the case of lever weights, the lever acts with a vibratory motion, due to the unavoidable vibration in the machine and also to the differences in the quality of the cotton which passes through the machine between the rolls. Some authorities state that dead weights can only be adopted in frames where fine light cotton is being worked, because of the fact that where the slivers are heavy and the fibres composing them are long and harsh, the rolls require a heavy weight to keep them down firmly, and dead weights would then be impractical as too many would have to be hung from the rolls. In this case, lever weights serve the purpose better and are generally used, being made adjustable so as to bear with more or less weight on the rolls as may be required by the character of the cotton under operation.

In order to understand the dead weighting mechanism, we will take for an example a frame where one weight is made to serve for both ends of one roll, it being hung from the bushings of the roll by wire hooks. Two hooks are generally used to hang the weight from each bushing, one hook being known as the stirrup and the other as the saddle. These hooks are connected to each other, end to end, and the other end of the saddle is hung over the top of the bushing in the groove made for it, the other end of the stirrup being hooked into a hole at the upper end of the weight. The hooks, on each side, should be of exactly the same length in order that the weight, when hung in proper position, will be perfectly level, for in case it slants over to one side an extra weight is put on one end of the top roll, which causes the other end of the roll to rise slightly, and thus produce uneven work. By having the weight out of position, the latter is also liable to come in contact with the frame of the machine; or weights may come in contact with each other—resting against each other—thus causing unequal weighting of the roll.

Referring back to Fig. 149, dead weighting by means of weights placed at each end of the rolls is shown. The saddle V or upper piece of the weighting device has its upper end V' made so that it fits loosely around the bushing of the roll, its lower end V'' being provided with a smaller hook to connect with the stirrup W, or lower piece of the weighting device, by means of an eye W' in the upper portion of the latter. The lower end W'' of the stirrup is hook shaped in order to receive the required weight. Holes are cut in the beam of the drawing frame to permit the stirrups to be passed through them, washers having a larger outside diameter than the hole bored being generally used on the stirrup and are placed above the beam. The object in having the washers is to prevent the weights from dropping to the floor when the saddles are unhooked from the stirrups, as they will rest on the washers by the upper end of the stirrup. When weighting the rolls, care should be taken that the hooks swing clear and the weights are also clear of one another, and that the saddle hooks hang free from the bottom steel rolls. The saddle on the front top roll should be bent and hung so that the open part of the hook is facing the back or feed end of the machine, because the saddle is then easy to take off; and for the same reason the saddle for the back top roll should face the delivery end of the frame. The other two saddles can then be hung either one way or the other.

On frames where separate weights are used, a spring is sometimes placed between the stirrup and the weight as weighting the front roll, for the purpose of taking the jar off of the front roll when starting the machine.

Another arrangement of dead weighting by means of placing weights at each end of the rolls is shown by means of Figs. 164 and 165. In this arrangement the object aimed at is to provide means whereby the pressure on the sliver between the top and bottom rolls of a drawing frame is increased or decreased automatically, i. e., the pressure being increased when a thick or lumpy sliver passes through the rolls, and decreased after the same has passed through.

Fig. 164 is a transverse section of the rolls of a drawing frame,

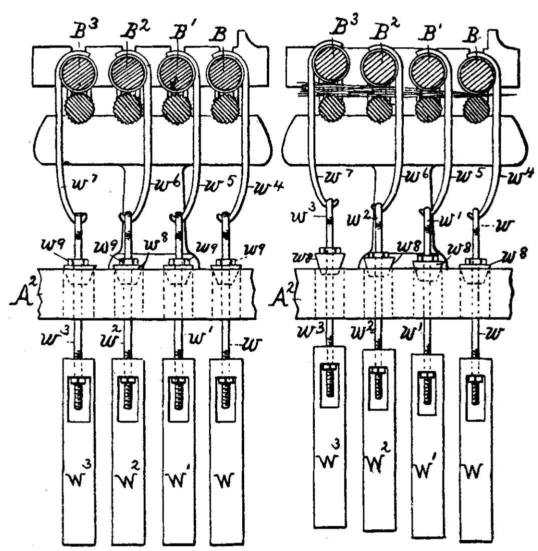


FIG. 164. FIG. 165.

clearly showing the stirrup attachment applied thereto. Fig. 165 is also a transverse section, but shows how the top rolls become automatically heavily weighted by the passage of a thick sliver.

Examining the illustrations, we find attached to each top roll B B^1 B^2 B^3 its respective saddle w^4 w^5 w^6 and w^7, to the lower ends of which are attached the stirrups w w^1 w^2 w^3, the same passing through holes in the beam A^2 of the drawing frame, having secured to them weights W W^1 W^2 W^3. Each stirrup is threaded for a portion of its length, and on said threaded portion is placed a conical piece of iron w^8, above which is placed a check nut w^9. Each stirrup hole in the beam A^2 is cylindrical and has a smaller diameter than that of the conical piece w^8, and thus forms for the cone a seat whose line of contact with the cone is a circle lying between the base and the apex of the cone, and having its diameter less than that of the base of the cone, the contact faces of said cone and said seat lying in different planes. This construction of seats and nuts having faces which lie in different planes permits the dust and cotton to accumulate, if at all, only between the seat and nut along their point of contact, and then only to fall by their own weight away from said point when the nut is lifted off its seat. It will be readily seen that each weight has two possible points of support, i. e., one on the top roll, as B^3, and the other on beam A^2, either one or the other, according to the position assumed by the saddle and the cone relatively to each other. If they are nearer together than said points of support, then the top roll becomes heavily weighted; if not, the heavy weight is borne on the beam A^2, and the top roll by reason of its own weight simply rests on the bottom roll. In operation each cone is so adjusted on the shank of its stirrup (see Fig. 164) as to allow the sliver to pass between the rolls and yet to raise the top roll enough to allow the weight just to begin to act, and thus keep the rolls together and in contact. If perchance the sliver is too thick or contains lumpy matter, as shown in Fig. 165, then said lumps raise up the top rolls, their saddles and stirrups, and consequently the cones, from their seats, and the top rolls become heavily weighted, and, with their respective bottom rolls, do their required work. The lumps having disappeared and the sliver having resumed its usual thickness, the top rolls drop into their normal positions, the weights draw the cones down into their seats, and the upper rolls are relieved of their heavy weights by their cones, now firmly seated in the beam A^2 of the drawing frame.

The amount of weight suspended from each roll depends upon the weight per yard of sliver being run, as it will at once be seen that if a heavy sliver is to be run, it will require a larger amount of weight than if the same machine was running a lighter sliver, this being necessary in order to keep the rolls from jumping and slipping, due to the large bulk of cotton fed. It is generally the rule to place a different amount of weight on different rolls in the same machine, the front roll being generally the roll to carry the extra weight, owing to the excessive speed of this roll over the others. The following weights for the different rolls would be satisfactory when working a medium weight sliver in the machine: When only one weight is used for each roll, the amount is 40 pounds for each roll. When two weights are used to a roll, the amount is, for the front roll, 22 pounds; second, third and back rolls, 17 pounds each. It is advisable to always use as light weights as possible, and still produce good work.

Where metallic rolls are used, only slight weighting of the top rolls is necessary, usually a weight of about 14 pounds being used on each of the four rolls on the frame. Some machine builders vary this, using a graded weighting for the rolls, i. e., 10 lbs. for the front top roll, 12, 14 and 16 lbs. for the 2nd, 3rd and back rolls respectively; the weighting in this instance being done more for preventing the rolls from jolting on account of their high speed, since the flutes and grooves in the rolls, meshing together, give a positive grip to the cotton, and consequently do not require much pressure.

A very important motion used in connection with weighting the drawing rolls is the weight relieving motion. Where leather covered top rolls are used, in order to preserve them as much as possible, when the machine is stopped for a length of time, the weights of the rolls should be released, so that the flutes of the steel roll do not continue to press so hard into one particular place on the leather, because in that case, a flat place on the roll would be made, and by thus destroying its true shape, the roll would not be able to perform its work satisfactorily and a new covering would be necessary. The work of releasing each weight when a stop was made and of putting them up again when work was resumed was very tedious, and the object of the weight relieving device is to systematically relieve and hang the weights with a minimum of labor and time.

One of the methods of relieving the weights is accomplished by having the weights cast with an oblong hole in them, the longest sides of the holes being horizontal. An eccentric shaped bar is inserted into the holes of the four weights situated directly back of each other, and rests at each end in brackets. The smaller diameter of the bar is placed in the holes so that when the weights are in their proper positions for the frame to be working, it will not touch either side of the oblong spaces in the weights, and thus the weights are entirely free from the relieving motion. Situated near the front end of this eccentric shaped bar, and between the eccentric portion and the front bearing, is a squared portion of the bar, on to which is fitted a handled lever, which, when the eccentric is in its free position, will hang vertically downward. The weights are raised by simply swinging the lever upwards to the right for a quarter of a revolution, when during this time, the larger diameter of the eccentric will come into contact with the weights and as the lever is moved up, the weights are also raised, so that when the lever stops, the rolls are entirely free from the weights. It only requires an instant to perform the movement, and the lever is retained in the raised position by having a hook to catch and hold it, or in some instances, the back end of the eccentric has a ratchet gear attached to it, a pawl being so placed that it will hold the eccentric, through the ratchet gear, in the desired position. The weights of the rolls of each delivery are fitted with an eccentric, so that each has to be raised separately. It will be seen that this is a very convenient method of raising the weights, either in case the top roll is to be taken out or the weights taken from the top rolls.

Another method of relieving the top rolls of their weights is seen in Fig. 166 which is a transverse section of a portion of a drawing frame, showing the construction of this weighting mechanism. The journals

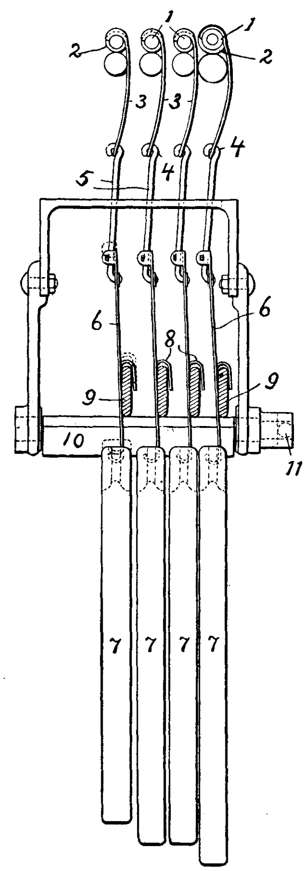


FIG. 166.

1 of the top drawing rolls 2 have saddles 3 suspended therefrom, the lower end of each saddle having a hole adapted to be engaged by the upper end 4 of a link 5. The lower ends of these links carry plates 6 to which are attached the weights 7, the middle portions of the plates being provided with down turned fingers 8 to engage lifter bars 9, which are supported on the shafts 10, and are adapted to be lowered by turning a handle 11 when the frame is started, so that the weights 7 act

on the top rolls 2. When the frame is stopped the handle 11 is again turned, thus raising the lifter bars 9 to bring the down turned fingers 8 into engagement with said lifter bars, and in turn relieve the rolls from all weight, said weights being supported by the fingers 8 resting on the "thus raised" lifter bars 9.

Clearers.—All slivers, which have been prepared for the drawing process, contain more or less short fibres or broken ones which is practically the same thing, and this is especially the case when dealing with sliver directly from the card. These short and broken fibres in the slivers have a tendency to fly out when the latter are leaving the front rolls of the drawing frame, especially if there is much electricity in the air, which occurs when the air of the room in which the frames are running is dry. The most frequent occurrence is for them to curl around the top rolls producing what is known as "licking." If this licking of short fibres is not prevented, they will draw other fibres of the sliver around with them until at last all of the sliver will be delivered around the front roll and cause a bung-up in the machine if it was not noticed in time by the operator, or if the stop motion which is in some cases placed on machines for this purpose, did not act quickly enough. To prevent any licking of the short fibres around either the top or bottom rolls is the object of top and under clearers. They are devices placed in contact with the rolls for the purpose of taking up any fibres which cling to the rolls, and also help to prevent the sliver from licking when it breaks between the front and calender rolls.

Both clearers are important parts to a drawing frame, but as the tendency of the fibres is to fly upward and stick to the top rolls, the top clearer is the more important of the two, especially is this the case when leather top rolls are used.

There are several types of under clearers in use, differing from each other only in their construction, the principle on which they are made being the same, a piece of woolen or other cloth being used to press against the front and second rolls along their width so as to remove any fibres which may be attached to the rolls.

One form of under clearer consists of a triangular shaped piece of wood as long as the flutes on the rolls, and which has two sides made concave so that each side may press evenly on part of the circumference of the rolls. These sides are covered with clearer cloth which is glued on evenly, thus making an easy friction for the rolls and which is just enough to remove any fibres clinging to the rolls. The clearers are held in contact with the rolls by a pair of small weights, which are attached to each end of a clearer by a strip of rawhide leather, fastened to the clearer and passed up over the neck of the roll, having the weight attached to it at the front side of the roll. The length of the strip of rawhide should be just long enough to allow the clearer to be pressed down by hand for cleaning when so required, and never so long that the weights rest on the framing of the machine, since in such a case the clearer would not press firmly against the rolls. Under clearers are not used between the third and last bottom rolls, because the chance for licking is so small and thus few fibres attach themselves to these rolls.

Another form of under clearer, which differs somewhat from the one just described, is seen by referring back to Fig. 149, see *X*. This clearer is of the same length as the previous one explained, but has a different shape. A cross section of the wood is almost rectangular and it is made so that when in position, the front side projects slightly beyond the front roll and extends back a little distance beyond the centre of the second roll. Its upper side is made slightly concave near the front end in order to fit the shape of the front roll, the other portion of the clearer being straight, a covering of clearer cloth being put on the working surface of the clearer in the same manner as described in connection with the previously quoted shape of under clearer. By having the clearer project past the front roll, it allows the front part of the clearer to be in contact with the front roll for a greater part of its circumference and thus makes the clearing action more thorough. The clearer is held in contact with the rolls by strips of rawhide leather attached at both ends of the clearer and passing over the neck of the bottom roll, having weights attached to their free ends. In some cases, guides are attached to the under clearers, which extend up from each end of the clearer between the first and second rolls to about the centre of the top rolls. The object of these guides is to keep the selvages of the sliver smooth and thus prevent, to a certain extent, a tendency of the fibres to lick around the rolls. The guides are fixed in a slot on the under side of the clearer and may be adjusted for different widths. The guide bars are frequently of brass and must be kept smooth.

Top clearers are also made in several different forms and have been the subject for a great many improvements. The tendency for the cotton to lap around the top rolls is greater than for the bottom rolls, and hence the construction of this clearer must be suited to properly clear all of the top rolls.

A simple form of top clearer is to have a board about three-eighths to one-half an inch in thickness, slightly wider than the distance from the back roll to the front roll, and extending across the length of the rolls. To this board is attached an endless band of clearer cloth, being secured to the front end of the piece of wood by passing a wire between the band and driving its pointed ends into the wood. The back end is similarly secured to the wood, thus making the cloth tight across the board. This board is placed on the top rolls; the cloth, covering the top of all the top rolls, projects slightly over the front top roll, in this manner cleaning all of the rolls as they rotate. In order to make the clearer remain in position on the rolls, it is attached to the top cover of the rolls. This top is provided with iron projections on each side, with holes in them to receive screws which are placed in them and screwed into the sides of the board at the centre of its width, so that it will balance or tip forward and backward, but have very little play from side to side. The slots in each of the projections of the cover are made so that the clearer can rise slightly, and thus while the clearer is always held firmly in contact with the rolls, it is not absolutely rigid.

The top clearer as shown in connection with Fig. 149, see *Y*, is of the same general construction as the one just mentioned, except in the manner of its attachment to the top cover, and the substitution of an iron piece in place of wood. As is shown in the illustration, the clearer is held by having a projection *Z*, at the centre of the top cover, pass through a hole in the top of the iron piece, and a screw put in the end, to prevent it from slipping off.

This form of top clearer requires frequent cleaning by the operator, for in case it is not attended to, the short fibres which have been collected will finally drop back into the good cotton and produce lumpy and uneven work.

A rotary form of top clearer is given in Fig. 167, which is a cross section through the rolls and clearers. Two clearers are used and are

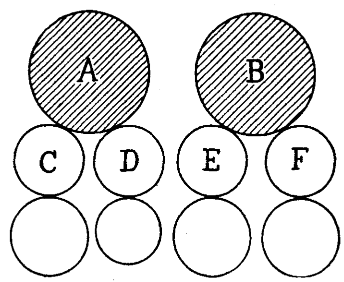


Fig. 167.

made by covering two wooden rolls *A*, *B*, with clearer cloth. Clearer *A* is positioned so that it rests on the top sides of the first and second top rolls *C* and *D* respectively, and is positively driven by gears, the surface speed of this clearer being slightly different from that of the drawing rolls, and in thus revolving under friction, collects the waste and forms it into a lap on its surface. The other clearer *B* is placed on the third and back rolls (*E* and *F* respectively) and is rotated by friction from these rolls. Its cleaning action is also very thorough, due to the fact that the two rolls *E* and *F* revolve at different surface speeds and as the tendency of each is to revolve the clearer, a friction is set up and as a consequence each top roll is thoroughly cleaned. Both clearers are held in contact with the rolls by a weighted lever, the amount of weight on the clearers being changed by changing the position of a weight on the lever. A longitudinal traverse motion is also imparted to the clearers in order to increase their cleaning action. The waste fibres accumulate on the clearers around their entire circumferences, the clearers running for a comparatively long time without having to be cleaned, a feature which in connection with this style of clearers is easily accomplished when necessary.

Another construction of a rotary top clearer consists of a band of clearer cloth drawn over two rolls which are held at their ends in a framework, so that they may be adjusted to suit the setting of the drawing rolls. The front roll of the clearer, which rests on the front edges of the top leather roll, and the back roll of the clearer, is placed slightly beyond the back top leather roll. The front roll of the clearer is rotated by the front leather top roll when the machine is in operation, due to the frictional contact of the two rolls, and as the clearer cloth passes around the clearer roll, it is given a rotary movement by the roll and thus presents different parts of its surface to the top rolls with which it is in contact, in this manner preventing the dirt and waste from collecting in one place on the cloth. The waste collected by the clearer cloth is removed by having a comb to scrape the waste off, and by having a suitable receptacle to catch the waste, or a circular brush may be used to perform the cleaning action. Another roll is sometimes placed between the layers of clearer cloth, in order to take up any slack in the clearer cloth and keep it pressed firmly in contact with the top rolls.

CALCULATIONS.—The principal calculations, in connection with the drawing frame, are the drafts between the rolls and the production of the machine. The meaning of drafts must be thoroughly understood in order to use them correctly in the machine. Draft, as applied to cotton spinning indicates the number of times that the cotton is drawn out in length from its original length during the operation. To illustrate this we will suppose that one yard of cotton sliver is subjected to a draft of six, and when the delivered sliver will measure six yards in length. The weight per yard of this resulting sliver will be only one-sixth as heavy as the original yard fed, from the fact that the one yard of cotton was simply drawn out or attenuated to six yards, the amount or weight of cotton remaining unchanged. A large draft can not be used with a single sliver, since the resulting sliver would be too delicate to be delivered. Doubling slivers at the back (feeding) of the machine, allows a larger draft to be used, besides producing a more even sliver as previously explained. All drawing frames are made with four pairs of drawing rolls (except in extreme cases where three pairs only may be employed), because the slivers fed to the machine are heavy and the combined bulk must be treated gradually, otherwise uneven work would result. By having four pairs of rolls we obtain three drafts and by making them gradually larger between the succeeding pairs of rolls, the cotton receives a gradual attenuation and consequently more even work is produced than if only three pairs of drawing rolls were used.

A diagram of the action of draft between the rolls on the slivers is given in Fig. 168, which shows the condition of the fibres between the successive pairs of rolls. It will be noticed that when the slivers are fed to the back pair of rolls A, the fibres composing them are in a more or less tangled condition, but as they pass between the succeeding pairs of rolls B, C, and D, the fibres in turn become gradually straighter, and the slivers lighter, according to the amount of draft between the rolls.

Provided we are dealing with slivers containing irregular lengths of fibres, they should be worked with a low draft and the weight of the sliver made as light as possible, but at the same time a high speed of the rolls may be retained. The speed of the rolls however must be reduced, provided the draft is increased, since a combination of high speed and large draft will invariably produce a larger percentage of waste.

Different methods are used for figuring the total draft on a machine when different kinds of data pertaining to draft are given. The draft may be figured from the weights of the slivers fed to and delivered from a delivery of the machine, or it may be figured from the gears on the machine and the diameters of the back and calender rolls. It may also be figured from a draft constant of the machine, and again by multiplying together all of the individual drafts in the machine which in turn will give the total draft of the machine.

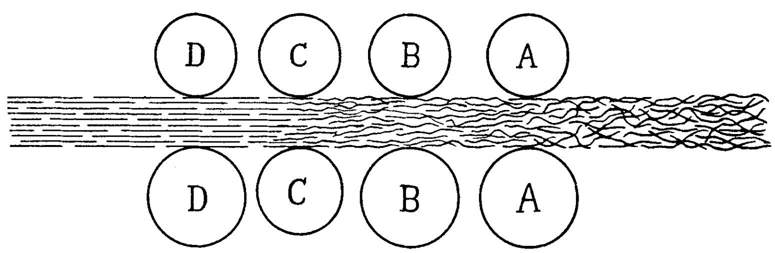


FIG. 168.

The rule for calculating the draft from the weights of the slivers is as follows: Multiply the weight per yard of the sliver fed to the drawing rolls by the number of slivers fed to each delivery and divide the product by the weight per yard of the delivered sliver.

Example: What is the draft on a drawing frame where the sliver fed to the machine weighs 60 grains per yard, we double six, and the delivered sliver weighs 58 grains per yard?

60 grains $\times$ 6 = 360 grains.
360 grains $\div$ 58 grains = 6.21 draft.

The calculation of the draft from the machine is made by getting the ratio of the surface speeds between the first pair of rolls that grips the cotton and the pair of delivery rolls. The first pair of rolls to grip the cotton is usually the pair of "single preventer" rolls, but in machines where such is not employed, the back pair of drawing rolls first grip the cotton. When the former is used, calculation for draft is made from there, and when omitted, the draft is then calculated from the back pair of drawing rolls. The calender roll is the last or the delivery roll of the sliver, however, the draft between the front roll and the calender roll is very small.

It is the custom with many superintendents to figure draft of a drawing frame simply between back and front rolls, ignoring the draft between front roll and calender roll, and between the preventer and back rolls. Although these drafts are quite small, by omitting them in the calculation an error in the result will be obtained, and this error when repeated in each of the three processes, would multiply and lead to trouble in calculating weights.

The usual rule for finding this ratio of the surface speeds between the first and last pairs of rolls to be taken into consideration, and one which may always be depended upon is: Consider the gear on the back roll as a driver and then multiply the diameter of the delivery roll by all of the driving gears, and divide the product by the product of the diameter of the feed roll multiplied by all of the driven gears. This rule also holds good for calculating draft between any two pairs of rolls. In this case, consider the gear on the back pair of rolls under consideration as a driver and substitute the diameters of the front and back rolls under consideration for the delivery and feed rolls respectively in the rule.

Draft constants for the total draft of the machine should always be figured out and kept on hand, thus saving labor when it becomes necessary to change the draft of the machine and a new draft gear has to be figured, as otherwise the gears would have to be counted on the machine in order to get at the constant as required to be known for any change in draft. This constant is figured exactly as the draft, except that the draft gear is omitted in the calculation.

Proportion is sometimes used to obtain a new draft gear, but it is not as accurate as using the constant of the machine, from the fact that the draft on the machine is rarely ever exactly what is calculated, because certain drafts call for fractions of teeth in the draft change gear which is impossible to have. By using proportion, a fraction of a tooth for the required gear is liable to be called for and when the two errors together will make a difference in draft on the machine to that figured, and the more often changes have to be made on the machine, the less one thus knows about the actual draft on the machine for a certain draft gear by calculating in this manner.

A change of draft on any cotton spinning machine is gotten by changing the speed of either the front or back roll, and on the drawing frame, as well as any other machine, the speed of the feed roll is the one changed for a change of draft, because the front roll is positively driven from a pulley and its speed should remain constant on account of the proper delivery of the sliver. The feed roll, being driven from the front roll, is very easily changed by changing a gear in the train of gears connecting them.

Drafts between different rolls are called intermediate drafts and are made gradually larger toward the front of the drawing frame, as previously explained.

The break draft is the one which is changed whenever a new draft change gear is put on the machine, and under ordinary circumstances it is the only draft changed after the machines have once been started up. The break draft is situated differently in different makes of machines. In case the second and third rolls are driven from the back roll, the break draft will come between the first and second rolls, whereas if the back roll drives the third roll and the front roll drives the second roll, the break draft will come between the second and third rolls.

In calculating for the proper draft on a drawing frame, some overseers make allowance in the figured draft for the influence of the weight of the sliver as it passes from the can to the rolls. There is practically no twist in the card or comber sliver, and as it is drawn from the can, the friction and its weight have a tendency to draw the fibres out, or produce a small draft. This condition is more noticeable in weather favorable to drawing, although it exists in all weather, and thus it will be found that the actual draft produced in the sliver in some cases slightly exceeds the figured draft. Allowance is sometimes made for this and the figured draft is made slightly smaller than it should be under perfect conditions.

The draft of the machine, when using metallic drawing rolls is different from that when using leather top rolls, as the flutes of the rolls mesh into each other and the slivers in passing between them sink down into the grooves between the flutes and thus receive an extra draft, or we may consider that larger fluted rolls in connection with leather top rolls are used, the equivalents being given in the table on page 113.

The total draft of a drawing frame is generally nearly equal to the number of doublings at the back of each delivery, so that the weight per yard of the finished sliver is equal to the weight per yard of the sliver fed to the machine.

The usual weights of the delivered sliver per yard at the finisher drawing frame are different for different kinds of cotton, for instance with Sea Island cotton which has undergone the process of combing and is to be made into a fine class of yarn, 50 to 55 grains per yard is a good weight, and for all other cottons, unless for special purposes, 60 grains per yard is a good average. A variation of more than one grain over or under the standard, for each sliver, should not be allowed, and if that one grain is on the same side of the standard for several weighings, the fault must be found and remedied. Slivers at the first two processes should be weighed once a day, taking several yards of the same sliver and weighing each separately in order to get a good average weight per yard. Variations in the weight of the sliver are caused by variations in card or comber sliver; by spoon stop motion being out of proper working order, thus allowing singles to pass through; by the weights for the top rolls not hanging free, thus allowing top rolls to slip more or less, and also by using a wrong change draft gear on the machine.

Weighing the sliver at the finisher drawing frame is a most important matter, and should be done at least twice a day, and in connection with fine work, 3 or occasionally 4 times a day. If the weight of the sliver is properly adjusted at this frame, there will be fewer changes in the subsequent processes, which is desirable, for every correction made at the drawing frame will save several changes on the fly frames. Another reason is that it is best to get the yarn running evenly as early as possible in the process of its manufacture.

The speed of the front roll is generally spoken of as the speed of the machine and varies from 250 to 450 revolutions per minute, according to the class of cotton under operation and also according to the weight per yard of the sliver.

A mill is generally equipped with enough frames to allow the machines to be stopped for a short time, as it gives the one in charge of the frames a chance to clean them, which is absolutely necessary in order to produce satisfactory work. It is not always advisable to run the front roll up to the highest speed possible, because it will be found that a large percentage of lost time will occur through stoppages and also that more bung-ups will occur, from the fact that the automatic stop motions will very often not act so quickly as to prevent these accidents. Bung-ups often cause breakdowns, and breakdowns require considerable time to repair the machine, so that if the front roll had been run at a slower speed it would in the long run more than have made up for the amount of product which was gained by the increased speed of the front roll, on account of being able to run the machine more steady, while the increased speed of the front roll stopped the machine for repairs.

The Mason Drawing Frame.—The method of driving this frame is shown in Fig. 169, showing the plan of gearing for the drawing rolls separately. Power is transmitted to the bottom (main) shaft *A* of the frame, through a belt from the main line shafting of the room to the pulley *B*. On this bottom shaft is another pulley *C* which drives a pulley *D* fastened on the end of the front roll shaft *E*. *D'* is the loose pulley. Gears marked *L* are used in connection with leather top rolls and those marked *M* are used with metallic top rolls. Secured to the front roll shaft *E* is a 24 gear which drives a 51 gear on the same stud with a 54 *M* or 45 *L* gear, and this gear in turn drives the calender roll *F* through a 41 *M* or 45 *L* gear. The 24 gear on the front roll shaft *E* also drives a 27 gear on the same stud with a 30 *M* or 24 *L* gear which drives a 30 gear on the end of a horizontal shaft *G*. This horizontal shaft *G* has two other gears secured to it, one is a 20 bevel gear driving another 20 bevel gear on the same collar with a 23 gear and this in turn drives the coiler *H* through an 86 gear. The other gear 15, on the horizontal shaft *G* drives a 40 gear molded with a 16 bevel gear which in turn drives the bevel 34 secured to the vertical shaft *I* of the coiler arrangement. A change gear (11 to 15) is secured to the lower end of this shaft *I* and through an intermediate gear drives a 32 gear on the same collar with a 12 gear which in turn through an intermediate gear drives the coiler can stand *J* through an 80 gear.

The front roller-shaft *E* has also a 22 gear secured to it and this drives the 90 crown gear which is on the same stud with the draft change gear (30 to 60), which in turn drives a gear on the end of the back roll *K*

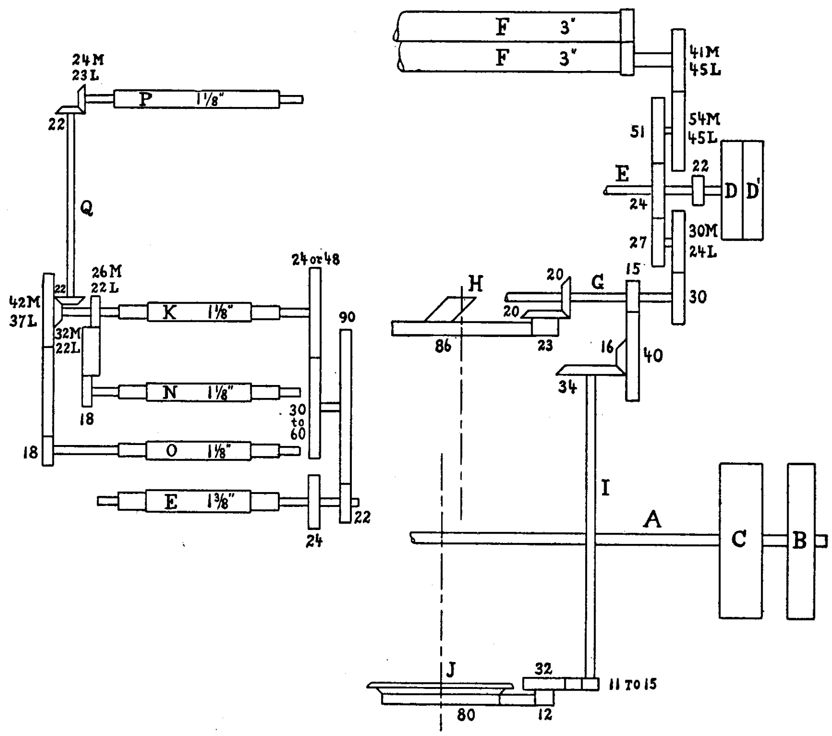


FIG. 169.

which may be either 24 or 48 teeth, according to whether a low or high draft is required. On the other side of the back roll *K* is a 26 *M* or 22 *L* gear, which through an intermediate gear drives an 18 gear on the end of the third roll *N*. On the end of the back roll *K* are two gears molded together, one being a 32 *M* or 22 *L* bevel and the other a 42 *M* or 37 *L* spur gear, the latter through an intermediate gear driving an 18 gear on the end of the second roll *O*. The 32 *M* or 22 *L* bevel gear on the back roll *K* drives the lifting roll *P* through the bevel 22 on a horizontal shaft Q having another 22 bevel gear on its other end, which drives the 24 M or 23 L gear on the end of the lifting roll P.

The break draft in this machine is between the front and second rolls E and O respectively.

To ascertain total draft in connection with diagram given, using leather top rolls, the same is generally figured from a draft constant, in order to easily make any changes in the draft gear when the proper draft is known. There is a slight draft between the lifting or tension roll and the back roll, and also between the calender roll and the front roll, and in order to obtain the total draft of the machine, we must figure a constant between the lifting roll and the calender roll.

From the rule given, we figure the constant in the same manner as the draft, excepting that the draft gear is omitted in the calculation.

$$\frac{3 \times 23 \times 22 \times 48 \times 90 \times 24 \times 45}{1\frac{1}{8} \times 22 \times 22 \times * \times 22 \times 51 \times 45} = 257.6 \text{ Draft constant.}$$

Draft constant ÷ Draft = Gear.
Draft constant ÷ Gear = Draft.

Example: We wish to produce a total draft of 6 on the drawing frame, what draft gear will we have to use?

$$257.6 \div 6 = 42.9 = 43 \text{ gear.}$$

To find the actual draft produced with a 43 gear we have 257.6 ÷ 43 = 5.99 draft.

To find the total draft of drawing rolls; the intermediate drafts between the rolls; also the drafts between the lifting roll and the back drawing roll; and between the front drawing roll and the calender roll, we have:

Draft between the front and back rolls:

$$\frac{1\frac{3}{8} \times 48 \times 90}{1\frac{1}{8} \times 43 \times 22} = 5.581 \text{ draft.}$$

Draft between the lifting roll and back roll:

$$\frac{1\frac{1}{8} \times 23 \times 22}{1\frac{1}{8} \times 22 \times 22} = 1.045 \text{ draft.}$$

Draft between the back and third rolls:

$$\frac{1\frac{1}{8} \times 22}{1\frac{1}{8} \times 18} = 1.222 \text{ draft.}$$

Draft between the third and second rolls:

$$\frac{1\frac{1}{8}\times 18\times 37}{1\frac{1}{8}\times 22\times 18} = 1.682 \text{ draft.}$$

Draft between the second and front rolls:

$$\frac{1\frac{3}{8}\times 18\times 48\times 90}{1\frac{1}{8}\times 37\times 43\times 22} = 2.715 \text{ draft.}$$

Draft between the front and calender rolls:

$$\frac{3\ \times 24\times 45}{1\frac{3}{8}\times 51\times 45} = 1.026 \text{ draft.}$$

The total draft of the machine may be obtained by multiplying together all of the intermediate drafts, the draft between the lifting and back rolls, and between the front and calender rolls, but allowance must be made for dropping fractions in the multiplications.

The calculation for the coiler generally consists in finding the relative number of revolutions of the coiler to the coiler can stand, which we calculate by allowing the coiler can stand one revolution and using the proper change gear, for example 12.

$$\frac{1\times 80\times 32\times 34\times 40\times 20\times 23}{12\times 12\times 16\times 15\times 20\times 86} = 26.9 \text{ revolutions of the coiler to}$$

one revolution of the coiler can stand.

The production of a single delivery is figured from the number of yards delivered by the calender rolls per minute, the weight per yard of the sliver and the time run.

Example: What is the production of a delivery of drawing for a day of 10 hours, allowing 20% loss for cleaning, oiling, etc., the sliver weighing 60 grains per yard, and the front roll makes 300 r. p. m.?

Surface speed of calender rolls is figured from the speed of the front roll as follows:

$$\frac{300\times 24\times 45\times\ 3''\times 3.1416}{51\times 45\times 36''} = 36.96 \text{ yds. delivered per minute.}$$

10 hours = 600 minutes. 600 minutes — 20% = 480 minutes.

$$\frac{36.96\times 60\times 480}{7000} = 152.06 \text{ pounds per day per delivery.}$$

The foregoing calculations have been made for frames using leather top rolls, so that they will not apply to frames using metallic rolls, although the principle of calculation is identical.

The draft of metallic rolls is figured in the same manner as leather top rolls, but substituting the proper equivalents for the diameters of rolls, and adding a certain per cent to get the actual draft (see page 113). The per cent added varies slightly with the bulk or weight per yard of sliver, it being generally 10% for an ordinary weight sliver and a little less when the sliver is heavy and the draft low, and correspondingly higher when the draft is high or the sliver is light. It must be understood that the per cent is always taken on the figured draft.

The constant for the total draft is calculated thus:

$$\frac{3 \times 24 \times 22 \times 48 \times 90 \times 24 \times 54}{1\frac{1}{8} \times 22 \times 32 \times * \times 22 \times 51 \times 41} = 243.41 \text{ draft constant.}$$

Draft constant ÷ Draft = Gear.
Draft constant ÷ Gear = Draft.

Example: Suppose we put on a 40 draft change gear, what draft will it produce?

243.41 ÷ 40 = 6.085 figured draft, or
6.085 + 10% = 6.685 actual draft.

Using 16 pitch flutes for the back roll, 24 pitch for the third roll and 32 pitch flutes for the second and front rolls, the draft between the back and third rolls is thus:

$$\frac{\frac{9}{8} \times 26}{\frac{10}{8} \times 18} = 1.3 \text{ draft.}$$

Between the third and second rolls:

$$\frac{\frac{9}{8} \times 18 \times 42}{\frac{9}{8} \times 26 \times 18} = 1.615 \text{ draft.}$$

Between the second and front rolls:

$$\frac{\frac{11}{8} \times 18 \times 48 \times 90}{\frac{9}{8} \times 42 \times 40 \times 22} = 2.57 \text{ draft.}$$

The draft between the drawing rolls would then be:

1.3×1.615×2.57 = 5.4 figured draft, or
5.4+10% = 5.94 actual draft.

Draft between the lifting roll and back roll:

$$\frac{\frac{10}{8} \times 24 \times 22}{1\frac{1}{8} \times 22 \times 32} = 1.11 \text{ draft.}$$

Draft between the front roll and calender roll:

$$\frac{3 \times 24 \times 54}{\frac{11}{8} \times 51 \times 41} = 1.014 \text{ draft.}$$

The total draft of the machine then would be:

$$1.11 \times 5.94 \times 1.014 = 6.685 \text{ total draft.}$$

The production for a delivery is figured in the same manner as for leather top rolls.

Example: What is the production of a delivery of drawing for a day of 10 hours, allowing 20% loss for cleaning, oiling, etc., the sliver weighing 60 grains per yard, and the front roll makes 300 r. p. m.?

Surface speed of calender rolls is figured from the speed of the front rolls as follows:

$$\frac{300 \times 24 \times 54 \times 3'' \times 3.1416}{51 \times 41 \times 36''} = 48.68 \text{ yds. delivered per minute.}$$

$$600 \text{ minutes} - 20\% = 480 \text{ minutes.}$$

$$\frac{48.68 \times 60 \times 480}{7000} = 200.28 \text{ lbs., production per day, per delivery.}$$

The Saco and Pettee Drawing Frame.—Fig. 170 is a diagram of gearing of this drawing frame, the gearing of the coiler and can stand being in front elevation, while the gearing of the drawing rolls is a top plan view, the object of which is to show the connection between the rolls and the coiler. The bottom shaft *A* is driven from the main line shafting of the room, through a belt and pulley *B* and in turn drives the front roll shaft *C* by means of a pulley *D* on the bottom (main) shaft *A* and pulley *E* (*E′* = loose pulley) on the front roll shaft. Secured to this front roll shaft, are two 24 toothed gears; the one nearest pulley *E* drives a 100 gear on the same stud with the draft change gear * which in turn drives the back roll *F* through a 60 gear. On the opposite end of the back roll *F* is secured a 26 gear, which drives a 28 gear on the same stud with a 33 gear. This 33 gear drives the third roll *G* through a 20 gear. Situated on the opposite end of the front roll shaft *C* from the pulley *E*, is a 20 gear which drives a 37 gear on the same stud with a 28 gear, and this gear in turn drives the second roll *H* through a 32 gear. It will be noticed that on this drawing frame, the break draft comes between the second and third rolls. The other 24 gear secured to the front roll shaft *C* drives a 45 gear on the same stud with a change gear (30 to 33 for *L* rolls, 39 to 43 for *M* rolls) which drives the calender roll *I*

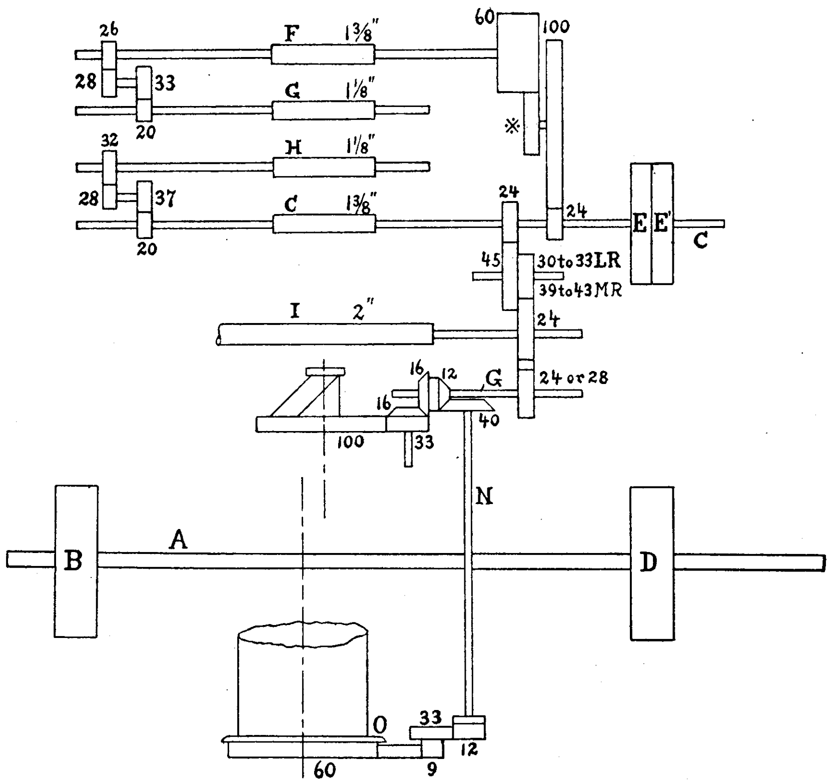


FIG. 170.

through a 24 gear. Also in mesh with this 24 gear through an intermediate gear is a 24 gear for 10 inch cans or a 28 gear for 12 inch cans, being on the same shaft *G* with a 12 and 16 bevel gear, molded together, the 16 gear driving the coiler through the gears 16, 33, and 100 respectively. The 12 bevel gear drives a 40 bevel on the end of an upright shaft *N*, the other end of which carries a 12 gear which meshes into a 33 gear on the same stud with a 9 gear, which through an intermediate gear and a 60 gear drives the coiler can stand *O*.

The draft constant for this drawing frame, using leather top rolls, is found as follows:

$$\frac{2 \times 60 \times 100 \times 24 \times 33}{1\frac{3}{8} \times * \times 24 \times 45 \times 24} = 266.66 \text{ draft constant.}$$

Draft constant ÷ Draft = Gear.
Draft constant ÷ Gear = Draft.

Example: We want to produce a draft of 6 on the drawing frame, what draft change gear will we use?

$$266.66 \div 6 = 44.44 = 44 \text{ gear.}$$

Then the actual draft, using a 44 gear will be 266.66 ÷ 44 = 6.06 actual draft.

Draft between the back and third rolls:

$$\frac{1\frac{1}{8} \times 26 \times 33}{1\frac{3}{8} \times 28 \times 20} = 1.253 \text{ draft.}$$

Draft between the third and second rolls:

$$\frac{1\frac{1}{8} \times 20 \times 28 \times 60 \times 100 \times 20 \times 28}{1\frac{1}{8} \times 33 \times 26 \times 44 \times 24 \times 37 \times 32} = 1.754 \text{ draft.}$$

Draft between the second and front rolls:

$$\frac{1\frac{3}{8} \times 32 \times 37}{1\frac{1}{8} \times 28 \times 20} = 2.584 \text{ draft.}$$

Draft between the front and calender rolls, using a 33 gear:

$$\frac{2 \times 24 \times 33}{1\frac{3}{8} \times 45 \times 24} = 1.0666 \text{ draft.}$$

By multiplying these drafts together, we obtain the total draft as follows:

$$1.253 \times 1.754 \times 2.584 \times 1.0666 = 6.06 \text{ total draft.}$$

The calculation for production of a single delivery of drawing is best shown by an

Example: What is the production of a delivery of drawing for a day of 10 hours, allowing 20% loss for cleaning, oiling, etc., the sliver weighing 55 grains per yard and the front roll makes 320 r. p. m.?

The surface speed of the calender roll is figured from the r. p. m. of the front roll as follows:

$$\frac{320 \times 24 \times 33 \times 2'' \times 3.1416}{45 \times 24 \times 36''} = 40.96 \text{ yards per minute.}$$

600 minutes — 20% = 480 minutes.

$$\frac{40.96 \times 55 \times 480}{7000} = 154.47 \text{ lbs. production per day per delivery.}$$

The number of revolutions of the coiler to one revolution of the coiler can stand is figured as follows:

$$\frac{1 \times 60 \times 33 \times 40 \times 16 \times 33}{9 \times 12 \times 12 \times 16 \times 100} = 20.16 \text{ revolutions of the coiler to one of the stand.}$$

When metallic rolls are used, the proper equivalents must be used for the diameters of rolls in the calculation. The only change in the gearing on this frame in changing from leather top rolls to metallic rolls is that in place of the 30 to 33 gear between the front and calender rolls, a 39 to 43 gear is used, this being necessary in order that the calender roll may properly take up the extra length delivered by the metallic rolls.

The draft constant for metallic rolls is figured as follows:

$$\frac{2 \times 60 \times 100 \times 24 \times 43}{1\frac{2}{6} \times * \times 24 \times 45 \times 24} = 238.88 \text{ draft constant.}$$

Draft constant ÷ Draft = Gear.
Draft constant ÷ Gear = Draft.

Example: What draft will be produced, if we use a 40 draft change gear?

238.88 ÷ 40 = 5.97 figured draft.
5.97 + 10% = 6.56 actual draft.

Draft between the back and third rolls:

$$\frac{\frac{9}{8} \times 26 \times 33}{\frac{12}{8} \times 28 \times 20} = 1.149 \text{ draft.}$$

Draft between the third and second rolls:

$$\frac{\frac{9}{8} \times 20 \times 28 \times 60 \times 100 \times 20 \times 28}{\frac{9}{8} \times 33 \times 26 \times 40 \times 24 \times 37 \times 32} = 1.93 \text{ draft.}$$

Draft between the second and front rolls:

$$\frac{\frac{11}{8} \times 32 \times 37}{\frac{9}{8} \times 28 \times 20} = 2.584 \text{ draft.}$$

The draft between the back and front rolls would then be:

$1.149 \times 1.93 \times 2.584 = 5.729$ figured draft, and
$5.72 + 10\% = 6.299$ actual draft.

Draft between the front and calender rolls:

$$\frac{2 \times 24 \times 43}{\frac{11}{8} \times 45 \times 24} = 1.042 \text{ draft.}$$

Then the total draft of the machine will be:

$6.299 \times 1.042 = 6.56$ total draft.

The production is calculated in a similar manner as when using leather top rolls.

Example: What is the production of a delivery of drawing for a day of 10 hours, allowing 20% loss for cleaning, oiling, etc., the sliver weighing 55 grains per yard and the front roll makes 320 r. p. m.?

The surface speed of the calender roll is figured as follows:

$$\frac{320 \times 24 \times 43 \times 2'' \times 3.1416}{45 \times 24 \times 36''} = 53.37 \text{ yards per minute.}$$

$600 - 20\% = 480$ minutes.

$$\frac{53.37 \times 55 \times 480}{7000} = 201.28 \text{ lbs. production per day per delivery.}$$

The Howard & Bullough Drawing Frame.—The method of driving the Howard & Bullough drawing frame (see also Fig. 148 for perspective view of this machine) is shown by means of diagram Fig. 171, the plan diagram showing the gearing connections of the drawing rolls for both leather and metallic top rolls, while the gearing from the front roll to the calender roll in this plan diagram only refers to metallic rolls, the proper gearing for the leather rolls being shown separately in side elevation. The frame is driven from the main line shafting of the room to the bottom shaft *A* of the frame, a pulley *B* attached to the bottom shaft transmitting the rotation to a pulley *C* (*C'* loose pulley) on the end of the front roll shaft *D*. Secured to this front roll shaft, near the pulley *C* is a 22 gear, which drives a 98 gear on the same stud with the change (*) gear 55 to 65 or more or less. This change gear drives the back roll *E* through a 69*L* or 66*M* gear, the back roll having secured to it, on the opposite side, a 24*L* or 29*M* gear, which drives a 36*L* or 33*M* gear on the same stud with a 40*L* or 36*M* gear respectively, this gear in turn driving the third drawing roll *F* through a 24*L* or 23*M* gear. The 24*L* or 29*M* gear on the back roll shaft *E* also drives the electric roll *G*, at the back of the machine, through intermediates and a 24*L* or 20*M* gear secured on the end of the electric roll shaft *G*.

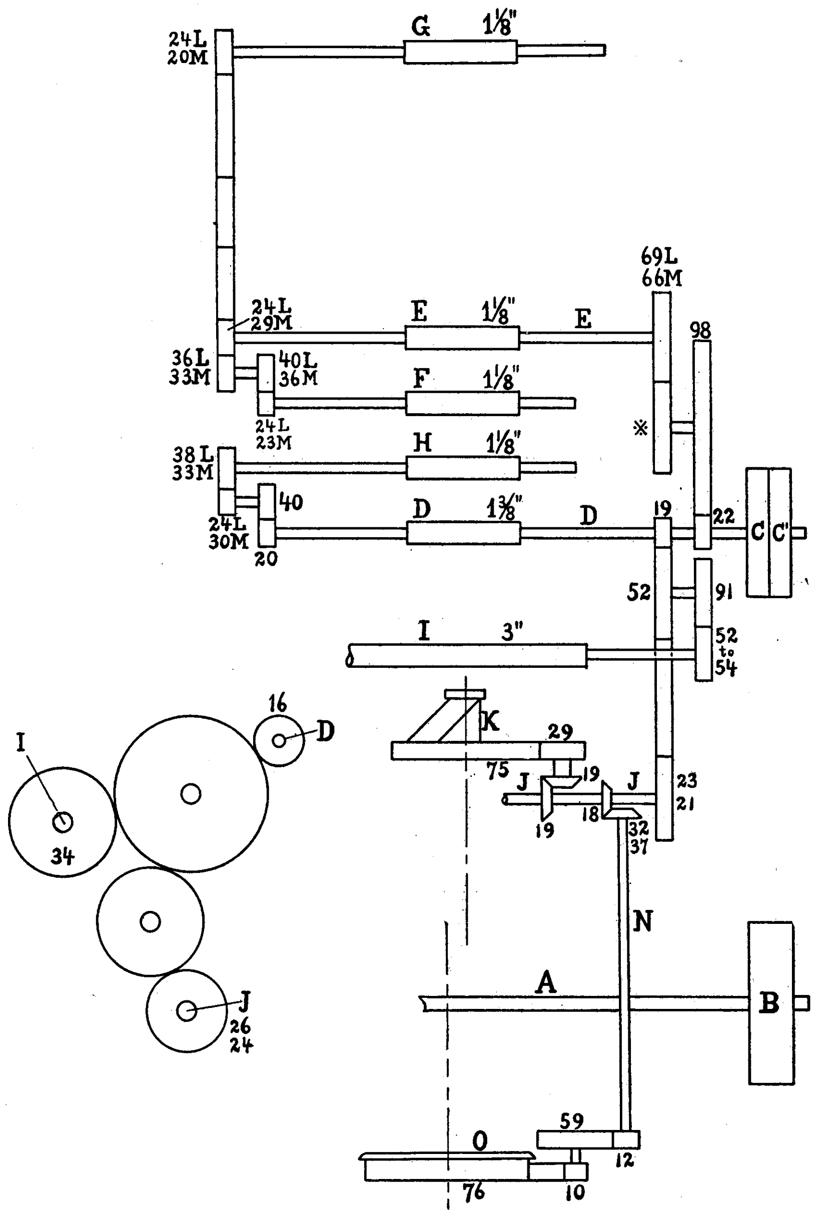
The front roll shaft *D* has secured to it on the opposite end from the pulley *C*, a 20 gear driving a 40 gear on the same stud with a 24*L* or 30*M* gear, which drives the second roll *H* through a 38*L* or 33*M* gear secured on the end of said roll shaft.

With metallic rolls (see plan diagram), the calender roll *I* and horizontal coiler shaft *J* are driven as follows: A 19 gear on the front roll shaft *D* drives a 52 gear on the same stud with a 91 gear which drives the calender roll *I* through a 52 to 54 gear attached to it.

The horizontal coiler shaft *J* is driven through two intermediates from the front roll 19 gear by means of a 23 gear for 10" cans or a 21 gear for 12" cans, on the end of said shaft *J*. For leather rolls (see side elevation diagram), a 16 gear on the front roll shaft *D* drives the calender roll *I* through an intermediate and a 34 gear, on the end of the roll. The horizontal coiler shaft is driven from the front roll through two intermediates and a 26 gear for 10" cans or 24 gear for 12" cans on the end of the horizontal coiler shaft *J*.

The coiler *K* is driven for either metallic or leather rolls from the horizontal coiler shaft *J* through a 19 bevel gear which drives another 19 bevel gear on the same stud with a 29 gear, the latter gear driving the 75 gear on the coiler *K*. An 18 bevel gear is also secured to the horizontal coiler shaft *J* and drives a 32 bevel gear for 10" cans or a 37 bevel gear for 12" cans, respectively secured to the end of the upright shaft *N*, the other end of which has a 12 gear secured to it and which drives a 59 gear on the same stud with a 10 gear, the latter in turn, through an intermediate, driving a 76 gear on the coiler can stand *O*.

The draft constant for the frame when using leather top rolls is figured between the back drawing roll and the calender roll, owing to


24L
20M
G
1⅛"
69L
66M
24L
29M
E
1⅛"
E
98
36L
33M
40L
36M
F
1⅛"
24L
23M
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38L
33M
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24L
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D
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22
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3"
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16
D
I
K
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75
J
19
J
23
21
19
18
32
37
34
N
A
B
J
26
24
59
O
12
76
10

Fig. 171.

the fact that there is no draft between the electric and back rolls, and is as follows:

$$\frac{3 \times 69 \times 98 \times 16}{1\frac{1}{8} \times * \times 22 \times 34} = 385.71 \text{ draft constant.}$$

Draft constant ÷ Draft = Gear.
Draft constant ÷ Gear = Draft.

Example: We want to produce a draft of 6 on the machine, what draft change gear will we use?

$385.71 \div 6 = 64.28 = 64$ gear.
$385.71 \div 64 = 6.027$ actual draft.

Draft between the back and third rolls:

$$\frac{1\frac{1}{8} \times 24 \times 40}{1\frac{1}{8} \times 36 \times 24} = 1.111 \text{ draft.}$$

Draft between the third and second rolls:

$$\frac{1\frac{1}{8} \times 24 \times 36 \times 69 \times 98 \times 20 \times 24}{1\frac{1}{8} \times 40 \times 24 \times 64 \times 22 \times 40 \times 38} = 1.365 \text{ draft.}$$

Draft between the second and front rolls:

$$\frac{1\frac{3}{8} \times 38 \times 40}{1\frac{1}{8} \times 24 \times 20} = 3.87 \text{ draft.}$$

Draft between the front and calender rolls:

$$\frac{3 \times 16}{1\frac{3}{8} \times 34} = 1.027 \text{ draft.}$$

Then the total draft would equal:

$$1.111 \times 1.365 \times 3.87 \times 1.027 = 6.027 \text{ total draft.}$$

The number of revolutions of the coiler to one revolution of the coiler can stand for 10″ cans is figured as follows:

$$\frac{1 \times 76 \times 59 \times 32 \times 19 \times 29}{10 \times 12 \times 18 \times 19 \times 75} = 25.68 \text{ revolutions.}$$

The production of a single delivery of drawing will be explained by an

Example: What is the production of a single delivery of drawing for a day of 10 hours, allowing 20% loss for cleaning, oiling, etc., the sliver weighing 50 grains per yard and the front roll makes 368 r. p. m.?

The surface speed of the calender rolls is found as follows:

$$\frac{368 \times 16 \times 3'' \times 3.1416}{34 \times 36''} = 45.34 \text{ yards per minute.}$$

600 minutes — 20% = 480 minutes.

$$\frac{45.34 \times 50 \times 480}{7000} = 155.45 \text{ lbs. production per day per delivery.}$$

When metallic rolls are used, the total draft of the machine must be figured between the electric and calender rolls, and from the diagram given is figured as follows:

$$\frac{3 \times 20 \times 66 \times 98 \times 19 \times 91}{1\frac{1}{8} \times 29 \times * \times 22 \times 52 \times 53} = 339.20 \text{ draft constant.}$$

Draft constant ÷ Draft = Gear.
Draft constant ÷ Gear = Draft.

Example: What draft will a 62 draft change gear produce?

339.20 ÷ 62 = 5.471 figured draft.
5.471 + 10% = 6.018 actual draft.

Draft between electric and back rolls, using the proper equivalent for the back metallic roll:

$$\frac{\frac{10}{8} \times 20}{\frac{9}{8} \times 29} = 1.021 \text{ draft.}$$

Draft between the back and third rolls:

$$\frac{\frac{9}{8} \times 29 \times 36}{\frac{10}{8} \times 33 \times 23} = 1.238 \text{ draft.}$$

Draft between the third and second rolls:

$$\frac{\frac{9}{8} \times 23 \times 33 \times 66 \times 98 \times 20 \times 30}{\frac{9}{8} \times 36 \times 29 \times 62 \times 22 \times 40 \times 33} = 1.567 \text{ draft.}$$

Draft between the second and front rolls:

$$\frac{\frac{11}{8}\times 33\times 40}{\frac{9}{8}\times 30\times 20} = 2.688 \text{ draft.}$$

Draft between the drawing rolls:

$$1.238\times 1.567\times 2.688 = 5.214 \text{ figured draft.}$$

$$5.214 + 10\% = 5.735 \text{ actual draft.}$$

Draft between the front and calender rolls:

$$\frac{3\times 19\times 91}{\frac{11}{8}\times 52\times 53} = 1.026 \text{ draft.}$$

Total draft of the machine:

$$1.021 \times 5.735 \times 1.026 = 6.018 \text{ total draft.}$$

How to calculate the production for this machine is best explained by means of an

Example: What is the production of a single delivery of drawing for a day of 10 hours, allowing 20% loss for cleaning, oiling, etc., the sliver weighing 50 grains per yard and the front roll makes 368 r.p. m.?

The surface speed of the calender rolls is:

$$\frac{368\times 19\times 91\times 3''\times 3.1416}{52\times 53\times 36''} = 60.43 \text{ yards per minute.}$$

$$600 \text{ minutes} - 20\% = 480 \text{ minutes.}$$

$$\frac{60.43\times 50\times 480}{7000} = 207.2 \text{ lbs., production per day per delivery.}$$

The Whitin Drawing Frame.—The driving of this machine is shown in Fig. 172. Power is transmitted to the bottom shaft of the machine (not shown) which in turn drives the front roll *A* by means of pulley *B* on said roll shaft *A* (*B'* is the loose pulley). Situated near the pulley *B* on the front roll shaft is a 30 gear driving a 72 gear on the same stud with the draft change gear 24 to 56, said draft change gear in turn driving the back roll *C* through a 69 to 71 gear secured to it. On the other end of the back roll is secured a 26*L* or 27*M* gear which drives the lifting roll *D* through a 32*L* or 23*M* gear secured to it. The 26*L* or 27*M* gear on the back roll *C* also drives a 30*L* or 27*M* gear on the same stud with a 36 gear which in turn drives a 24 gear on the end of the third roll *E*. Situated on the opposite end of the front roll *A* from the pulley *B* is a 20 gear driving a 40 gear on the same stud with a change gear 27 for 6 draft, 31 for 5 draft, or 36 for 4 draft, and which in turn drives a 30 gear on the end of the second roll *F*. Secured also to the front roll *A*

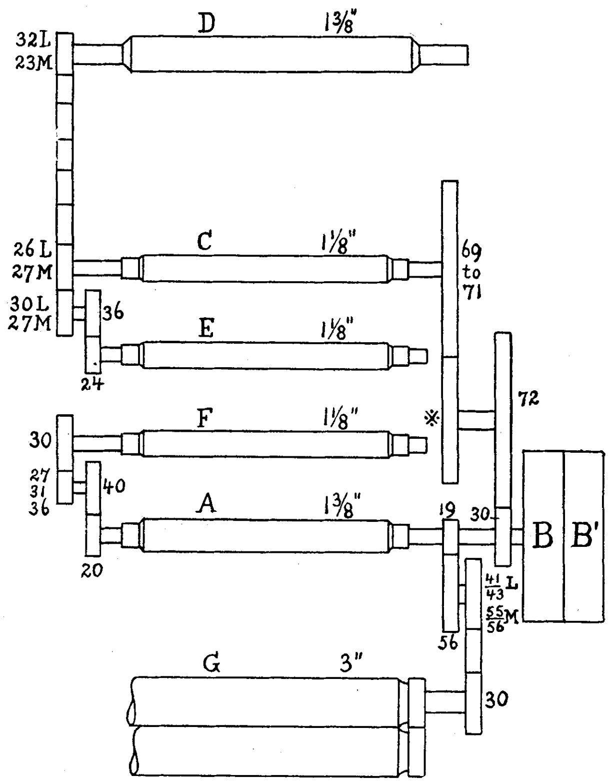

FIG. 172.

is a 19 gear which drives a 56 gear on the same stud with a gear 41 to 43*L* or 55, 56*M*, and this gear in turn, through an intermediate drives the calender roll *G* through a 30 gear secured to it. In connection with the diagram and calculations a 3 inch calender roll is used, a 2½ inch calender roll in connection with proper gearing being also supplied by the builders.

Draft constant of the frame using leather top rolls is found thus:

$$\frac{3 \times 32 \times 69 \times 72 \times 19 \times 42}{1\frac{3}{8} \times 26 \times * \times 30 \times 56 \times 30} = 211.22 \text{ draft constant.}$$

Draft constant ÷ Gear = Draft.
Draft constant ÷ Draft = Gear.

Example: We want to produce a draft of 6 on the drawing frame, what draft change gear will we use?

211.22 ÷ 6 = 35.20 = 35 gear.

Using a 35 draft change gear, the actual draft produced is thus:

211.22 ÷ 35 = 6.03 actual draft.

Draft between lifting and back rolls:

$$\frac{1\frac{1}{8} \times 32}{1\frac{3}{8} \times 26} = 1.007 \text{ draft.}$$

Draft between back and third rolls:

$$\frac{1\frac{1}{8} \times 26 \times 36}{1\frac{1}{8} \times 30 \times 24} = 1.3 \text{ draft.}$$

Draft between the third and second rolls:

$$\frac{1\frac{1}{8} \times 24 \times 30 \times 69 \times 72 \times 20 \times 27}{1\frac{1}{8} \times 36 \times 26 \times 35 \times 30 \times 40 \times 30} = 1.637 \text{ draft.}$$

Draft between the second and front rolls:

$$\frac{1\frac{3}{8} \times 30 \times 40}{1\frac{1}{8} \times 27 \times 20} = 2.716 \text{ draft.}$$

Draft between the front and calender rolls:

$$\frac{3 \times 19 \times 42}{1\frac{3}{8} \times 56 \times 30} = 1.036 \text{ draft.}$$

Multiplying these drafts together, we get the total draft thus:

$$1.007 \times 1.3 \times 1.637 \times 2.716 \times 1.036 = 6.03 \text{ draft.}$$

How to calculate the production for this machine is best explained by means of an .

Example: What is the production of a drawing for a day of 10 hours, allowing 20% loss for cleaning, oiling, etc., the sliver weighing 55 grains per yard, and the front roll makes 325 r. p. m.?

Surface speed of calender rolls:

$$\frac{325 \times 19 \times 42 \times 3'' \times 3.1416}{56 \times 30 \times 36''} = 40.3 \text{ yards per minute.}$$

600 minutes — 20% = 480 minutes.

$$\frac{40.3 \times 55 \times 480}{7000} = 151.98 \text{ lbs. delivered per day per delivery.}$$

Draft constant for metallic rolls is found thus:

$$\frac{3 \times 23 \times 69 \times 72 \times 19 \times 55}{1\tfrac{3}{8} \times 27 \times * \times 30 \times 56 \times 30} = 191.45 \text{ draft constant.}$$

Draft constant ÷ Gear = Draft.
Draft constant ÷ Draft = Gear.

Example: What draft will a 35 draft change gear produce?

191.45 ÷ 35 = 5.47 figured draft.
5.47 + 10% = 6.01 actual draft.

Draft between the lifting and back rolls:

$$\frac{\tfrac{10}{8} \times 23}{1\tfrac{3}{8} \times 27} = 1.033 \text{ draft.}$$

Draft between the back and third rolls:

$$\frac{\tfrac{9}{8} \times 27 \times 36}{\tfrac{10}{8} \times 27 \times 24} = 1.35 \text{ draft.}$$

Draft between the third and second rolls:

$$\frac{\frac{9}{6}\times 24\times 27\times 69\times 72\times 20\times 27}{\frac{9}{6}\times 36\times 27\times 35\times 30\times 40\times 30} = 1.42 \text{ draft.}$$

Draft between the second and front rolls:

$$\frac{\frac{11}{6}\times 30\times 40}{\frac{9}{6}\times 27\times 20} = 2.716 \text{ draft.}$$

Draft between the drawing rolls:

$$1.35\times 1.42\times 2.716 = 5.20$$
$$5.20 + 10\% = 5.72 \text{ draft.}$$

Draft between the front and calender rolls:

$$\frac{3\times 19\times 55}{\frac{11}{6}\times 56\times 30} = 1.017 \text{ draft.}$$

Multiplying the drafts, we have:

$$1.033 \times 5.72 \times 1.017 = 6.01 \text{ total draft.}$$

To calculate production with metallic rolls is best explained by means of an

Example: What is the production of a delivery of drawing for a day of 10 hours, allowing 20% loss for cleaning, oiling, etc., the sliver weighing 55 grains per yard and the front roll makes 325 r. p. m.?

Surface speed of the calender roll:

$$\frac{325\times 19\times 55\times 3''\times 3.1416}{56\times 30\times 36''} = 52.92 \text{ yds. delivered per minute.}$$

$$600 \text{ minutes} - 20\% = 480 \text{ minutes.}$$

$$\frac{52.92\times 55\times 480}{7000} = 199.44 \text{ lbs. production per day per delivery.}$$

The Dobson & Barlow Drawing Frame.—The diagram of gearing of this drawing frame is given in Fig. 173, which shows the coiler gearing in front elevation while the drawing roll gearing is shown elevated about the front roll.

The machine is driven from the main line shafting to the driving pulley on the driving shaft on which is also secured a pulley *B* which in turn drives the front roll through the pulley *C*. The front roll drives all of the rolls from one side, and has secured on it a gear *D* (20) which drives the gear *E* (115) on the same stud with the change gear *A* (40 to 90) and this gear in turn drives the back roll through the gear *F* (80). The gear *G* (45) on the back roll drives the second roll through inter-

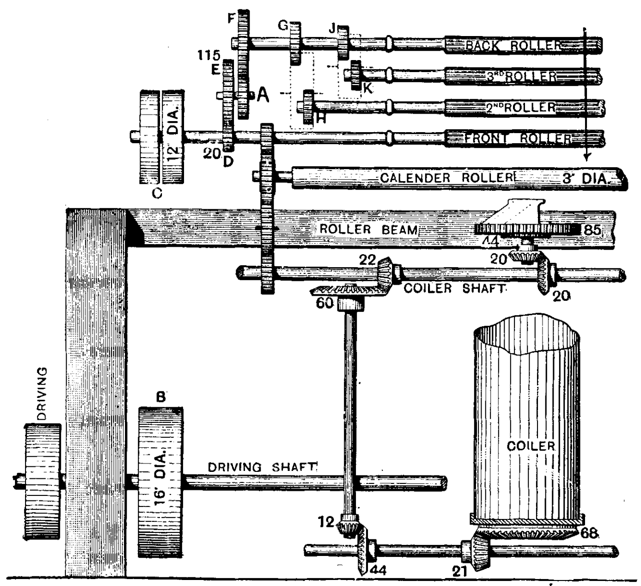

FIG. 173.

mediates and the gear *H* (20). Secured also to the back roll is the gear *J* (26) which drives the third roll through intermediates and the gear *K* (21). The calender roll is driven from the front roll through a train of gears and a continuation of the train drives the coiler shaft on which is secured a 20 bevel gear, driving another 20 bevel on the same stud with a 44 gear and this in turn drives the coiler through an 85 gear. Secured also to the coiler shaft is a 22 bevel gear which drives a 60 bevel gear on the end of a vertical shaft. A 12 bevel gear is secured to the lower end of this shaft and drives a 44 bevel on the same shaft with a 21 bevel, and this in turn drives the coiler can stand through a 68 gear. With reference to the diameter of the rolls, the second roll is $1\frac{1}{4}$ inches in diameter, the other three being $1\frac{1}{2}$ inches.

The number of slivers doubled at the back of this machine is eight. The draft constant as figured between the back and front rolls is:

$$\frac{\text{dia. front roll} \times F \times E}{\text{dia. back roll} \times * \times D} = \text{draft constant.}$$

$$\frac{1\frac{1}{2} \times 80 \times 115}{1\frac{1}{2} \times * \times 20} = 460 \text{ draft constant.}$$

Draft constant ÷ Draft = Gear.
Draft constant ÷ Gear = Draft.

Example: What draft change gear will be required to produce a draft of 8.5 on the machine?

$$460 \div 8.5 = 54.12 = 54 \text{ gear.}$$

The actual draft when using a 54 gear would be:

$$460 \div 54 = 8.52 \text{ draft.}$$

Draft between the back and third rolls:

$$\frac{1\frac{1}{2} \times J}{1\frac{1}{2} \times K} = \text{draft.}$$

$$\frac{1\frac{1}{2} \times 26}{1\frac{1}{2} \times 21} = 1.237 \text{ draft.}$$

Draft between third and second rolls:

$$\frac{1\frac{1}{4} \times K \times G}{1\frac{1}{2} \times J \times H} = \text{draft.}$$

$$\frac{1\frac{1}{4} \times 21 \times 45}{1\frac{1}{2} \times 26 \times 20} = 1.514 \text{ draft.}$$

Draft between the second and front rolls:

$$\frac{1\frac{1}{2} \times H \times F \times E}{1\frac{1}{4} \times G \times A \times D} = \text{draft.}$$

$$\frac{1\frac{1}{2}\times 20\times 80\times 115}{1\frac{1}{4}\times 45\times 54\times 20} = 4.543 \text{ draft.}$$

Multiplying these drafts together, we have

$$1.237 \times 1.514 \times 4.543 = 8.52 \text{ total draft.}$$

The number of revolutions of the coiler to one revolution of the coiler can stand is figured as follows:

$$\frac{1\times 68\times 44\times 60\times 20\times 44}{21\times 12\times 22\times 20\times 85} = 16.76 \text{ revolutions.}$$

How to calculate production of this machine, figured from the revolutions of the front roll, is best explained by an

Example: What is the production of a delivery of drawing for a day of 10 hours, allowing 20% loss for cleaning, oiling, etc., the sliver weighing 50 grains per yard, the front roll making 315 r. p. m.?

Surface speed of the front roll is:

$$\frac{315\times 1\frac{1}{2}''\times 3.1416}{36''} = 41.23 \text{ yards per minute.}$$

$$600 \text{ minutes} - 20\% = 480 \text{ minutes.}$$

$$\frac{41.23\times 50\times 480}{7000} = 141.36 \text{ lbs. production per day per delivery.}$$

The diagrams and calculations given for the different makes of drawing frames are for the most frequent styles, found in practical use in the respective makes of frames, although other systems of gearing and size of rolls for the frames are sometimes used by the machine builders in order to meet special conditions, such, for instance, as using a uniform pitch for all of the metallic drawing rolls in a frame, or when only four or five slivers are to be fed up behind the machine, or when a different size of calender roll, etc., is used. The calculations in these instances are made for the frames in the same manner as those given, care being taken to get the correct numbers of teeth in the gears on the frame, and when using a uniform pitch for metallic rolls, being careful to substitute the proper equivalents as given on page 113 for the rolls.

ROLLER COVERING.

The question of covering leather rollers, either solid or shell, as used in the various stages of cotton spinning is a very important one, from the fact that the quality of the yarn produced, depends to a large extent, on the character of the covering of the rollers. Badly covered rollers are a continual source of expense to a mill, since they need re-covering more frequently than properly covered rollers, the result being an increased consumption of roller cloth and leather, besides the cost of labor.

A great change has taken place during the last few years in the covering of rollers, the older methods of covering, with the aid of hand tools and appliances, gradually giving way to up to date machinery which is specially designed with a view to turning out perfect rollers, which will do their work thoroughly and besides last longer. Modern roller covering machinery has during the past few years been extensively adopted, although not without some little antagonism on the part of some roller coverers, as it was believed by some that the trade was threatened; however, as a matter of fact, the object of the mechanical methods of covering rollers as used in connection with the various stages of cotton spinning, has been to assist the roller coverer in turning out more perfect work.

Roller Cloth.—Before dealing with the various machines for covering rollers, it will be well to examine into the nature of the material which is used in the covering of rollers, i. e., cloth and leather. A thick woolen cloth is used in the first covering of the rollers, varying in weight from 10 to 26 ounces per yard of 27 inches width; however, the majority of cloths used varying from 16 to 22 ounces, the heaviest being used in the drawing of the heaviest slivers. The cloth should be firm and springy, evenly woven, and well felted.

In the manufacture of the best roller cloth, only the finest and soundest wool should be used, because of the fact that the cloth thus produced is the best, most serviceable, and most economical in the long run. The wool used in the manufacture of this cloth must possess strong felting qualities, since the same, before using, is passed through that process. Wool possessing felting qualities will shrink during fulling and the fibres will mat closely and firmly together, so that the resulting cloth then will have the appearance of felt, because the threads are so close and besides matted together in the fabric, so that the individual threads are not perceptible to the eye. The production of a level cloth requires that the yarns used in its construction must be carefully carded and spun, and all impurities thoroughly extracted. Care must also be taken when weaving the cloth, to get the correct weight and levelness (cover) in the fabric. The cloth after being woven is then subjected to fulling, being shrunk or felted up to the required width and weight.

Roller cloth produced from an inferior grade of wool, or such a wool in connection with waste, will be of a soft, pliable and fuzzy nature and its surface will become grooved or indented when in place on the rollers, caused by the cotton passing between the rollers, with the pressure on the top rollers. When a roller gets into this condition, it cannot perform the work properly, and consequently has to be re-covered, which of course will result in an increased expense to the mill. On the other hand, a stiff, hard cloth, especially if a stiffening constituent has been used in the finishing, will be thinner than is necessary and as a consequence the diameter of the roll will be smaller and then the leather cot will not fit it tightly, or, if it is put on tightly, in all probability the cloth will become loosened and break the joint of the leather cot. There would also be no spring or cushioning effect in the roller and one of the most important points aimed at in connection with roller covering would be lost.

In selecting roller cloth, it is a mistake to conclude that very white cloth is necessarily a good one, since the reverse is frequently the case, for if inferior wool or waste is used and a white fabric is required, a greater amount of bleaching is necessary, a feature which to some extent is detrimental to the durability of the fibres, and for which reason, in this instance, the unbleached roller cloth is superior. Although not so sightly it will wear better. As mentioned before, an inferior cloth will very soon groove or wear hollow by the passage of the sliver, whereas a covering of good cloth will outlast several leather coverings on the same roller.

It is the general practice in preparing the cloth for the roller, to tear it up into strips of the required width, but which is a bad practice, because the tearing has a harmful effect upon the edges of the cloth for quite half an inch inwards, as the web is disturbed, the strands being drawn out of position and elongated, besides leaving the edges soft, raw and fluffy, the result of which is that, when mounted on the roller, the cloth gradually tapers at each end and thus produces an uneven covering. For this reason the cloth should be cut with a sharp knife, either on a cutting board or mechanically. By cutting the cloth, the web is undisturbed and the exact width may be cut, so that the edges do not require trimming, thus saving material. Cut cloth, when mounted on the roller forms a true surface, and the full width of traverse may be taken advantage of; the rollers may also be ended more neatly.

Roller Leather.—The proper selection of roller leather requires a knowledge of the merits of the various kinds of skins to be found in the market, although the price of the skins may have to be taken into consideration, to some extent, to assist in the selection. It is practically impossible to have two makes of leather exactly alike, owing to their difference of manufacture, and when consequently the working qualities of the leathers will be different. Before buying the skins, if possible, it is a good plan to get samples of the leather, and after properly marking the cots thus made from them, so that they may be afterwards easily recognized, cover rolls with them and allow the different sample cots, if possible, to be run on the same machine, and noting which samples wear the longest. A good idea of the quality of the leather is gained by this means, although it must not be taken always for granted that the sample represents the quality of the entire lot of leather under consideration.

Then again, certain qualities of leather are more adapted for one or the other machines where cots are needed, so that before selecting the leather for covering rollers, we must ascertain where they are to be used, and then we may make use of certain practical rules. For low or coarse counts of yarn, a cheap quality of skin will answer satisfactorily, for medium counts, select a medium quality of skin, while for high or fine counts, only the best and finest skins should be selected. Rollers for the drawing frame, and for the preparatory machines in combing, require the heavy, large skins, the side portion of which may be used for the rollers in the slubber or intermediate. For slubbing, intermediate, and roving frames, for coarse work, the medium heavy large skins are used, whereas for fine intermediate, roving, jack, and detaching rollers, medium heavy, but small skins are most adapted. These are also largely employed for coarse spinning frames. For fine spinning frames the fine, light, small skins are best.

Large size skins are always of thick substance, from the fact that a healthy sheep will naturally have a thick skin, and it is a bad policy to ask for large skins of thin substance, because when skins are made thin by shaving, the fibrous structure of the skin will suffer in strength. When a skin of thin substance is wanted, get a lamb's skin which is fine, thin and delicate, and very suitable to be used for working fine fibres, whereas the skin of a full grown sheep is thick, coarse and rough, and should be used on rolls in the preparatory machines, like sliver and ribbon lap machines, combers and drawing frames only.

In purchasing skins, they should all measure over a minimum measurement determined on, or at least to be equal to it, that is, each skin must measure so many inches long and so many inches wide or more, and these measurements should be taken across the narrowest points, both lengthwise and across the skin. A diagram of the shape of the skin is shown in Fig. 174 with lines to indicate the proper measurements to be taken. The dotted line *A–B* represents the shortest length from shoulder to butt, and *C–D* the narrowest width across the skin. The calculation for the number of cots to a skin is made from the rectangle *E F G H*. In some instances, the skins are measured from *I* to *J* or *I* to *K* and *L* to *M*, which of course would only give an approximately correct result. The neck portion of the skin should not be measured, as it is unsuitable for roller covering, owing to the faults in it. The flesh side of the skin will always reveal any defects, like butcher's knife cuts, over shaving etc., in it; however, in the best grades of skins those defects should not be present, as they are detrimental to good work in spinning high class yarns, whereas for machinery, spinning lower counts of yarn, many flesh and grain defects in the skin will pass on. Another serious defect to a skin is the presence of fine hairs on it, and which skins should be rejected, the same if the skin feels rough and harsh when spread out flat on a table, the latter being an indication that the skin is not level and such a skin cannot be used in connection with fine or

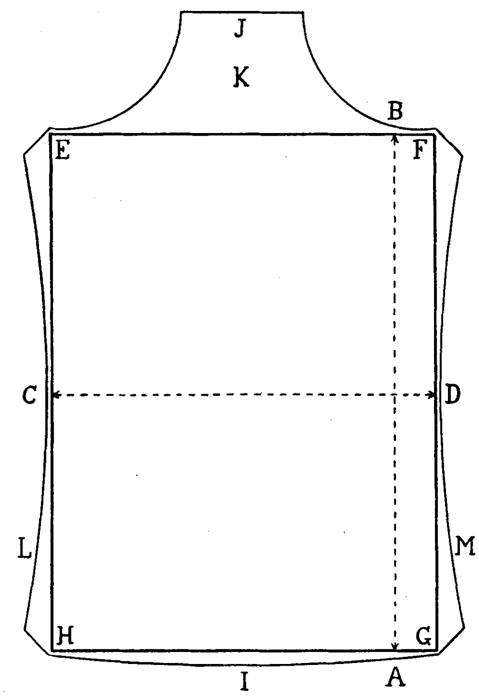

FIG. 174.

medium spinning. When handled, the skin should be very pliable, but when taken between the thumb and finger and these moved alternately in opposite directions, at the same time applying a little pressure, no feeling of looseness in the skin should be noticed. If the face side cannot be easily separated by just nicking the edge and then pulling, it is considered a good feature of the skin.

As we have intimated, it is an impossibility to obtain perfectly even skins, but there is much difference between a badly finished and a well finished skin. An untrue skin may be made true by the roller coverer, which process we will deal with later. Good skins should not feel harsh or hard, but soft and pliable, the surface well polished, and free from cracks and fissures. What is required, is a leather calculated to assist the cloth in its resilient or cushion effect upon the sliver; with a hard, unyielding leather, the resilient effect is neutralized, and there will be a tendency for both cloth and leather to become indented. A very good practice in mills is that of adopting several standard sizes of skins, which experience has shown to contain the desired range in the thickness and substance of the leather for the different machines. The actual measurements of each standard being those which will provide the maximum number of covers for the several sizes of rollers it is intended for.

Covering Rollers with Cloth.—We now commence to deal with the actual covering of the rollers. Having cut the cloth into a length of the necessary width, for the rollers to be covered, it is ready for the process of pasting, measuring, cutting into pieces, and final application to the rollers. This work was formerly done entirely by hand, but now is done also by machinery, a specimen of which is shown in Fig. 175 and which does this work more accurately and quicker than hand work.

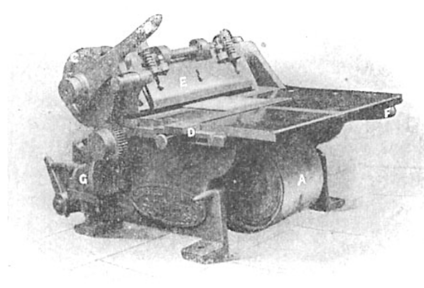

FIG. 175

The roll of cloth *A* is mounted on a spindle under the machine, and if the roll should be too large to go under the machine properly, a pair of hanging brackets may be screwed under the bench and a slot cut through the latter to pass the cloth through. The cloth is then passed under the machine through a paste box, over a feed roller *C*, and on to the receiving table. The box is then filled with paste, the back of the box forming a pressing plate fitted on strong springs, which, when released, presses the paste on to the cloth. The top of the box is made removable in order that it may be easily filled and can also be set backwards or forwards, thus increasing or decreasing the thickness of paste as required, by means of a screw. The edges of the cloth in the paste box are protected and guided by side plates *G*, which are adjustable to any width of cloth. For measuring, a figured scale is fitted into the receiving table, with an adjustable measuring plate *D* to act as a stop when the cloth has advanced sufficiently far. The cloth is measured through by pushing forward the handle *B*, and is cut by pressing down the lever *F*, which brings down the knife *E* through the cloth at a slight angle. After cutting, the knife springs back to its original position. It will thus be seen that the manner of using the machine is very simple and speedy, only two movements being necessary, that is, one to paste and measure the cloth and the other to cut the piece off. No waste of cloth takes place in the operation, as the cloth is fed through and pasted mechanically right to the end of the roll. After this operation, an iron drawing roller is rolled on to a cut piece of cloth, which is neatly glued to it, the roll then being passed on to the roller calender to be mechanically rolled, which operation results in a thorough bedding down of the cloth on the roller surface. The roller calender for this purpose should be used cold. Cloth should not be cut until it is ready to be used, as when it is cut and remains unused, a shrinkage in the cloth occurs. Paste is most generally used and should be of a nice even consistency, free from lumps, and not too hard. It is a mistake to prepare too much paste at one time, and when made it ought to be kept as nearly air tight as possible, with a damp cloth spread over it to prevent it from setting and becoming hard. The paste used should be easily and cheaply made, simple in application, capable of being thinly spread on the cloth, dry quickly and have good sticking qualities. The following is a good recipe for a paste which has proved satisfactory when used in connection with the machine:

3-lbs. best flour; 3-lbs. amber resin, crushed into fine powder; 3-tablespoonfuls of best turpentine. Place the flour in 1½ quarts of water, to steep several hours before making the paste. Place the resin in the pan with 1½ quarts of boiling water, and continue to boil for 25 minutes, then add the turpentine and boil another five minutes. Then add the steeped flour and boil all together, continually stirring to blend all ingredients together. Some coverers add a little boiled oil, but this prevents quick drying.

Care should be taken to remove all lumps from the paste, as these will be liable to choke up the slot in the machine which regulates the thickness of paste to be left upon the cloth.

Cutting the Leather.—When the rollers have been covered with cloth and dried, they are ready for covering with the leather sheath or "cot." The skins are cut, on a cutting board, into strips a trifle wider than the roller, so as to allow for ending. Skins should never be cut across the grain, but always from head to tail, which is the natural direction of the fibre-growth in the skin. A specimen of a cutting board for the special purpose of cutting skins into strips is shown in Fig. 176. This board is fitted with adjustable stops *A*, by the side of which measuring plates with scales are inserted. A planed straight edge extends across the board, with the cutting edge close to a slot for the knife to enter.

The bar is raised or lowered, both ends simultaneously, by the handle *B*, it being raised to pass the skins under, and lowered to grip the skins when cutting. Several skins may be cut up by this machine at the same time if required.

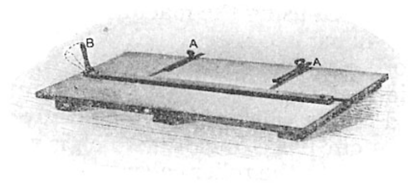

FIG. 176.

Equalizing Skins by Grinding.—The leather in perfect condition, i. e., provided the skins were perfectly even in thickness when cut into strips, would be ready for "splicing" or cutting up into pieces with beveled edges for making the cots, but all skins are more or less imperfect and can only be made true by grinding, a process which however is not always practicable when dealing with full sized skins. It may be taken for granted that very few skins are true when they arrive at the mill, but it is of the utmost importance that the leather used in roller covering should be perfectly even in thickness, as otherwise it is impossible to produce a true roller. The grinding of the leather for the rolls therefore ought to take place at this stage, and for this purpose a Leather Grinding Machine is made use of. The leather in the form of strips is fed to this machine, which grinds the leather from the flesh side just sufficiently to equalize it without any undue waste of fibre and strength. It may be mentioned that the flesh side of the leather refers to the side which was next to the true or inner skin of the sheep, while the grain side refers to the outside and from which the hairs have been removed. One end of the leather strip is passed through the slot in the carrier drum, flesh side up, and secured underneath by a thumb screw, the other end hanging down loose. Immediately behind the carrier drum revolves a grinding roller covered with glass filleting and behind this again is a fan to draw off the fibre, which is ground away, said fibre being deposited into a bag, or it may be taken away by a tube or funnel attached to the mouth of the fan. The carrier drum revolves slowly in the direction of the grinder, its arm wheel being used to set said drum into contact with the grinder, in order to get the necessary amount of cut. Before the leather comes into contact with the grinder, a presser bar holds it tight to the drum surface in order to prevent buckling. When the strip has passed through, the drum is stopped by pushing a handle, which throws the clutch gear out of motion without stopping the machine, thus allowing the leather to be examined or replaced with very little trouble or loss of time.

"Splicing" or Bevelling of the Leather.—Having ground the leather strips to an even thickness, the next operation is to cut the strips into pieces of the required size for covering a single roll, the cutting being known as "splicing," being one of the most important processes in the whole routine of roller covering. The principal method of splicing has been either with the aid of a long knife with a cranked handle and a sheet of glass set in a wood frame, or a marble slab; or in some cases, by the use of a splicing machine, a specimen of which is shown in Fig. 177.

It will be easily seen that if a joint as made with two bevelled edges is to be of the same thickness as the remaining portion of the leather when pieced together, these two bevelled edges must be cut at exactly the same angle, for if this is not done, the result would be that the width of splicing, or bevel cut with an obtuse angle, would be shorter than the bevel cut with the smaller, and an acute angle, and thus a portion of the

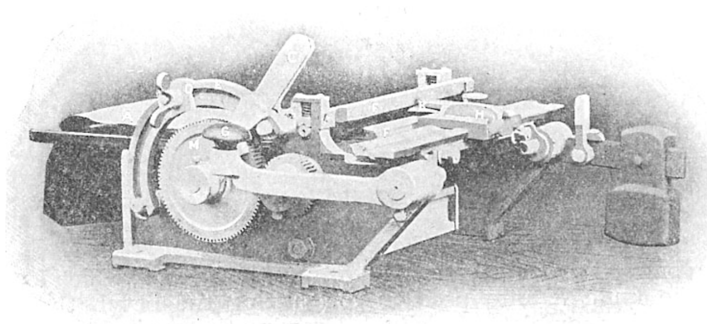

Fig. 177.

latter would overlap the former and cause a thick place in the cot. In order to show more clearly a correct and incorrect bevelling of the leather for the cots, Fig. 178 is given, the top sketch illustrating an incorrect bevel, as may be done by means of poor hand cutting, while the bottom sketch shows a correct bevel to produce a perfect piecing.

The machine cuts every bevel alike, at an angle of 12 degrees for sheepskin, and 15 degrees for calfskin, these two degrees resulting in a width of bevel which is most suitable. It is a mistake to have the bevels too wide or too narrow, as in the former case there is a tendency to cause a wide, hard line on the leather surface, and in the latter the piecing is liable to burst open. When splicing by hand, there is generally a difficulty in keeping the edge of the knife quite true, and consequently an irregularly cut line is very often the result. The strip of leather has also to be measured off for the rolls with callipers before proceeding to be cut up. Besides cutting the leather, the splicing machine, as shown in Fig. 177, also measures the correct length to be cut, and the two processes of measuring and cutting are thus made extremely simple. The leathers are placed on the table *A* with the flesh side up, and passed between feed rollers which are actuated by the handle *C*; the latter is made in two parts to grip the wheel *M* on either side. By drawing the handle forward, motion is given to the feed rolls through the gearing, the amount of movement being determined by the stop *D*, which may be moved to any point along the measuring scale *E* to suit the different lengths of leather required for the different sizes of rolls to be covered. The leather in passing through the feed rolls falls under the

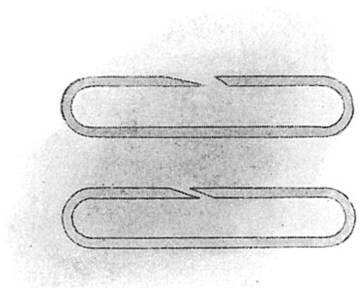

FIG. 178.

pressing bars *F*, which are pressed down by the lever *G*, which lever also brings the knife *K* into position for cutting the bevel, the cutting operation being completed by simply drawing the carriage *H* across the slide. The knife is made square, with four cutting edges, which in turn are used alternately until all four require sharpening. An arrangement is attached to the machine by which the edge of the knife receives a rub after every cut, this arrangement serving to keep the edge in good condition for a fair length of time. The knife *K*, when cutting, slides on a glass plate, and, to ensure the complete penetration of the knife through the leather, a spring is employed to adjust the knife holder.

Piecing the Leathers.—After bevelling the ends of the leather, the cut pieces have to be folded over with the grain side out and the bevelled edges pieced together with cement to form a cot. In making cement for piecing the leathers, only the very best materials should be used, and the joint, when made, should not be perceptible to the touch, but feel as smooth and soft as the remainder of the cot. For this purpose, the best gelatine must be selected, since many of the common glues and gelatines contain lime, acids, etc.

A simple recipe which will produce a cement to be used for piecing is as follows: Take 3 oz. of fine gelatine, soak in $\frac{1}{6}$ of a pint distilled water, stirring frequently until soft; then boil, stirring rapidly, until the gelatine is dissolved. When allowed to cool, the cement becomes solid, and in order to be used again, it must be melted and only used in that condition. Acetic acid is also used in connection with gelatine or isinglass, some coverers preferring to use half of each. Only a thin coat of the liquid cement is required for the piecing, which is best applied by holding the leather in the left hand, and applying the cement quickly with a small, thin stick. Immediately after the cement is laid on, the piecing is made by means of a common hand press, the cemented bevel being placed on one of the arms of the press, and the leather passed under and around the arm when the two bevels join, care being taken to see that the union is equal along the lap. Then rub the joint with a piece of very slightly sweet oiled linen and pass the cot and arm under the press, permitting it to remain there until the next cot is ready to be pressed. A press having a turntable, mounted on one of its supports is preferred, owing to the fact that by its use the leathers do not stick together inside after pressing, which is the case with a press without a turntable, and where it is found necessary to open out the cots with a piece of wood. With the turntable press, the pressure is also more equal than with other styles, and the leathers are not creased in pressing.

Drawing on the Cots.—After the cot is pieced and allowed to dry, it is ready for drawing on the roller over the cloth covering which has previously been applied. This operation is performed with the aid of a Pulling-on Machine, a specimen of which is shown in Fig. 179, which

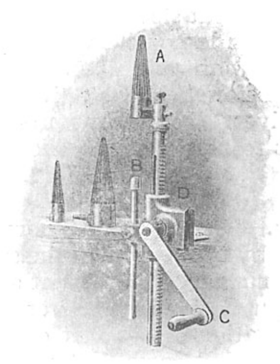

Fig. 179.

illustrates this machine in vertical working position, although it may be placed in a horizontal position. By the use of this machine, the drawing of the leather upon the roller is performed gradually, the cot being forced open gently, so that neither the piecing nor the flexibility of the leather suffers. The roller intended for covering is held in the stud *B*, the cot is placed on the spring *A*, different sizes of springs (three sizes shown in illustration) being supplied for the different kinds of rollers. By turning the handle *C*, the spring carrying the cot is brought down (see D = pinion and rack) centrically over the roller. When the cot has arrived in correct position upon the roller, the operator presses the top end, and by continuing to turn the handle gradually draws out the spring wires from between the leather and cloth. The leather in this way is thoroughly bedded, rendering slipping impossible.

The wires of the Pulling-on Machine must be made as thin as possible. Care must be taken in pulling the cot on to avoid violence, which would cause internal rupture of the finer fibres and sometimes minute fractures of the grain of the leather. One person can satisfactorily cover all of the small and medium sized rollers, but for all rollers with a boss of six inches or over, two persons must be employed, one to pull on with the handle, and the other to use his hands in guiding the cot on to the roll. If the Pulling-on Machine is operated so that the operator can use his hands for guiding on the cot, one person will suffice. The wires should always be longer than the leather cot to be drawn on, as otherwise the friction set up between the cloth and the flesh side of the cot will prevent an even covering and cause undue stretching of the leather. When putting on a long cot, the cloth covered roller is inserted in the machine, and the cot is carefully drawn over the wires, and when the assistant, with his right hand underneath his left, each gripping the leather and pressing downward, helps thus to prevent the cot from stretching lengthwise. In some cases it is necessary to work the leather on to the roller with the hands at the same time that the operator is turning the machine handle at a steady but slow rate. In this way the unevenness, which appears, especially in long rollers, is avoided. Leather cots will fit more glove like and draw on easier if they are kept in a slightly damp place for an hour or two before being used, in this manner permitting the fibres to release themselves. When drawn on, the cot should be tight enough on the roll so as to be practically incapable of being twisted by the hand.

Ending the Rollers.—The rollers are now ready for ending, i. e., the finishing of the ends by turning down the superfluous leather, which must be done in such a manner as to prevent any possibility of the ends rising again, and they must completely cover and shield the cloth edges from any possible penetration of oil. At one time this operation was performed with the aid of hot irons, but this system has now become obsolete, having given way to the use of machines in which the ending is done more neatly by friction. The machine for doing this work consists of a polished cylinder, balanced for high speed, from 700 to 1000 revolutions per minute. At the back of the cylinder is fixed a slide, carrying arms in which are set brass steps for the roller ends to revolve in. When worn, these steps allow of the worn piece being cut away, thus permitting them to be moved up and used again and again until too short to fix in the brackets. The steps are raised and lowered by a weighted lever, said weight putting pressure upon the roller, which then runs by friction in contact with the cylinder. When desired, a fan is attached to the machine. The same runs on a shaft behind the cylinder and is driven from the cylinder shaft. The smoke and fumes are thus made to escape through the fan mouth and are carried away by a tube or funnel attached to the same to the most convenient exit. The implement for turning down the ends of the roll is usually a smooth stick of boxwood, and the leather is turned down by the simple pressure of this against the ends of the roller.

Finishing the Rollers.—With the ending operation, the actual covering of the rollers is completed, but there is yet another process for the rollers to pass through before they are in perfect condition, that is calendering the rolls between hot surface plates, and which is performed by the Roller Calender. By means of calendering, a high polish is put upon the leather surface, and the rollers are further improved by having flat places, scaly surfaces, and buckled ends, caused by the ending pressure, remedied by this process, thus rendering the rollers more cylindrical. This machine is generally adapted for heating with steam, but if desired can be fitted to be heated with gas or oil. The steam chest is fitted with inlet and outlet taps, and a tap for drawing off the hot water (condensed steam). The top of the steam chest is planed and polished to form a surface plate, and over this is fixed a rolling plate, mounted on bowls to run on rails, and worked to and fro by cranks. The rollers are placed on the table of the machine, and each roller in turn is delivered on to the surface plate, rolled four times backward and forward, then delivered on to a receiving table and another roller fed in automatically by the feed motion to take its place. The roller is never at rest on the heated plate, but performs a constant rolling motion from start to finish. The top rolling plate is set up or down to the different diameters of rollers by an arm wheel.

Truing and Varnishing Rollers.—It is the general custom to grind and varnish large rollers, such as have to perform heavy work (although smaller ones may be treated thus also), and for which purpose a Truing and Varnishing Machine is used.

The rollers to be ground are carried in this machine in spring chucks, which run in ball bearings. The disc of the grinding machine is covered with a specially made emery tape, and is on the traversing emery wheel principle, with this difference, that in place of a double way screw, a single threaded screw is employed. The length of traverse given to the emery wheel is regulated by the stops on the strap guider, and as the boss of the wheel comes in contact with the stops, the direction of traverse is reversed. The centring arrangement as well as the reversing brackets of the machine are movable, and easily fixed in position for different lengths of rollers. The rollers are set up to the grinding disc by a hand wheel placed in front of the machine. At the back, the machine is formed in a dust chamber, which serves the purpose of a fan, and is easily cleaned out by lifting the back plate. No keys are required with the machine, all movable parts being fitted with thumb screws.

When varnishing, the reversing motion strap has to be detached, thus rendering the grinding disc stationary at one end of the tube and out of the way of the rollers. The varnishing of rollers, using for this purpose a flat brush, must be done carefully, a description of the procedure having been given previously on pages 106 to 108.

Testing Rollers.—A most valuable adjunct to a roller covering plant is an apparatus for testing the trueness of rollers, a specimen of which is given in Fig. 180, by means of which any irregularity in the roller, whether on the bare iron, after covering, or after grinding, is readily detected. This apparatus consists of two parallel surfaces, the upper

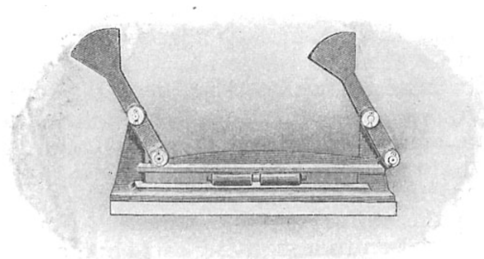

Fig. 180.

one being suspended to rise and fall to any diameter up to 2 inches, the bottom plate being grooved along its length to hold the roller in correct position for testing. This apparatus will reveal any inaccuracy by showing the spaces, if any, caused by the inability of the tester bar to touch the whole width of the surface of the roller. Provided there is no such special testing apparatus at hand, a good plan to ascertain if newly covered rollers are true, is to take two newly covered rollers, place them boss to boss, and hold them up to the light and turn them slowly. If there are imperfections in the coverings, either a thin strip of light will be seen part or the entire length of the roller, showing that the covered roller contains a ridge or a slightly projecting point; or a small dot of light will be seen, which indicates that the roller is hollow in certain places.

Hand Roller Covering.—In mills where the number of rollers covered does not warrant the introduction of the machines previously described, the work is performed by hand. The felted woolen cloth is then cut into strips, which are slightly less in width than the boss of the roller, and laid flat on a table. The iron roller, after being cleaned, then has its boss covered with glue, consisting of a preparation of flour, resin and turpentine, spread in a very thin layer, as evenly as possible upon it, care being taken that the roller is simply warm. The boss of the roller is then placed on one of the strips of cloth, which under pressure is wound on the surface of the roller until it begins to overlap itself, and when it is then cut through with a sharp knife. The cloth on the roller, after thus being cut, is pressed to its place, on the roller with the fingers in order to make a smooth seam. In other cases, roller coverers cut the cloth in quantities to correct size, before pasting them on the rollers, in this instance, piling the cloth in strips, one on top of the other, until about 15 layers are obtained, when they then place the strips in a mitre box, and block them up, cutting through the whole 15 in one operation, thus making the cloth into proper lengths to cover the surfaces of the rollers. Again the 15 strips may be placed on a flat table, and a wooden pattern used in cutting them into the correct lengths. The disadvantage to cutting the cloth in quantities, ahead before pasting, into small pieces, is that they are more liable to contract and become too small if left standing for a time, than would be the case with the long strips. If the work is done properly the two ends of the cloth should touch each other all across. The greatest of care must be exercised by the roller coverer in his work, since the slightest variations in the length of cloth cut, the straightness of the cutting, or the spreading of the paste, would each prevent the formation of a perfect surface, being faults arising frequently even with the best roller coverer, when the work is done manually.

After rollers are thus covered with cloth, they are placed between evening or smoothing rolls for the purpose of smoothing out any lumps that may have been left in the glue, thereby producing a perfectly true and even surface to the roller.

The leather for the outside covering of the rollers is cut up into strips, slightly wider (but not too much since this would mean waste) than the boss of the roller, in order to allow for a neat ending off of the roller by burning off. The leather strips then have to be cut into small lengths, just sufficient to extend around the boss of the cloth covered roller. The strips are marked into the proper lengths, by means of a gauge or a pair of compasses, where they have to be cut. After cutting the strips into these short lengths, the edges of which are to be pieced together are then bevelled, so as to permit a piecing to be made as smooth as the other portion of the leather. Cutting the correct bevel on the leather requires careful work, and is best done by laying the leather, grain side down, on a smooth slab or piece of glass, and cut the bevel with a sharp knife. Some roller coverers cut these leathers slightly diagonal instead of at right angles to the strip of leather, the aim being to prevent the piecing being parallel with the axis of the roller when the leathers have been drawn on. The claims for this method are that the leathers are easier to put on, and that the life of the cover is somewhat lengthened. Any variations in the thickness of the part pieced, will produce a more gradual and extended vertical movement of the weight than with the parallel joint, and thus offer less resistance. The surface of the sliver cannot be affected over the whole of its width by the less resiliency of the spliced portion, since it is not in a straight line. The resiliency of the surface will be less affected. This method of cutting is more difficult than cutting the edges at right angles.

The leather piece is then made into a cot by cementing the bevelled edges together with care and then placing the cot in a press for a short time, in order to insure a perfect joint.

The cot is then drawn on the roller, similar to drawing a glove on to the fingers, in the same manner as explained before in connection with machine covering. The projecting ends are then burned off by the friction of a piece of hard wood against the end of each boss of the roller when the latter is revolving at a high rate of speed in a lathe. An important point to notice is that the cot should be drawn on the roller, so that when placed in the machine, the outside end of the bevel will follow the joint instead of leading it, for in the latter case the tendency would be for the bevelled end to become loose.

In order to prevent channeling of the leather top roller, its diameter when covered must be different from that of its bottom roller, so that the flutes of the latter will continually come in contact with different portions of the leather. To determine the correct diameter of a covered top roller, a gauge is used, of which there are several styles in use. The one most frequently used is shaped like a collar, and through which the roller to be gauged is passed, the inside measurement of this gauge being the required diameter of the roller.

For special purposes rollers are sometimes "spiral covered." In this instance, after the cloth has been applied in the regular manner as previously explained, the skin after having been cut in narrow strips, is wound spirally around the roller from one end of the boss to the other end, and instead of the leather skin being cemented straight across to form a cot before placing it on the roller, it is bevelled and cemented spirally directly on to the roller. This, of course, causes a roller with less cushion and at the same time the roller is not as true and consequently has to pass through a leveling-up process; however a roll thus covered will stand considerable wear.

FLY FRAMES.

The cotton under operation leaves the third process of drawing in the form of a comparatively even sliver. The fibres thus far have been cleaned and straightened, laid in approximately parallel order to form a sliver and at the drawing process made as uniformly distributed in the sliver as possible. Thus two of the three specific objects to be obtained before the spinning process can be started with are accomplished; the three objects being to thoroughly clean the cotton, to produce evenness of work, and to attenuate the lap to the fine roving. The third object is partly obtained, as the lap has been attenuated to the sliver, but this form is too bulky for spinning and consequently has to be further attenuated. It will be seen at the outset, that this process is clearly one of attenuation, although doubling will be made use of in the several machines, in order to make the resulting roving as uniform and even as possible. This attenuation is obtained by means of roller drafting, the extent to which it is carried on being easily shown by considering the weight per yard of the drawing sliver as fed to the first frame of this process and the weight per yard of the roving from the last frame in the process, calculations to this effect being given later.

There are generally three machines used in this process, one for making *slubbing*, one for *intermediate* roving and one for fine *roving;* after which for fine work (additional) a finer roving frame, called a *jack frame* is used. The operations required in the production of the rovings in all of these processes are exactly the same, i. e., drawing, twisting and winding on bobbins. Each successive machine delivers the stock in a more attenuated condition than it received it, thus the weight per yard is less, or what is the same, the number of the roving is higher.

These machines when spoken of as a class are known as "fly frames," from the fact that in each machine one of the principal parts used in their construction is a flyer. There are different names for the different machines composing this class, the most common practice being to call the first or coarsest frame a "slubber," the second the "intermediate frame," and the third the "roving frame." The latter two are also sometimes called "speeders" from the fact that these frames are run at a high rate of speed. The intermediate is the first frame after the slubber, and consequently the work produced on it is coarser than on the roving frame.

In mills using either Sea Island or Egyptian cotton, or both, in the production of very fine yarns, i. e., above 60's, as previously referred to, a still finer roving is made before the spinnings, it being known as "jack roving." The machine used for the production of this roving is called the "jack" frame, or jack roving frame, it being identical in operation with the intermediate and roving frames, the only difference being that the jack frame is built in smaller proportions and consequently makes a finer roving. The frames in the process would then be slubbing, intermediate, roving and jack frames. What we thus term as the roving frame is in some mills also known as the "fine frame."

As mentioned, all three or four frames used are identical in their construction, the only differences being in the sizes and the systems of gearing, hence any reference to fly frames given in a general way, refers to all. Differences in different makes of these machines are in detail only, so that general descriptions given apply to all makes. The reason for using three or four different frames, as the case may be, is to reduce the sliver as coming from the drawing frame to the desired counts more gradually, than would be the case if only one or two frames were used; so that we shall have a finer hank roving in the intermediate than the slubbing, a still finer in the roving frame than in the intermediate frame, and again a finer hank in the jack frame than in the roving frame.

The slubber differs principally from the other machines in the manner of feeding the material to the machine, this being due to the difference in the method of delivering the material from the drawing frame and from the fly frames. The slivers from the drawing frame, as delivered into cans, are fed up to the slubber from the rear, the cans containing the slivers being placed on the floor behind the machine, one can or sliver to a flyer, i. e., no doubling taking place. The sliver then passes through three pairs of drawing rollers. From the drawing rollers, the sliver, now called slubbing, passes to a revolving flyer carried upon a vertical spindle, by which it is twisted and then wound upon a bobbin revolving loose upon the same spindle. The flyer runs at a constant speed, while the bobbin is driven by means of a differential motion at a speed varying according to its increasing diameter as the slubbing is wound on. The lifting movement for raising and lowering the bobbin upon the spindle, so as to wind the slubbing in regular coils, is also worked by the same differential motion. The speed of the flyer is from 600 to 800 revolutions per minute. If the slubbing, then for example, is delivered from the drawing roller at 50 feet per minute, and the speed of the spindle, i. e., flyer, is say 600 r. p. m., then the number of turns per inch imparted to the roving in this machine is ($50' = 600''$ and $600''$: 500 r. p. m. :: $1''$: x r. p. m. =) $\frac{5}{6}$th.

The full bobbins as made on the slubber are then placed in the creel on the intermediate frame and the roving from two bobbins doubled into one, and thus fed to the machine, being drawn down by the rolls to a finer strand, twisted and wound on to bobbins for the next process. It is in all respects a repetition of the slubbing process, though the machine contains rather more spindles, the bobbins are smaller and the roving (vice versa slubbing) as it is now called, finer. The spindles run at from 850 to 1100 revolutions per minute, and about $1\frac{1}{4}$ turns twist per inch are put in the roving. In the same manner, the full bobbins as made on the intermediate frame are in turn placed in the creel of the roving frame and the roving (doubled) fed to that machine; the same being also true for the jack frame, when it is used.

The roving frame is a copy of the intermediate, excepting in the arrangement of the rolls and size of its different parts, which are much smaller; the rolls have two ends to a boss or four to the roll. Here the strand of cotton is reduced to such proportions that, under ordinary circumstances, it can easily be drafted in the process of spinning to the required counts. The bobbins are still less than the intermediate, and the counts finer. The spindles in this machine run from 1050 to 1250 revolutions per minute, and from 2 to 4 turns of twist per inch are put in the roving according to the hank of roving being made.

The roving frame is the last process machine in the carding room, unless the fourth or jack frame is used to double and draw the roving finer, in order to reduce the draft to a minimum on the spinning frame or mule for fine yarns. The spindles in this machine run from 1200 to 1800 revolutions per minute.

Fly frames are constructed with the object in view of attenuating the sliver, but with this attenuation, new conditions are brought into the sliver which render other operations on the frame necessary, because as the sliver is reduced in size it naturally becomes weaker and consequently has to be twisted sufficiently in order to enable the fibres composing it to hold together with sufficient friction to be delivered from the frame, and to be strong enough for further handling. By thus having to put twist into what is now called slubbing or roving instead of sliver, a special method of delivering must be used in connection with the twisting operation. This method is to wind the slubbing or roving on to a bobbin in a systematic manner during the time that twist is being put in, thus making a continuous operation for the frame.

In summarizing the three necessary operations of the machines, we have:

1st. Attenuation or drafting of the sliver, slubbing or roving.

2nd. Twisting of the slubbing or roving.

3rd. Winding of the slubbing or roving on to bobbin.

The method of obtaining the first operation is very simple, consisting in roller drafting, the same as is practiced in the drawing frame. In following the passage of the cotton through the several fly frames, the reduction of the sliver takes place gradually, that is, the draft is made larger in each succeeding frame. The exact amount of the total drafts, of course, depends upon the character of the cotton used, and also upon the counts of the yarn to be spun; the disposal of the total draft among the different frames being generally within certain limits which have been found to be best adapted to the frames. The draft on the slubber when using Mainland cotton is from 4 to 5, for the intermediate frame from 5 to 6, and for the roving frame from $5\frac{1}{2}$ to $6\frac{1}{2}$. When long staple cotton (Sea Island, Egyptian) is used for the production of high counts of yarn, the draft on the slubber is from 5 to $5\frac{1}{2}$, for the intermediate from $5\frac{1}{2}$ to $6\frac{1}{2}$, for the roving frame from $6\frac{1}{2}$ to 8, and for the jack frame, which would be used in this instance, from $5\frac{1}{2}$ upwards. Variations in the amount of draft on different machines are frequently introduced in order to obtain the same total draft, the reason for this being easily seen when considering the process as a whole. The three frames through which the cotton must pass, easily allow a variety of divisions in the arrangements of the drafts, which is taken advantage of in making changes only in one or two frames instead of changing all when another hank of roving is to be made. However, this variation should not be carried too far, the safest plan being to let each frame do its share in the work of making the roving finer.

The method of putting twist into the slubbing or roving calls for a rapidly revolving spindle which carries a flyer placed on the top end, said flyer being so constructed that it can be threaded with the roving through its axis of rotation at the top, said roving then being guided through a hole situated out of the centre of rotation, so that as the flyer is revolved, the roving is carried around the centre of rotation and consequently receives a twist for each revolution of the spindle; arrangements being made in the frames whereby the amount of twist, as going into the roving, can be easily and accurately regulated. The amount of twist per inch to put in the roving remains to a certain extent a matter of experience, depending upon several conditions; amongst others upon the length of the staple, the uniformity and cohesiveness of the fibres, etc., although a certain basis exists from which to work. The amount should never exceed that which is necessary to give it just sufficient strength for handling, for it must be understood that the merest excess of twist in the roving will interfere, to a proportionate extent, with any further drawing in the successive machines. Thus we can see that although the twisting is a necessity for giving cohesion to the fibres during the winding operation, yet the succeeding processes must be kept in view, and the twist arranged so that the effectiveness of any future drawing action required will not be interfered with by said twist.

Winding is the most complicated of the three operations previously mentioned, the mechanisms used for winding a bobbin requiring a careful study by the student.

The roving is wound on the bobbin by placing said bobbin over the spindle and allowing the delivery portion of the flyer to deposit the roving on to the bobbin, the difference in speed between the flyer and bobbin being just sufficient to allow the bobbin to take up the delivered roving. The roving is coiled around the bobbin so that the coils lie side by side in one layer, this being obtained by the upward and downward traverse of the bobbin, the traverse becoming shorter after each layer of roving is deposited, in order to make the bobbin cone shaped at each end.

A fly frame is easily distinguished in a mill by having a large number of spindles running in a single frame, each spindle being a duplicate of the other and producing similar bobbins. Fig. 181 shows the fly frame (roving frame) as built by Howard & Bullough American Machine Co. Ltd., in its—front—perspective view; Fig. 182 being a back view of the

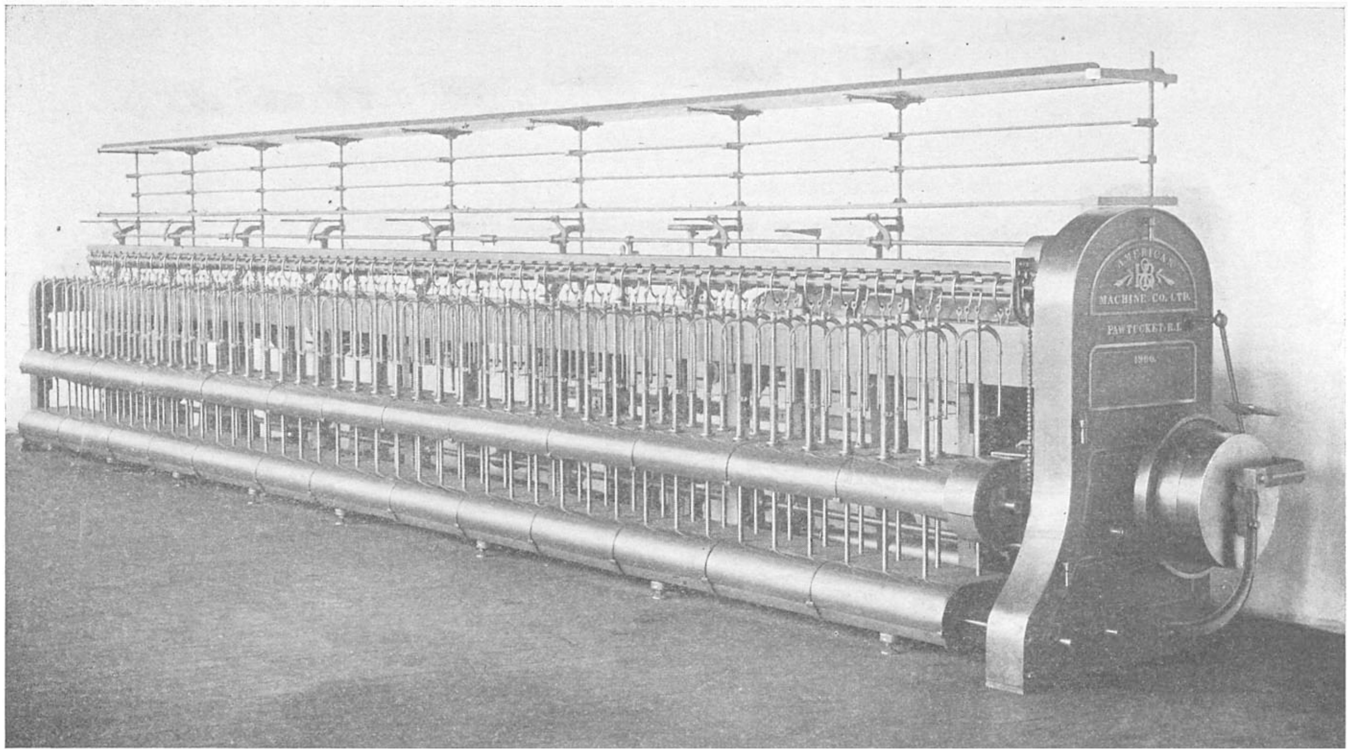

FIG. 181.

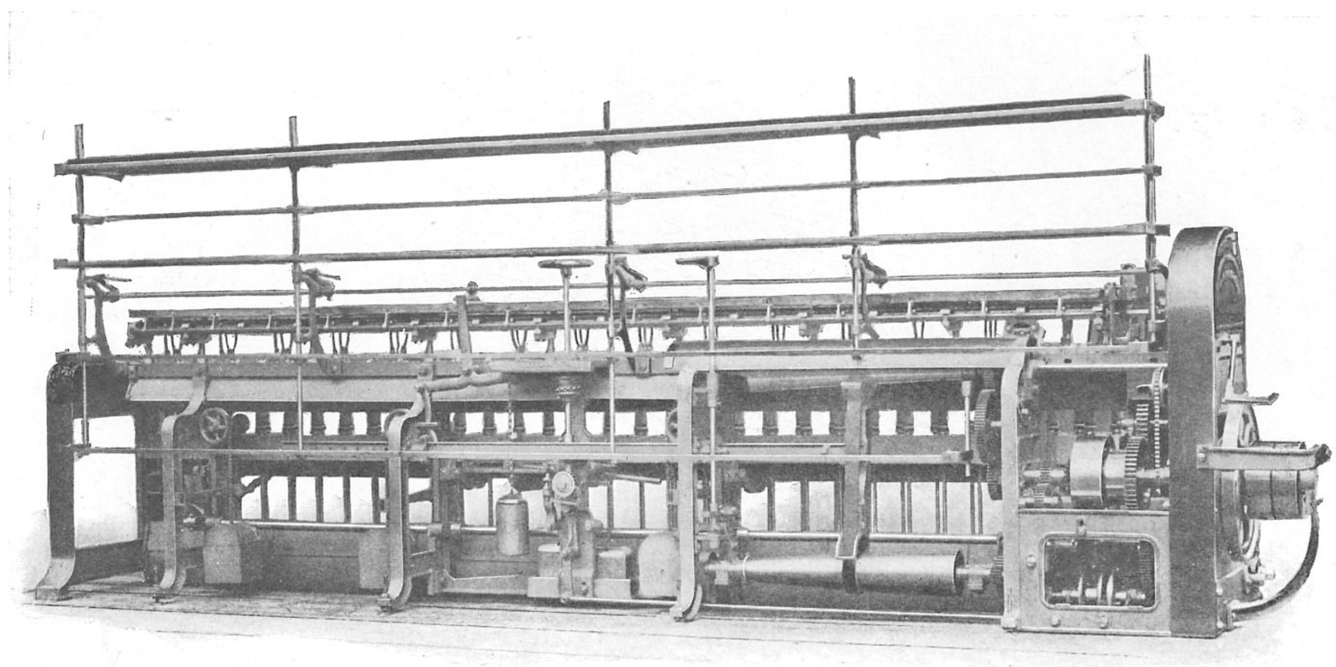

Fig. 182.

same make of frame, being given to more particularly show its working parts.

At the slubber, the slivers are passed up from the sliver cans (one sliver to each flyer) through guides at the back of the slubber (hence no creel to this fly frame necessary) over a slowly revolving octagonal shaped roll, whose object is to aid the slivers in passing from the cans to the drafting, i. e., drawing rolls. The slivers are then passed forward through the frame, the resulting rovings (now termed slubbing) being wound on bobbins, which when full are taken off of the frame and then put up in the "creel" of the intermediate frame, to be in turn (two slubbing strands doubled for each flyer) fed to that machine, the resulting roving strands being then wound on bobbins in a similar manner to those on the slubber, which when full are placed in the creel of the roving frame to be fed (doubled) to that machine. As the rovings are made smaller at each succeeding process, smaller bobbins are used in turn to wind the delivered roving on. The empty bobbins used on these frames are usually made of wood, although substitutes, made of paper, etc., have been tried. The best bobbins are made by having the lower ends of the bobbins protected by a wire placed in a groove, this tending to keep them from splitting. The bobbins are notched on the bottom so as to get a grip on the revolving holder. All bobbins on any machine should be of exact dimensions, so as to fit the spindles as closely as possible without binding, they also must have a uniform outside diameter, since roving cannot be wound on bobbins varying in this manner; bobbin gauges being now used to accurately test both the inside and outside diameters of a bobbin before it is run on the frame.

The creel on a fly frame (intermediate, roving and jack frame) consists of a framework that extends the whole length of the machine and is used to hold the skewers on which the full bobbins are placed. Skewers are rounded pieces of wood, which are run into the holes in the bobbins, to hold them in proper position in the creel, having both ends pointed for bearings, so as to reduce the friction and thus require less pull to rotate the bobbin. Near the lower end of the skewer a knob is fitted on, for the bobbin to rest upon. The ends of the skewer extend a little farther than the bobbin, so as to permit them to be placed in position in the creel, using these ends as bearings.

Fig. 183 is a diagram showing the principles of the working of a fly frame, i. e., the run of the roving (or sliver on the slubber, or slubbing on the intermediate) through the machine. With reference to the creel portion (and which does not refer to the slubber), the same is generally made up of three back rails *A*, *B* and *C* respectively, a front rail *D* and a top board *E*, all of which extend the entire length of the frame. These rails and the top board are held by the arms *F*, and which in turn are secured to the upright rods *G* (one of which only can be seen, duplicates of which are placed throughout the length of the machine) by means of screws *H*, in the arms, thus making said rails adjustable in the creel to suit different sizes of bobbins used.

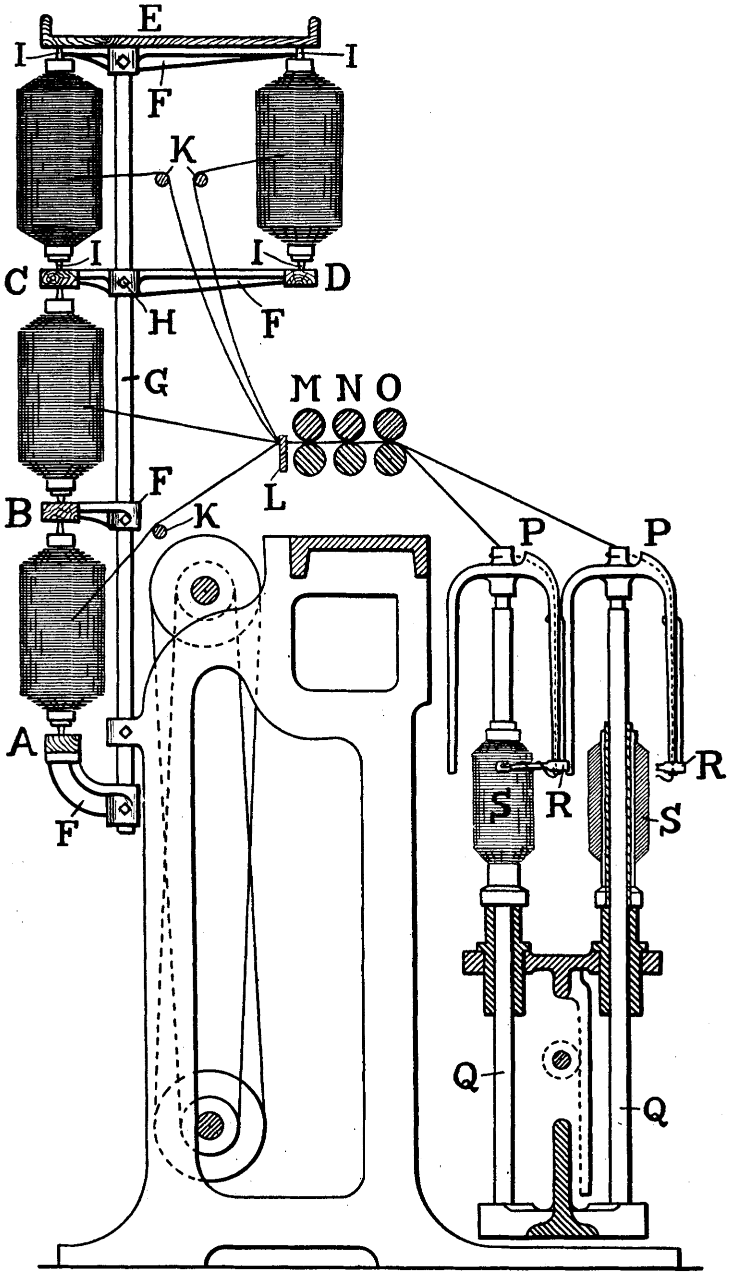

Fig. 183.

These rails are generally made of wood, having porcelain or glass cups in the upper side to carry the bottoms or lower bearings of the skewers *I*. The tops of these skewers are made to either extend into holes drilled into the bottoms of rails *B*, *C* and the top board *E*, said holes being fitted with brass rings in order to prevent wearing out of the wood; or said rails and the top board are provided with wire eyes *J* (see Fig. 184) on the edge, to carry the top bearings of the skewers. In connection with the latter arrangement a different shape of brackets or arms *F* has been shown.

When placing a bobbin in the creel, a skewer (*I*) is passed through the central hole of the bobbin and the upper tapering point of said skewer (provided arrangement shown in Fig. 183 is used) in turn entered in its respective hole in the rails *B*, *C* or the top board *E*. In connection with arrangement shown in Fig. 184, the wire eyes *J* take the place of the holes in the underside of the rails and the top board previously

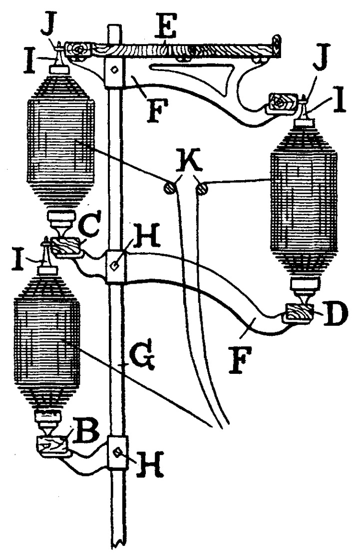

FIG. 184.

referred to. The lower pointed end of the skewer is then set in the porcelain or glass cup in its respective rail and the bobbin is then in position for feeding the roving to the drafting rolls of the frame. The top board *E* of the creel is used to hold a number of full bobbins, which are ready for replacing empty bobbins in the creel, they being placed on the top board simply for the convenience of the operator.

The ends of the roving on the bobbins, as placed in the creel, are then drawn from the bobbins and passed over their respective guide rods *K*, through guide eyes on the traverse rod *L* (see Fig. 183 only) as situated directly behind the rolls. This traverse rod *L* has a slow horizontal traverse motion imparted to it, the object of this being to prevent the sliver, slubbing or roving, as the case may be, from passing through between the three pair of rolls continually on the same surface and thus wearing a groove in the top leather roll, while the other portion of the roll would remain unused.

The drafting rolls on these frames consist of three pair of rolls *M*, *N* and *O*, the bottom rolls being fluted steel rolls while the top ones are leather covered. Metallic rolls are used to some extent on the slubber but not on the succeeding machines. Occasionally frames may be met with having four pair of rolls, but this is an old form of construction, now out of date.

During the passage of the sliver, slubbing or roving between the three pair of rolls *M*, *N* and *O*, as will be readily understood, the same is subjected to the required amount of drafting. From the front pair of rolls *O*, the slubbing or roving then passes to a flyer *P*, which rests securely on a revolving spindle *Q*. The flyer has a hole in its top end and in the side connecting with this one, a hole being also provided through one leg of the flyer. The slubbing or roving passes in turn through these holes to the eye in the presser foot *R*, which is a part of the flyer, and from there onto the bobbin *S*. The presser foot *R* is shown complete in connection with the flyer nearest the frame, the one in connection with outside situated flyer being shown broken off on account of showing section of bobbin. From illustration Fig. 183, it may look to the student as if the bobbin *S* is connected with the spindle *Q*, but which is not so, it being driven separately by special mechanism.

The slubbing or roving is twisted between the bite of the rolls *O* and the top of the flyer, by the combined revolving of the flyer and bobbin. Although the flyer puts the actual twist into the slubbing or roving, the revolution of the bobbin makes the operation practicable. As was mentioned, the bobbins are traversed vertically in the frame, while the roving is being wound upon them, so as to lay the coils of roving side by side on the bobbin, thus forming smooth layers.

All fly frames are made with two rows of spindles which are spaced so as to be able to use a maximum number of spindles in a given length without interfering with each other during operation. The system of placing the spindles in the frame is shown in Fig. 185, from which it will be seen that they are arranged alternately, i. e., in a zig-zag order. In some machines they are placed exactly midway between each other, each row remaining distinct, while in other makes, the spindles of the back row are not placed exactly midway between the centres of those in the front row, but slightly to one side, in order to make the back row more accessible for the operator in piecing up ends or when doffing. The distance from the centre of one spindle to the centre of the next in the same row, as from *A* to *A*, or *B* to *B*, is known as the "space" of the spindles, all of the spaces being the same between the spindles of both rows. Another method of indicating the distances of the spindles, and one which is frequently used, is the term "gauge," the spindles in the machine then being spoken of as having a certain gauge, i. e., a certain number of spindles in a given distance, considering in this instance both rows of spindles. The gauge of the spindles is indicated in the diagram by the distance *C* to *C*, in other words, we may say that in this case it is the distance which contains eight spindles, i. e., four spindles in each row.

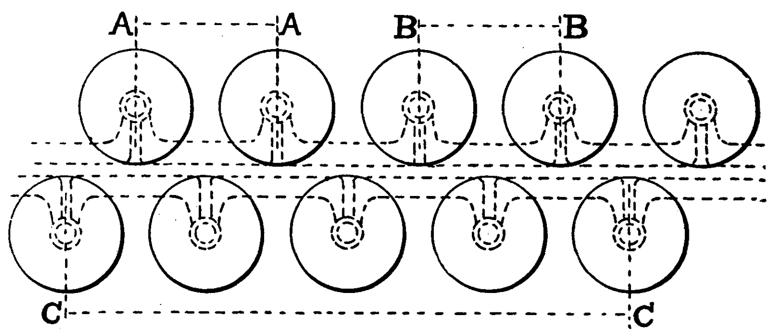

FIG. 185.

Although fly frames are divided into the three or four processes mentioned, i. e., slubbers, intermediates, etc., yet we find that each process frame is made in different sizes with different numbers of spindles, different lengths of the traverse, and different diameters of bobbin made. Thus a frame spoken of to indicate its size as a 128 spindle $7 \times 3\frac{1}{2}$, means that the frame contains 2 rows of spindles, 64 in each row, that the greatest possible traverse of the bobbin is 7 inches in length, which would mean that the first layer of coils put on the bobbin occupies this space, and that when the bobbin is full of roving it is $3\frac{1}{2}$ inches in diameter across the last layer.

The different process frames are all built within certain limits which have been found by experience to be best suited for certain classes of work.

The traverse for slubbers is from 9 to 12 inches, for intermediates 8 to 10 inches, for roving frames from 6 to 8 inches, and for jack roving frames from $4\frac{1}{2}$ to 7 inches. The reason of this diminishing in traverse is that as the roving becomes attenuated by the processes and consequently reduced in strength, it requires to be wound on a smaller size bobbin in order that said bobbin will not be too heavy to be afterwards pulled round by the roving without straining it when placed in the creel of the succeeding machine.

The diameter of a full bobbin made on the different process frames is proportionately small according to the length of traverse, the diameters being limited on any frame by the space of the spindles, which is raranged to correspond with the traverse so as to build a standard shaped bobbin. This shape is obtained by making the diameter of the bobbin one-half that of the length of the traverse, which will be easily seen by referring to some of the sizes, as for example a 10 inch traverse frame makes a 5 inch bobbin, usually expressed 10×5. Exceptions are sometimes made to this rule, as for example 7×3.

Standard sizes of fly frames are: Slubber 12×6, $11 \times 5\frac{1}{2}$, 10×5, $9 \times 4\frac{1}{2}$; Intermediate 10×5, $9 \times 4\frac{1}{2}$, 8×4, $8 \times 3\frac{1}{2}$; Roving Frame 8×4, $8 \times 3\frac{1}{2}$, $7 \times 3\frac{1}{2}$, 7×3, 6×3; Jack Frame 7×3, 6×3, $6 \times 2\frac{1}{2}$, $5 \times 2\frac{1}{2}$, $5 \times 2\frac{1}{4}$, $4\frac{1}{2} \times 2\frac{1}{2}$, $4\frac{1}{2} \times 2\frac{1}{4}$.

Drafting Rolls.—These rolls are similar in construction and operation to the rolls used on the drawing frame and as the subject of rolls was fully explained in connection with that machine, only the principal differences between the two will be pointed out at this time.

As was mentioned before, leather top rolls are used almost exclusively on the fly frames, the exception being made only on slubbers, in which case metallic rolls are sometimes substituted. The bottom steel rolls are made up in sections and rest in stands provided for them on the roller beam. A side view of one of the stands for holding said rolls is shown in Fig. 186 and in which the rolls are shown in cross section resting in their bearings. The rolls are made long enough for any size frame by simply connecting the required number of sections together in the usual manner, i. e., fitting the squared end of one section into the squared recess of another.

The stands are equally spaced on the roller beam from each other, being placed from 18 to 22 inches apart, according to the gauge of the spindles. The sections of the rolls have to be made to fit the stands, as otherwise the bearing points would not fall in the proper places. The rolls are made with fluted bosses in the same manner as described for the drawing frame, which grip the slubbing or roving in conjunction with the top rolls. The bosses are made in different sizes for different frames, that is, they are made long enough to pass two separate ends of slubbing or roving and deliver them to two spindles, in which case they are known as "double" or "long" boss rolls. Again they are made with "short" or "single" bosses, in this case, only one slubbing or roving being delivered by each boss to a spindle.

There is always the same number of spindles between stands on certain frames and consequently a similar number of bosses, except where two rovings are delivered by each boss, in which case half the number are necessary. Slubbers are usually made with 4 spindles to a section of the rolls, intermediates have 6 or 8, and roving and jack frames 8. The gauge of the rolls is thus sometimes expressed as 4 spindles per roll, 6 per roll, etc., or 4 spindles in 16 inches, 8 spindles in 18 inches, etc.

The rolls in fly frames have much finer pitch flutes than the drawing frame rolls, for the reason that the sliver, slubbing or roving is so much more delicate than the heavy sliver as fed to the drawing frames.

Usual diameters of rolls working cotton of from $\frac{7}{8}$ to $1\frac{1}{2}$ inch staple are: For the slubber—front roll $1\frac{1}{4}$ inch, second roll 1 inch, third roll 1 inch; For the intermediate—front roll $1\frac{1}{4}$ inch, for second roll 1 inch, and back roll 1 inch; For the roving frame—front roll $1\frac{1}{8}$ inch, second roll 1 inch, and back roll 1 inch.

For Egyptian or Sea Island cotton, the diameters of the rolls are: For the slubber—front roll $1\frac{3}{8}$ inch, second roll 1 inch, back roll 1 inch; For the intermediate—front roll $1\frac{1}{4}$ inch, second roll 1 inch, and back roll 1 inch; For the roving frame—front roll $1\frac{1}{8}$ inch, second roll 1 inch and back roll 1 inch; For the jack frame—front roll $1\frac{1}{8}$ inch, second roll 1 inch, and back roll 1 inch.

It must be understood that the longer stapled cottons may be run on machines which have smaller diameter rolls than those given, and the

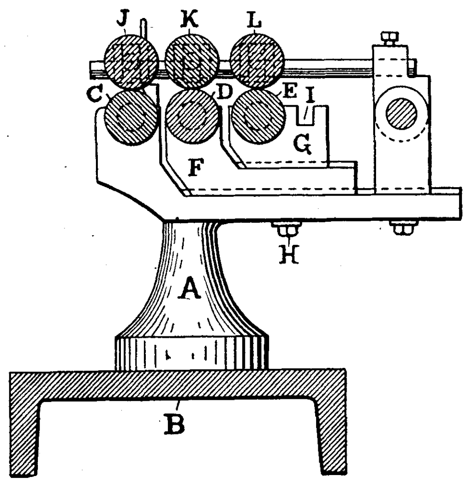

FIG. 186.

work turned off compare favorably with that turned off by the machines having rolls of larger diameter. The advantages gained by using larger diameter rolls are that in a great many cases it helps to stop licking of the fibres around the rolls, because by the diameter being larger, the fibres, whose ends stand out, have to travel a greater distance before being lapped, and in many cases the loosened fibre will be delivered from the bite of the roll and either be drawn along and twisted with the other fibres passing forward, or drop to the beam roll; whereas, if a smaller diameter of roll were used, loose fibres would curl around the smaller front roll before their other end had become loosened by the bite of the front pair of rolls, a feature having a tendency to draw other fibres with it and thus cause a "lap" on the roll.

Another advantage of using large rolls is, that the production may be increased without an increase in the speed of the rolls as compared to the smaller diameter rolls, or, if desired, the same production may be delivered with a slower speed of the front roll as compared with smaller diameter front rolls. The necks of the rolls are also larger and not so liable to bend or become sprung as the smaller diameter rolls, besides, being heavier, the rolls will run steadier.

Referring again to Fig. 186 for the details of the roll stand, we find that the stand *A* itself is permanently fixed on the roller beam *B*, and that it carries the front roll *C* in a fixed bearing. The other two bearings for the second and third rolls, *D* and *E* respectively, are separate, being carried by the slide pieces *F* and *G*, which are so arranged on the main stand *A* that their distances from each other and also the distance from the front bearing, can be adjusted so as to set the rolls for various lengths of staple of cotton under operation at one time. The two rear bearings, when in position, are fixed securely to the stand by means of the set screw *H*. The recess *I* is made in the slide piece *G* for holding the traverse rod (*L* in Fig. 183), which, as stated before, moves the sliver on the slubber, the slubbing on the intermediate, or the roving on the roving or jack frame, as the case may be, back and forth across the rolls, in order to get a uniform wear over the entire surface of the top leather covered rolls. These top rolls are similar to the top rolls of the drawing frame, the chief difference being that these are all double boss rolls, different sizes being used for different frames. Both solid and loose boss top rolls are used, the solid rolls for the two back rolls, while the loose boss is used for the front. Sometimes solid top rolls are used entirely on the frame, but the practice is not advisable. In addition to these types of rolls, we also meet with a ball bearing top roll, a specimen of which is shown in Fig. 187, both in its section and perspective view.

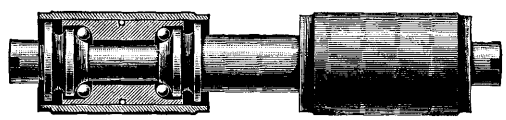

FIG. 187.

In covering double boss top rolls, the leather cots should be put on each boss with the splice of each cot pointing in the same direction, and the diameters of the two bosses, when finished, should be exactly the same. When top rolls are placed in their working positions on the frame, the splices of the cots should always follow the rotation of the rolls rather than lead it. The observance of these items will have a marked influence in preserving the life of the leather on the rolls. The leather cots used for covering top rolls for fly frames are made principally from selected sheep and calf skins. Some carders prefer small calf skins, which, although they are said not to give the best results in fine work and are more costly, yet their wearing properties and decreased wastage in cutting up render them more economical for some classes of work.

These rolls *J*, *K* and *L* in Fig. 186, are held in position by an arrangement of cap-bars placed along on the machine, which are simply end supports for the rolls. The rolls are simply laid in them so that when the weights are removed, they can be readily taken out. When the bottom rolls have to be taken out, the cap-bars are very easily turned back out of the way so that they do not interfere with said rolls.

Fig. 188 shows the arrangement of these cap-bars for fly frames as built by the Howard & Bullough-American Machine Company. In the same, diagram 1 shows view from back of frame of a cap-bar applied to a machine with four spindles in a box; diagram 2 the end view of same, and diagrams 3, 4 and 5 enlarged details of cap-bar.

As shown in these illustrations, the cap-bar is fixed on the roll stand by an independent bracket, and the roll slides are free to move, allowing of the rolls being reset without moving the cap-bar. The neb for the

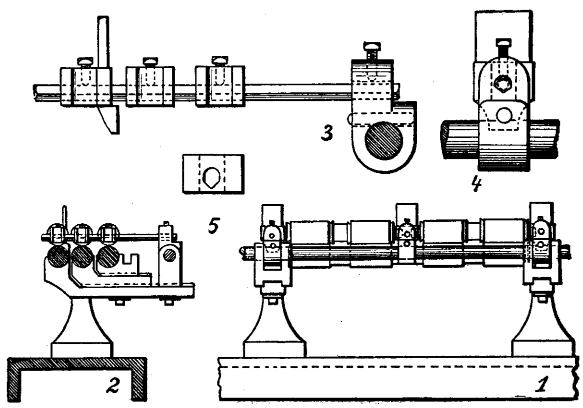

Fig. 188.

front top roll does not have to be disturbed as only the nebs for the other rolls have to be reset when moving the bottom rolls.

The cap-bars consist principally of an upright support which is secured to the roll stand by means of a screw bolt, and carries a bar on which are fixed brackets, one at every stand and one between these stands, because two sets of top rolls are placed between said stands to rest on the bottom rolls. Fitted into these brackets are bars, square or pentagonal in cross section, the bar in the figure being pentagonal. The cap-nebs which are made with vertical side pieces to act as supports for the top rolls are placed on this bar, the holes through the nebs being similar to the cross section of the bar, so that said nebs are prevented from turning on the bar. The nebs are kept in the proper positions on the bar by means of set screws in the nebs, which are screwed down on a flat surface of the bar. The nebs are thus capable of adjustment along the bars to suit any changes made in setting the bottom rolls, so as to have the top rolls always directly over the bottom rolls. The last cap-neb is provided with two vertical projections, the upper one serving as a rest for the top cover of the rolls, while the lower one is used to keep the bar in a horizontal position by resting on the stand.

Setting the Rolls.—The spread of the rolls, or in other words, the distances from centre to centre of the rolls in fly frames depend on four conditions, viz: the length of staple under operation, the size of the roving to be attenuated, the quantity of twist in the roving, and the amount of the draft required; being items similarly to those as taken into consideration at the drawing frame. The length of the fibres is the most important point, and it is necessary to make the distance from the centre of one pair of rolls to that of the next, slightly in excess of the mean length of the staple, so as to avoid breaking or straining the fibres by having a quicker running pair of rolls grip a fibre while it is still held by the preceding pair. It is also important to keep these rolls from being set too wide apart, as this would allow the fibres too much freedom in their passage through the pairs of rolls and when consequently drafting would be difficult.

With regard to the other three points previously referred to, i. e., the size of the roving, the amount of twist and draft, each of these affects the settings to a certain extent, for the fact that a thick roving requires wider spreading of the rolls than a fine roving, so will also an extra amount of twist in the roving necessitate wider setting than slack twisted roving; again the draft affects the setting on account of the difference in speed between the successive lines of rolls, it being necessary to set closer in connection with a very large draft and in turn adopt a more open (rolls more spread) setting in connection with a very small draft.

The settings for the rolls on a slubber for short staple cotton, where the sliver is heavy and a low hank roving is being made with a high speed of front roller, should be thus: Set the centre of the second roll from the centre of the front roll $\frac{1}{8}''$ more than the length of the staple of cotton under operation and increase this distance by $\frac{1}{8}''$ to $\frac{1}{4}''$ between the second and back rolls. When dealing with long staple cotton, or the sliver is light, which is usually the case with long staple cotton, and a medium speed of front roll is used with the machine making an average hank, the second roll is set $\frac{1}{16}''$ plus the length of the staple of cotton being run, from the front roll, while the back roll is set from the second roll $\frac{1}{16}''$ wider apart than the distance between the front and second rolls. For example, suppose that a $1\frac{1}{8}''$ staple was being run on a slubber, under ordinary conditions, that is, a rather low hank is being made and the speed of the front roll is high. Then set the second roll from the front roll $1\frac{1}{4}''$ from centre of each roll and set the third roll from the second roll $1\frac{3}{8}''$ to $1\frac{1}{2}''$ from centre of each roll. When dealing with Sea Island cotton of say $1\frac{3}{4}''$ staple, the sliver used being light with a rather high hank being made, the following settings should be used: Set the second roll from the front roll $1\frac{3}{16}''$ from the centre of each roll, and set the back roll from the second roll $1\frac{7}{8}''$ from centre of each roll.

In setting the bottom steel rolls in drawing frames no attention was paid to the setting of the top rolls, for the reason that the stands which hold the bottom rolls also hold the top rolls and consequently that in setting the bottom rolls, we also set the top rolls and that the centre of top roll is directly over the centre of the bottom roll, only a very slight amount of play being allowed between the sides of the stands and the bushings of the top rolls; whereas at the slubber, the cap-nebs, as explained, must be set to suit the settings of the bottom rolls.

The rule for setting the rolls of the intermediate frame is to set the second roll from the front roll a distance $\frac{1}{16}''$ greater than the length of the staple, and to set the third roll $\frac{1}{16}''$ farther than the distance between the front and second rolls. When running combed stock, the distance between the front and second rolls only slightly exceeds the length of the staple, and this distance is increased by $\frac{1}{16}''$ between the second and back rolls. On very coarse stock, or in connection with a coarse hank or high speed of the machine, the distance given in the first rule is increased $\frac{1}{8}''$ between second and back roll. The rule as used for the intermediate, applies also to the roving frame, and to the jack frame when such is used.

When the rolls in a fly frame are set too far apart, this may be detected by taking out the top, front, and middle rolls, without disturbing the cotton, and then noticing at what points drawing by the rolls commences and ceases, said points being indicated by the varying number of the fibres between the two points. The distance of the point at which the lessening of fibres in the sliver commences, from the centre of the slower moving roller, represents the excess in the distance for proper setting. If the lessening of the fibres commences at the centre of the slower roll and extends to a point opposite the centre of the quicker moving roll, it is an indication that the rolls are set too closely together and the necessary change should be made.

When there is any difficulty in ascertaining whether the rolls are set too closely or not, the top front roll only may be taken out and the ends of the fibres, as are in a position opposite the centre of the bottom roll, gripped by means of a pair of light, broad, tweezers, by this means ascertaining whether they are gripped by the second pair of rolls or not. If they are held by the latter, it is an indication that the setting is too close, because the grip by the tweezers was simply a substitution for the grip by the front pair of rolls.

Weighting the Rolls.—The weighting of top rolls on the fly frames, in order to establish a sufficient pressure between the top and bottom roll, to properly grip the roving, is very simple in application, the chief point being to put the proper weights on the different rolls in the several machines.

Better action of the top rolls is obtained by adjusting them so that the centre of each top roll is directly over the centre of its corresponding bottom roll.

The weights are applied at the necks of the top rolls, said neck being the bare portion of the roll connecting the two leather covered bosses. In this manner the weight is placed equally on both bosses. Different systems of applying the weights are used, among which may be mentioned "*direct*" weighting, "*double*" weighting and "*lever*" weighting.

In "*direct*" weighting, there is a separate weight for each top roll, i. e., for front, middle and back rolls. This method is the simplest but it is not used to any extent in this country.

"*Double*" weighting finds the most extensive use in American built machines, by this system a direct weight being hung on the front roll, and one weight on a saddle which rests on both middle and back rolls.

"*Lever*" weighting consists of an arrangement in which all or part of the weights hang by means of levers, which weights, by moving them on the levers, increases or decreases the amount of weight on the rolls.

In connection with double weighting, the front roll is weighted separately, the saddle which rests over the roll and the stirrup to which the weight is connected being similar to the weighting arrangement used in connection with the drawing frame rolls. The weighting arrangement of the two back rolls consists of a saddle, made of iron, and of such a shape that it rests on both the neck of the back top roll and the neck of the middle top roll. This saddle has a notch cut into its upper side, which is situated a little less than half way between the two ends, and it is on this notch that the stirrup and weight hang. The stirrup is cast with a square hole in it, near the top end, and into which the saddle is inserted said stirrup in turn resting in the notch on the saddle. The lower end of the stirrup is round, of a small diameter, and is threaded a part of the way up its length. This threaded end is inserted through a hole in the weight, being screwed into a nut so that after the nut is screwed upon the threaded end of the stirrup, the latter may be lifted, the saddle slipped through the square end and fitted in place on the necks of the two top rolls with the weight hanging freely. The weight is of course underneath the roller beam and the stirrup has to be inserted through a hole cut in this beam. To connect the weight and stirrups, the nut is first placed in the hole in the weight, next the stirrup is put through the hole in the beam, and then the weight is held so that the stirrup comes in contact with the threaded hole in the nut, the stirrup then being turned until the nut has been screwed on, thus securing the weight. The stirrup is then placed upon the saddle. A collar is made on the stirrup a few inches below the square hole in the upper end, which is slightly larger than the hole in the beam, so that when the saddle is withdrawn from the hole in the stirrup, which is then allowed to drop, the weight will hang from the beam by this collar, and not fall to the floor as would be the case if no means were provided to prevent this.

It was mentioned that the notch was not exactly in the centre of the saddle, which is for the purpose of putting more weight on one roll than on the other. When the saddle is placed in the frame so that the weight hangs closer to the middle roll, more weight will naturally rest on that roll, which condition is desired in the frame. Thus the saddles are always placed with the notch closest to the middle roll.

A simple and effective method of lubricating the bearing points of the saddle is obtained by making the ends just over the bearing of the middle and back rolls hollow, and have a piece of cotton wicking in them, these wicks extending to the upper side of the saddle and connecting together at a central hole. The wicking is oiled on the upper side of the saddle, and when the oil will then run to the lower ends of the wicks and as these rest on the bearing of the rolls, the necks will always be kept lubricated.

The amount of weight required for the rolls becomes less in the succeeding frames, because the roving under operation is naturally lighter and hence less weight for the rolls to grip the cotton is required.

When two rovings are delivered by each boss, more weight is required than for a roll delivering one roving for each boss.

Weights frequently met with are:

Slubber:	Front 18 lbs.,	Middle 14 lbs.,	Back 10 lbs.
Intermediate:	" 14 "	" 10 "	" 8 "
Roving Frame: (2 rovings delivered from each boss)	" 18 "	" 14 "	" 12 "

On the machine only two weights are hung for a set of rolls, the proper division of one weight being obtained for the middle and back rolls by the saddle and stirrup arrangement as explained. Thus for the slubber, a 24 pound weight, by the position of the notch on the saddle will bear with 14 pounds on the middle roll and with 10 pounds on the back roll, the same practice being observed in the succeeding machines.

Sometimes on the finer fly frames, where very high counts of roving are made, self weighted top rolls are used; but these rolls are only used for the middle and back rolls of the machine and never for the front rolls. The rolls, as their names indicate, are self weighted, i. e., they are sufficiently heavy as to require no other weight for gripping the cotton. They are constructed out of steel and are highly polished, their outside surfaces being very smooth. An example of the size and weight of a self weighted roll used for the middle roll of a roving frame is: diameter $\frac{5}{8}''$, the weight being $3\frac{1}{2}$ ounces. The back roll of the same machine also self weighted, has a diameter of $2''$, weighing in this instance about $1\frac{7}{8}$ lbs.

The same care as mentioned in connection with drawing frames must be taken on the fly frames, i. e., to relieve the rolls of their weights during a long stop of the machine, as otherwise longitudinal grooves on the rolls will result, besides the rolls are not as firm as those used on the drawing frame. All of the weights have to be relieved and hung again by hand, which consequently makes more trouble than where a weight relieving motion is used, as on the drawing frame.

Draft.—A general division of the total draft among the different fly frames has been previously indicated for different lengths of staple to be operated upon, and it is only necessary to state that these different drafts are obtained in the frames by taking into consideration the ratio of the surface speeds between the back or feed roll and the front or delivery roll, in the same manner as for the drawing frame. The draft between the different rolls in the latter machine is made gradual from the back roll, but in the fly frames where only three pairs of rolls are used, this arrangement is not carried out. In some machines there is no draft at all between the back and middle rolls, but the general practice on American machines is to have a slight draft at this point. The diameters of the middle and back rolls being generally the same, and the slight draft between them is gotten by having the gear on the end of the middle roll made with one tooth less than the gear on the end of the back roll, since the gear on the back roll, through an intermediate gear, drives the former gear.

The main draft consequently falls between the middle and front rolls. In making the calculations for the drafts on the machines, it will only be necessary to take into consideration the draft between the front and back rolls.

In practice it will be found that the twist, which the flyers put in the slubbing or roving during the process, shortens the length of the latter after it leaves the front roll, and when consequently the length wound on the bobbins is less than length of roving delivered by front roll, said difference being termed "contraction," the amount of it depending upon the amount of twist per inch put in the roving. It will be readily understood that in consequence of this contraction, the slubbing or roving as is delivered by the fly frame always weighs more per yard than calculations will give, although some of the waste made during the process will tend to counterbalance this increase caused by contraction; the result of both tendencies being an increase in weight for the slubbing or roving of from 1 to 4% above the result of the calculations, and for which reason the draft gear to be used must have correspondingly from 1 to 4% fewer teeth than calculated. In order to distinguish this draft from the calculated draft it is termed "actual draft."

The intermediate frame is the first fly frame where a twisted strand has to be drawn, thus the draft there should be reduced compared to the draft in the slubber, where the sliver delivered to it is untwisted. The roving frame in turn can be run with a greater draft (although both bobbins put up in the creel are twisted) for the fact that then we deal with a much finer hank than at the intermediate frame. Two ends are usually put up at the back of the intermediate as well as the roving frame, in turn drawing them into one end at the front.

A series of fly frames cannot always be arranged so as to give the best theoretical drafts, for the reason that one process of fly frames has to keep up with another, for which reason overseers frequently must change the draft until production of all processes of fly frames is balanced. For example: Suppose the slubbers are making too many bobbins for the intermediates, then the draft in the slubbers is increased so as to make a finer roving, and correspondingly the draft in the intermediates decreased, since then feeding a finer hank; both changes made, resulting in the same roving at the front of the intermediate, only using there a greater length of roving fed.

Roll Traverse Motions.—The need of a roll traverse motion in connection with fly frames cannot be overestimated in the question of satisfactory and economical running of the machines, and is even more important on these frames than on the drawing frame. The benefits sought in this instance, as with the drawing frame, are to save wear and consequent expense in roll leather and expense of covering, besides improving the quality of the rovings produced. The object of all roll traverse motions is to guide the roving back and forth across the bosses of the rolls as it is being fed, so as to prevent any one portion of the roll from being worn more than the remainder of the roll. In these motions, the guide for the rovings consists of a long wooden rectangular shaped rod (see *L* Fig. 183 for cross section of it) which extends the entire length of the machine, being situated directly behind the rolls, in the slides prepared for it on the roll stand (see *I* Fig. 186). Metal guide trumpets are fitted into this rod, they being spaced to correspond to the bosses of the rolls, so that when the rod is placed in position, every trumpet is directly opposite the central point of its boss. By giving this rod the correct reciprocating motion, we thus get the required traverse of the roving. It will be understood that the traverse motion should be set to move the rovings over the surfaces of the rolls as far as possible, i. e., guide them to the ends of the rolls as near as practicable, i. e., without running them off. This fault is sometimes found on one end, and in trying to remedy it by resetting the rod, the evil is simply transferred to the other side. The trouble arises often from the fact that the roving does not reverse promptly when the traverse rod is reversed, owing to the distance between the trumpet and the back roll. This distance naturally allows a little play in the roving and in order to overcome this, allowance must be made in the length of traverse.

The reciprocating motion is obtained in all styles of traverses by converting circular motion into reciprocating motion, either by means of a crank or an eccentric cam connection.

In the simple crank arrangement for the traverse motion, a disk gear is provided with a projecting stud on its surface which fits into a crank rod, the other end of said rod being attached to the long rod carrying the guide trumpets. The disk is slowly rotated by means of a worm situated near one end of the back roll. By this movement, the stud on the disk in connection with the disk acts as a crank, and consequently the crank rod, to which the stud is connected, is given a reciprocating motion, which in turn gives a similar movement to the guide rod carrying the trumpets.

One of the chief advantages of the crank arrangement is the firmness of the movement imparted to the guide rod, thus resulting in the absence of lost motion at the change in direction of traverse. The chief defect of the arrangement is that the motion imparted to the guide rod bar is not uniform, but is simply harmonic, that is, the rod moves most quickly when the trumpets are opposite the middle of the roll bosses and most slowly when near the ends of the traverse.

Unless the disk is given a comparatively quick revolution, when the rod is passing the dead centres at each end of the traverse, there will be a tendency for the rovings to run off from between the rolls, this being particularly the case if the extent of traverse is long in comparison with the length of bosses. For the same reason, the tendency will be for the leather to wear most at the points where the direction of traverse changes. It will be understood that the length of traverse in each direction is always constant.

The simple eccentric cam arrangement is similar in operation to the crank motion but is an improvement on the latter, and when well constructed, with the parts in good order, is very satisfactory. The shape of the cam is varied somewhat in different makes of machines according to the ideas of the makers, however the outline in general is heart shaped. A worm, situated on the back roll, drives a worm gear which is connected to the cam, at a slow speed. The cam presses against a short stud on a rod which is connected to the traverse rod, and hence gives it the required movement. The stud is kept in contact with the cam for both movements of the traverse by means of a spiral spring.

An improvement in regard to roll traverse motions gives the rovings a variable traverse across the bosses of the rolls. This variation consists in gradually increasing the length of traverse and then decreasing this length in the same manner. After the rovings have been traversed across the rolls for the first time by the traverse rod, the next reciprocal movement of the traverse rod is slightly diminished in length, with each succeeding traverse similarly decreased until a minimum length of traverse is obtained, the decrease taking place equally from each side so that the traverse is always centred in respect to the bosses. When this minimum traverse has been made, a gradual increase in length of traverse is obtained similar to the decrease, until the maximum length of traverse is made, thus completing a cycle of variations, and when the same decrease and consequent increase again takes place.

The details of this motion are shown in Fig. 189, giving a side view of the motion with the traverse rod placed in the centre of its traverse.

The principle of the motion is the combination of the movements of two eccentrics which are driven at different rates of speed.

Referring to the illustration, *A* indicates a bracket, secured on the roller beam, which carries a stud *B*. Mounted upon this stud *B* are two toothed wheels *C* and *D*, the wheel *C* containing one more tooth than wheel *D*. Centred with and secured on each of these wheels is an eccentric *E* and *F*, which operate the rods *G* and *H* respectively, as connected on the eccentrics at one end. The other ends of these two rods are connected to a common bracket *I*, the rod *H* being secured to the bracket at the bottom by means of a stud *J* which allows a vertical movement of the rod *H*, while the other rod *G* is secured about half way up on the bracket by means of a similar stud *K*. The top end of the bracket *I* is connected with the traverse rod *L* by means of the stud *M*, passing through a hole in a bracket *N* as attached to the traverse rod *L*. Bracket *I* is capable of adjustment and may be moved up or down on the stud *M*, by having a vertical slot *O* at its upper end, thus it may be adjusted to give a longer or shorter extreme traverse, as may be desired. The gear wheels *C* and *D* are driven by a worm *P*, cut on the back roller in a similar manner as explained in connection with the crank motion. Since this worm drives both the wheels *C* and *D*, with one wheel having more teeth than the other, one eccentric will continually vary its position in relation to the other, so that at one time, the two eccentrics will be

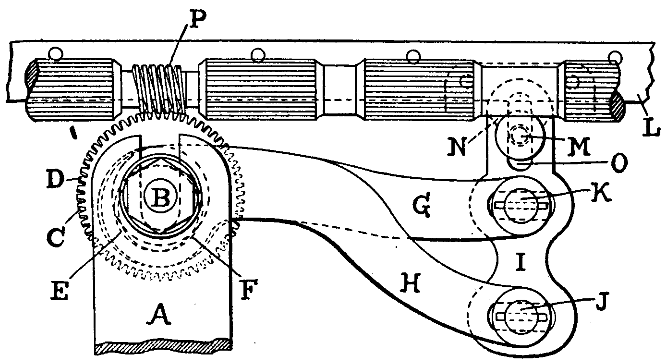

FIG. 189.

FIG. 190.

moving both the rods *G* and *H* in the same direction and consequently the bracket *I*, and at another time one eccentric will be throwing its rod in one direction and the other eccentric its rod in the opposite direction, thus, by the different combinations of motion, giving a constantly varying length of traverse, as shown in the diagram Fig. 190, the same being a facsimile of the traverse of the roving through the rolls.

In order to illustrate the motion of the traverse, we will take a practical example. Let us consider that the maximum traverse of the rod is $1\frac{1}{2}''$ and the minimum traverse is $\frac{3}{8}''$, while the two wheels have 30 and 31 teeth respectively, being driven by a single worm on the back fluted roll. This roll will have to make 900 revolutions before the traverse makes the complete cycle of changes, i. e., from $\frac{3}{8}''$ to $1\frac{1}{2}''$ and back again to $\frac{3}{8}''$, which may be shown by the following calculations: When the back roll, which carries the worm for driving the wheels, has made 15 revolutions, the thirty tooth wheel has made one half of a revolution and consequently has completed the traverse of the rod connected to it in one direction. When this wheel has completed a revolution, the roll has made 30 revolutions and the backward traverse of the rod has been completed. The 30 tooth wheel, necessarily gains one tooth upon the 31 tooth wheel for each revolution, so that the former wheel must make thirty revolutions before both wheels come again to the same relative position. Multiplying 30 revolutions of the back roll for one of the wheels, by 30 revolutions of the wheel, we have 900 revolutions of the back roll in order to make the length of traverse change from $\frac{3}{8}$ to $1\frac{1}{2}''$ and back again to $\frac{3}{8}''$. If the front roll makes 4 times as many revolutions as the back roll, it will consequently make 3600 revolutions before the traverse takes place over the same length under the same conditions, or, in other words, the sliver, slubbing or roving, as the case may be, instead of passing over the entire length of the boss twice for every 30 revolutions of the back roll as with an ordinary traverse motion, will pass twice in every 900 revolutions, although the middle portion of the boss is continually being gone over by the roving. It has been stated by some, that by reason of the eccentrics varying their relative positions, the rods are both on the dead centre, i. e., at rest, only once in every 450 revolutions of the back roll, thus practically ensuring a continuous movement. The first part of the statement is true, but we also, in this connection, have to take into consideration the fact that each rod, independent of the other, is on a dead centre twice for every revolution of its eccentric, which must be true, since otherwise no back and forth traverse would result. From the illustration Fig. 189 we can easily see that the rod comes to a stop after each traverse across the rolls, in order to make the return movement, although it must be understood that the stops are only for an instant. No springs are required in connection with the motion and consequently any disadvantage arising from their use is not present.

In order to get the proper traverse of the rovings, the motion must be properly set, which is done by placing the traverse rod *L* with the guide trumpets opposite to the centres of roll bosses, and then fixing the studs *J* and *K* in the centre of their respective slots. The gear wheels *C* and *D* are then turned so that the longest throws of the eccentrics are at the bottom. The wheels are then put in gear with the worm *P*, after which the bracket *N* is screwed to the traverse rod *L*. The length of traverse is regulated by the position of the stud *M* in the slot *O*, and in order to lengthen the traverse, the bracket is lowered, and to lessen the traverse it is raised, a nut of course having to be loosened in order to make the adjustment, which nut is afterwards tightened.

Another style of variable traverse motion, but which is built on a different idea from the one explained, has the traverse rod to move the rovings with a uniform sweep, but not entirely across the bosses at every traverse; instead of this, the sweep is small, and is moved gradually to different portions of the boss of the roll within certain limits and then back again over the same portion previously traversed, the traverse rod during this bodily movement performing its regular back and forth movements.

Twisting the Roving.—We can readily see from the explanation previously given of drafting the slivers, slubbings and rovings, that they emerge from the delivery or front rolls of the machines in a rather delicate state, that is, the number of fibres in a cross section of the material is small and these fibres have not much cohesion with each other, this condition being kept up in each succeeding frame, so that it would be impracticable, if not impossible, to deliver the slubbing and roving in the same manner as at the drawing frame. In other words, the slubbing and roving has to be sufficiently strengthened to be delivered, and which strength is obtained by means of twisting the same, a feature which in turn requires a special system of delivering said slubbing or roving from the frame.

In order to put twist into a certain length of sliver, slubbing, roving, or any arrangement of fibres, it is necessary to have one of its ends rotated about its axis in a ratio different from one in relation to the other end. When applied mechanically in the frame, it has been found most practicable to hold one end of the slubbing or roving with the rolls while the other receives a rotation about its axis. It will be understood that the delivery of the slubbing and roving from the front rolls is continuous, so that in stating that the rolls hold it, we mean that this grip on the slubbing or roving prevents any twist from running out at that end, and that no rotation is given to the slubbing or roving from that end; thus by a continuous rotation of the other end of the slubbing or roving, the twist will run up into the same as fast as it is delivered from the front rolls.

The method of putting twist into the slubbing or roving, by means of the spindle and flyer, is shown in connection with Fig. 191, showing respectively flyer, spindle, bobbin, etc. in elevation and section, and from which it will be seen that the spindle *A* on which the flyer *B* fits, consists of a long steel rod, the diameter of which varies with the different sizes of machines, being $\frac{7}{8}''$ in slubbing frames down to $\frac{9}{16}''$ in roving frames. The length of the spindle also varies with the size of the machine on which it is used. The rapid revolution of the spindle in the frame requires that it is well supported in suitable bearings, to prevent vibration and reduce friction, with a consequent reduction in driving power required, as much as possible. For this reason the spindle is supported in a foot step bearing, by having its bottom end rest in it (not shown), and in a bolster bearing *C* which fits over part of its length.

The number of turns per inch put in the slubbing or roving depends on the ratio of the revolutions made by the flyer, which puts in the twist, to the number of inches delivered by the front pair of drafting rolls, in a given time.

For example: Suppose the flyer makes 100 revolutions while the front roll is delivering 50 inches roving; then (100 ÷ 50) there would be 2 complete turns put into every inch of the roving delivered.

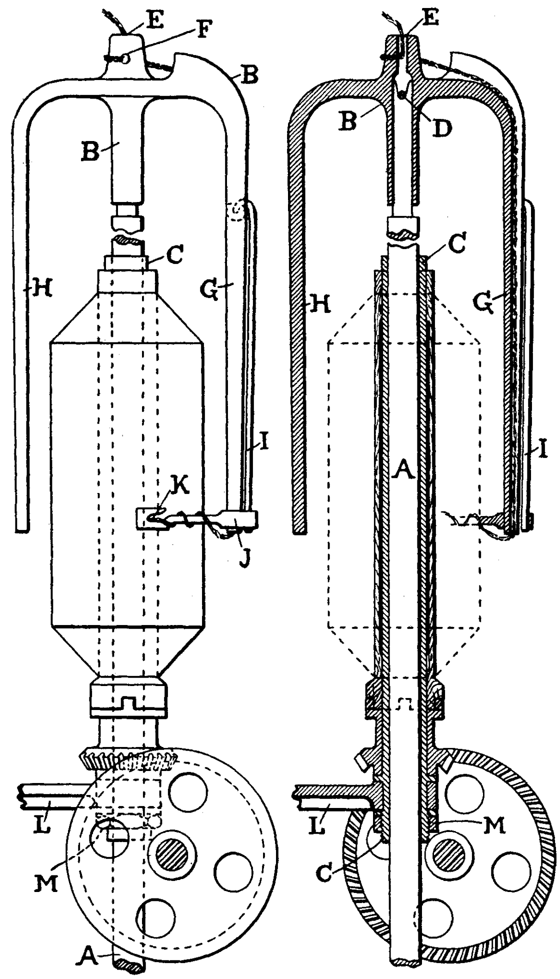

FIG. 191.

Another example: Suppose the flyer makes 500 revolutions per minute, and a $1\frac{1}{8}$ inch front roller made 100 revolutions per minute, what would be the twist per inch?

$100 \times 3.1416 \times 1\frac{1}{8} = 353.43$ inches delivered by front roller in one minute, and $500 \div 353.43 = 1.41$ twist per inch. Ans.

The twist as put in the slubbing or roving should be enough to insure good running work and roving strong enough to unwind in creel of succeeding machine without breaking, and also to keep it from breaking when it is wound onto the bobbin. However, we must remember that if a slubbing or roving is twisted too tightly it cannot be drawn as it passes through the rolls; again, if not twisted at all it will be drawn apart too easily and come from the rolls partially in tufts instead of a continuous regular length. Between these two extremes there is a degree of twist that will permit drawing, but at the same time offer sufficient resistance to it that the fibres are straightened out in the process of sliding over each other, for which reason the minimum of twist for holding a roving together is not the basis, it being the maximum of twist that will enable the fibres to slide over each other during the drawing process, in order that they are straightened out and regularity to the roving is produced. At the same time twist imparts strength to the slubbing or roving by causing the fibres to dispose themselves in the screw line of the twist in the slubbing or roving, causing the short fibres to fly off into the air; the slubbing or roving not suffering by this with reference to its quality. Cleanliness being an important factor for good slubbing and roving, such "flyings" should be frequently cleaned off from the flyers in order to prevent their entering again into the slubbing or the roving.

The amount of twist to put in slubbing or roving is determined by its hank, the quality of the stock that is being used, and the speed of the frame; some overseers for this purpose, in order to ascertain the number of turns per inch to give to the slubbing or roving, multiply the square root of the hank by 1.2; whereas others in connection with slubbing, multiply the square root of the hank by 1, and in connection with the intermediate by 1.1, and with the roving frame by 1.2. This latter calculation is preferable and approximately correct, however it must be remembered that a better quality of stock or a slow running frame permits the slubbing or roving to be run with less twist than if the reverse is the case.

A good test to ascertain whether sufficient twist is being put in the slubbing or roving is to feel the bobbin, i. e., see that it is not too hard or too soft, although we must remember that a hard bobbin can be formed from soft slubbing or roving, provided a heavy vertical rod is used in connection with the flyer.

Never increase or decrease twist to increase or decrease production, neither increase the twist to assist bad pointed skewers. If in connection with perfect skewers the roving stretches or breaks in the creel and does not unwind properly, then increase the twist until slubbing or roving winds off easily. Provided the latter has too much twist, as will be readily understood, it will not draw well between the drawing rolls of the next frame, and when this twist should be decreased until the slubbing or roving draws smoothly.

Although twist is introduced into the slubbing or roving, it is not preserved in its passage through the drawing rolls of the succeeding machines, but is, in each case, when the slubbing or roving leaves the bite of the front roll, practically removed, and for which reason calculate the twists in each case as if an untwisted strand is dealt with.

In discussing the twist put into the roving, its purpose, etc., the question will sometimes arise as to where all the twist goes to that is put into the roving at the different processes used in making a finished roving. To illustrate this, say that we start at the slubber and put in a certain amount of twist and then put the roving made, up at the back of the next process; then when we calculate for the correct amount of twist at this machine we make the calculation on the basis that there is no twist then in the roving. A practical test can be made by breaking down an end at the front roll of a fly frame and letting the end run in the hand for a short space of time so that it may be examined. If the roving was doubled at the back of this machine, the two ends coming out together will be noticed to have a flattened appearance and will be parallel to each other. This shows that the twist already put into the roving, before this process was reached is not now noticeable, and second, that there is no twist put into the roving on the machine until it has passed the front roll, which of course is obvious. The reason for the apparent loss of twist may be readily seen when we consider that in the fly frames there is considerable draft, and that by drawing out the roving, the length of the roving is increased and consequently the twist spread out over this length.

For example, suppose the twist of a 4-hank roving to be 2.4 turns per inch, now if this roving be subjected to a draft of 6, there will be only 0.4 of a turn per inch when the roving is delivered at the front roll, or one complete turn would be contained in $2\frac{1}{2}''$. This would be a slight twist, but if the rovings be examined, it will be noticed that there is a slight tendency for the roving to twist a little less than this extent. The reason for this condition is the fact that of all the twist does not enter the rolls, part of it being forced back by the back pair of rolls, due to the pressure between them. There is no definite method by which this amount may be figured, because if the roving at the back contains a considerable amount of twist, less twist will be pushed back than when the roving being passed through, contains less twist. We may thus conclude that the reason for neglecting the twist in the roving when making a calculation for the next frame is that the amount of twist in the flattened roving as it comes from the rolls is not only small, but does not give any strength to the roving, so that in order to give it the proper strength, the total amount calculated must be put in.

The spindle is made smaller both at the bottom bearing and at the top where the flyer is placed, than the remainder of the spindle. The tapered end of the spindle is grooved in, across its diameter, in order to form a recess for the pin *D* to fit into, said pin being secured in the hole as passing through the flyer, in this manner causing the flyer to revolve with the spindle.

The slubbing or roving as coming from the front rolls to be twisted, is first inserted into the hole *E*, at the top of the flyer, and then passed through a small opening *F* in the side and near the top of said flyer. It is this arrangement for the passing of the roving that gives to the flyer its ability to twist said roving, because, as will be clearly seen, the hole *F* is out of the centre of the spindle, and consequently describes a small circle around the centre of said spindle as the flyer revolves. Every revolution of the spindle therefore puts one turn of twist into the roving, the amount of turns of twist put in the roving, as it is delivered from the front roll of the frame, depending on the relation between the speed of the spindle and the surface speed of the front roll. This relation is generally expressed as so many twists per inch.

A flyer is a most highly polished device used in connection with cotton machinery, special attention being paid to have the presser as smooth as possible. The flyer must be of the finest material and made perfectly smooth over its entire surface in order to prevent accumulations of "fly" as much as possible, which are very often the cause of bad and lumpy roving.

The flyer, shown in connection with illustration Fig. 191, has two downward projecting legs *G* and *H*, which act as bearings for the arm *I* as carrying the presser *J*, said presser acting as a guide for the roving to the bobbin, giving also a slight pressure on the bobbin in order to wind the roving on the bobbin in a firmer manner. The roving on coming out of the hole *F*, is taken about $\frac{3}{4}$ of a turn around the top of the flyer to the top of the hole in the hollow leg *G* and passed down through the hole to the presser *J*, around which it is then wound once, twice or three times, and then passed through the eye *K* to the bobbin. It will be understood that winding the roving around the presser does not put any twist in said roving, but only winds it more firmly on the bobbin. The hollow leg *G* is provided with a longitudinal slot, as shown in special illustration of specimens of flyer legs Figs. 192 and 193, in order to easily thread the leg. This slot is generally made straight, as seen in Fig. 192 for ordinary work, but where the speed of the flyers is high, as in roving and jack frames, this slot is made in a curved form as shown in Fig. 193, the object of this construction being to prevent the roving from flying out of the hole through the slot by the centrifugal action set up by the speed of the flyer.

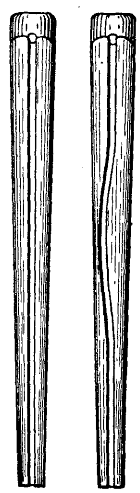

Fig. 192. Fig. 193.

The presser arm *I* (see Fig. 191) is simply a round rod with a hook at its upper end and the presser *J* bent to or secured to it at a right angle at its lower end. By means of its bearing points in connection with the leg of the flyer to which it is secured, the presser arm and presser are capable of free movement, in other words, the presser can be in contact with the bobbin when it is beginning to build and remain in contact until it is completed. The inner part of the presser containing the guide eye is made flat, being sometimes known as the paddle. The presser is of such a length that the eye will lie about opposite the centre of the empty bobbin. The other leg *H* of the flyer is made solid, its object being to balance the flyer by adding sufficient weight to the opposite side from the hollow leg and presser.

With reference to the action of the presser *J* on the bobbin, it would seem at first sight, that the presser instead of pressing against the bobbin would swing outwardly, due to the revolution of the flyer, but this is not the case, since the weight of the presser arm *I* is greater than that of the presser *J*, and also since it revolves at a greater distance from the centre of revolution of the spindle it will therefore have a greater tendency than said presser to fly away from the centre.

As the centrifugal force thus tends to move the presser arm outwards, said arm will swing on its bearing, and the presser, by being connected to it, will be swung inwardly against a lesser force, tending to swing it outwardly. In this manner it is caused to press against the slubbing or roving on the bobbin, and thus make it firm.

By altering the weights of the presser arm and the presser, the amount of pressure on the bobbins may be regulated, although this regulation is always made by the machine builder. The difference in weight is made in flyers for different frames to suit the conditions of the machine. The hardness of the slubbing or roving itself is not effected by the presser, since the twist in the slubbing or roving regulates this, no twist being put in by the presser.

Some flyers of the older type and others which are imperfectly made, have a roughness in the hollow leg which is always a source of trouble in the process, from the fact that any roughness interferes with the passage of the slubbing or roving and causes the fibres to mass together at times and become an obstruction, which will result either in a breakage of the slubbing or roving, or the whole of the fibres may pass forward in bulk and produce what is known as a "slub," which may be described as a swollen part of a roving caused by some imperfection in the flyer, and which is more loosely twisted than the rest of the strand of which it forms a part.

The breakage of a slub in the fly frames is an advantage to the spinner, because its further progress is at once stopped, and it is taken out and consigned to the waste box. A small slub may pass on and be doubled with another roving, which has the effect of tightening it up, or of lengthening it out, and making a long bad end, conspicuous for its whiteness and thickness. Such bad ends often break as the roving is being drawn over the guide rods from the roving bobbin in the creel of the mule; but if not, it will make a heavy place in the completed yarn.

Another style of flyer, commonly known as the Dunn flyer, is shown in Fig. 194, which is a perspective view of the same with the roving shown guided to the bobbin. It will be seen that the flyer leg and balance arm are very much shortened in comparison to the previous flyer, the flyer leg having a presser leg pivoted to it. The lower end of the leg is counter-balanced by an enlarged portion of the top, said leg being pivoted so that it may swing outwardly as the bobbin builds and increases in diameter. The presser at the lower end of the presser leg is quite short and is made only to contain a guide eye for guiding the slubbing or roving to the bobbin.

The flyer is threaded at the top in the same manner as in the previous flyer and after being passed around the top part, it enters the short hollow arm, then passes out upon the presser leg around which it is wound twice, then down until it reaches the foot, where it makes a very easy turn and is passed through the guide eye to the bobbin. The action of centrifugal force upon the slubbing or roving when it is upon the presser arm tends to relieve the friction, which it does to a certain extent. This enables the making of very soft and even slubbing or roving. The tension on the slubbing or roving with this flyer is different from that of the first explained flyer, the reason for this being that the slubbing or roving as delivered to the bobbin is in a softer condition and consequently the layers are flattened to a more elliptical form, which enables more layers to be placed upon the bobbin in a given diameter. To illustrate this, take two strings and twist them together, then pull at each of the twisted strings and you will notice that the strain has a tendency to set the twist and make the string hard, which will cause it to retain its roundness; but apply less strain, and it will be softer and allow of some compression. The latter condition is found in the slubbing or roving on this flyer and hence it is delivered to the bobbin in a soft and even condition. The production is increased with these flyers by this condition, and also from the fact that they are lighter and supplied with short arms which do not spread, thus enabling the speed to be increased from 10 to 15 per cent without material increase in power or repairs. An increased diameter of bobbin can also be obtained on the same spaced frame, which will lengthen the time between doffs. When an end breaks, it is very easy to piece it up as the flyer can be readily threaded up again.

A flyer somewhat similar in outline to the one just described is shown in Fig. 195 in diagram *A* in its perspective view, diagram *B* being a detail, cross sectional view, showing the manner of mounting the presser sleeve.

Referring to the illustrations, *a* and *b* represent respectively the arms of the flyer, the arm *b* carrying the slubbing or roving *y*, said arm being for this purpose provided with a plate *c* fastened at one edge to the upper portion of the arm *b*. This plate contains an eye c' near its upper end and a notch c^2 at its lower end. The slubbing or roving *y*, in coming from the front rolls of the frame is threaded through the top hole, through the guide *g* and then turned around the top and passed along the upper end of the arm *b* to the eye c' in the plate *c*, in which it is threaded and thence down along the inner side of said plate through the notch c^2 at the bottom. *d* indicates the presser, and d' its eye through which the slubbing or roving is led in its travel onto the bobbin. This presser *d* is carried on a sleeve *e*, held on the reduced lower end of the arm *b* by a pin b' in said arm, which works in a slot e' in the sleeve *e*. This allows the sleeve to rock sufficiently on the arm, while the bobbin is

Fig. 194.

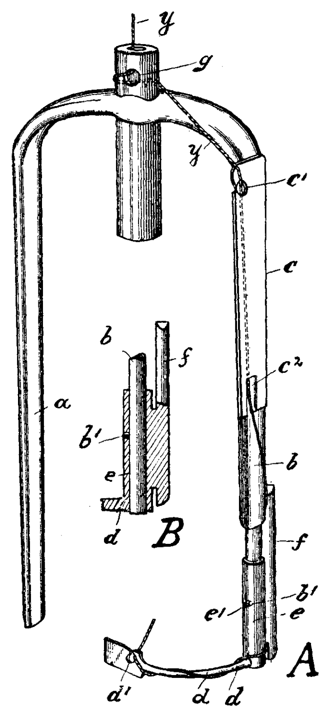

Fig. 195.

building, but it holds the sleeve from any longitudinal movement. Carried by the sleeve *e* is a tension bar *f*, which has its end portions separated from the sleeve, as seen in diagram *B*, and is joined to the sleeve at an intermediate point between the ends.

The slubbing or roving *y* is led from the notch c^2, of the plate *c*, downward partly around the arm *b* and between said arm and the upper end of the tension bar *f*. It is then passed down along the side of this bar and between the lower end of the tension bar *f* and the lower end of the sleeve *e*, after which it is wound around the presser finger and led through the eye *d'*, as mentioned before, onto the bobbin.

The bolster for the spindle, which acts as its upper bearing to revolve in, consists of a collar which is securely fixed to the bolster rail of the bobbin carriage. The collars of the bolsters are made either long or short (see Fig. 191), preference at the present time being given to the long collar. These collars are secured in the rail *L* by means of nuts *M*, threaded on their lower ends. The lower portion of the collar fits a hole bored in the rail, and by means of a shoulder is bedded accurately to a milled surface provided for that purpose. Some bolsters, and especially those of American make, have the collars cast with a piece at right angles to the length of the collar near the bottom, and this piece is bolted to the side of the bolster rail, both surfaces being accurately milled in order to have the collars stand perpendicularly in the frame.

One of the advantages of the short collar is that it is able to use a smaller diameter empty bobbin, and thus wind more stock on it, since the collar in this instance does not extend up into the barrel of the bobbin, so that said bobbin fits only over the spindle of smaller diameter. The collar is simply used to form an upper bearing for the spindle. A disadvantage to this collar is the fact that as the spindle extends a good portion above its bearing, and also carries a flyer, said spindle is more or less liable to be out of balance throughout the building of the bobbin. In other words, it is best to give as much support as possible to the spindle in the frame, and more especially where high speeds are used.

The long collar fits over the spindle and when the bobbin carriage is in its highest position, the top end of said collar almost comes in contact with the under side of the flyer. This provides sufficient support for the spindle and flyer and consequently they will run very steadily. In the present form of long collar, two bearing surfaces are made, one at the bottom and the other at the top, the intermediate surface being bored out so as not to touch the spindle. The top bearing surface is about three inches long, while the lower bearing surface is much longer. With the long collar, a larger empty bobbin is necessary, owing to the fact that a larger hole is required to fit over the collar, which causes more weight, but the disadvantage is very slight in comparison with the number of distinct advantages obtained by its use.

Winding the Roving.—The operation of winding the roving on to the bobbin is very closely related to the twisting operation, but carrying it out requires the use of additional mechanism which is of a more or less complicated character.

The general principle of winding is to have both, bobbin and spindle, revolve in the same direction but at different relative surface speeds, each being independently driven, but both revolving around a common axis. Thus, in order to wind the roving properly, there must be a certain relative velocity existing between the surface speed of the flyer eye and the outside surface of the bobbin and which must be maintained throughout the building of the bobbin. This relation is necessary to the operation of winding, since a definite and constant length of roving is delivered from the rolls, which has to be disposed of by being wound on the bobbin in a systematic manner. The relation between the surface speeds of the flyer eye and the surface of the bobbin may be obtained in several different ways, but which practically have been narrowed down to only one system, or at most two, viz:

(1) The flyer and bobbin revolving in the same direction, the flyer eye however being made to rotate at a quicker speed than the bobbin in order that the roving may be wound on the surface of the latter; this system of winding being known as "flyer leads."

(2) The flyer and bobbin revolving again in the same direction, but in this instance the bobbin being revolved at a quicker velocity than that of the flyer, so that said bobbin will draw the roving from the flyer eye and wind it upon its own surface. This system of winding is known as "bobbin leads," indicating again the leading feature in connection with the operation.

These are the two methods of winding which have been practically employed, but at the present time, for economy in running the frames, only the last, or "bobbin leads," is used.

A practical application of the "flyer and bobbin leads," to the flyer and bobbin, may be seen by referring to Figs. 196 and 197, the "bobbin lead" being shown in Fig. 196 and the "flyer lead" in Fig. 197. From the direction of the arrows, it will be seen that both, bobbin and flyer, run "right handed" in both instances, or as is sometimes said they run clockwise, i. e., in the direction of the hands of a clock.

In the case of "bobbin lead," the bobbin is running faster than the flyer, as was mentioned, and hence the roving is drawn on to the bobbin right handed. It will be noticed that the presser *P* is pointing in the direction of motion of the bobbin and flyer, which is necessary, since the presser has to point in the same direction that the roving is being delivered, in order to avoid unnecessary friction to the roving as it leaves the flyer. The presser could not be made to point in this direction if the flyer revolved faster than the bobbin, for in that case, the presser would mash with its end into the roving on the bobbin and thus spoil it.

With reference to Fig. 197, showing a flyer and bobbin arranged for "flyer lead," the flyer is traveling faster than the bobbin and the presser *P* has to extend in the opposite direction from that of the presser of the "bobbin lead," in order that the roving will be delivered in the same direction that the presser is pointing, for the same reason given in the first case. The roving in being laid on the bobbin by the flyer instead of laying itself on the bobbin, is placed on said bobbin in a left hand direction, although as mentioned, the flyer and bobbin revolve in a right hand direction.

In the discussion given, only the winding on of one layer of roving was considered, and in which case the diameter of the bobbin remained the same during the winding of that layer, but it will be readily seen that on the completion of the layer, the bobbin has increased in diameter by twice the thickness of the roving wound on, although, owing to the approximately round shape of a cross section of the roving, this new surface will not be perfectly smooth but will have small spaces between them at the outer surface, and which spaces become smaller until the point of contact between the two coils of roving is reached, when they of course disappear. The winding on of the roving for the next layer on tne bobbin will necessitate a change in the conditions for winding the first

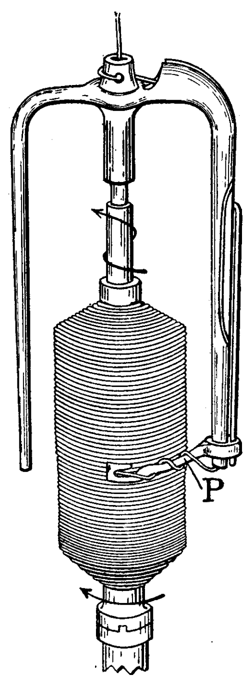

Fig. 196.

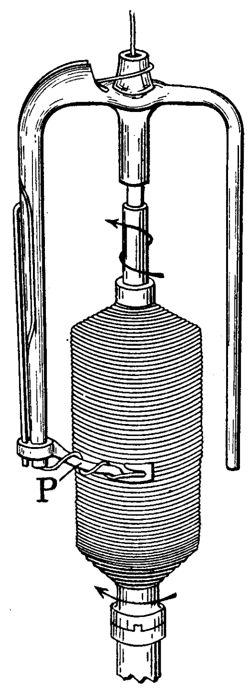

Fig. 197.

layer on, i. e., provision must be made in the arrangement to allow for the increased diameter of the bobbin.

Take a simple example of winding where the circumference of the front roll and bobbin are 4 inches, then if the excess speed of the bobbin is the same as the number of revolutions of the front roll, the roving will be wound on the bobbin properly for that layer. Now say that the circumference of the bobbin is increased to $4\frac{1}{2}$ inches, while the delivery of the front roll of course remains the same, then it is clear that the same number of revolutions of the bobbin, i. e., the excess speed, cannot be used, since every excess revolution of the bobbin would wind on $4\frac{1}{2}$ inches, while only 4 inches were delivered by the rolls and consequently the roving would be immediately broken by the strain put on it. It is therefore necessary to provide some means of taking care of this increased diameter of the bobbin, which is done by decreasing the excess speed of the bobbin in such a manner as to have the surface speed of the bobbin just sufficient to take up the roving as delivered from the rolls, with the "bobbin lead." Provided a "flyer lead" were used, it would be necessary to increase the speed of the bobbin in order not to have the roving pulled apart by the revolution of the flyer.

With reference to this decrease or increase in the speed of the bobbin as it fills, it may be mentioned at this point that said decrease or increase, as the case may be, is obtained by means of cones which transmit the required variation of speed to the bobbin through the medium of a special arrangement of gearing known as the "differential motion."

Having explained the operations of the two systems of winding, and stated that the "bobbin lead" is almost entirely used at the present time, it will be well to look into the advantages and disadvantages of the two systems and find the reason for selecting the "bobbin lead." A serious objection to the "flyer lead" is the increase of speed, which is necessary for the bobbin as it enlarges and becomes heavier, since in that instance an increased speed and weight requires in turn more power to drive, resulting also in an increased strain on the parts of the frame as a direct result of this extra speed. This is the chief disadvantage to the "flyer lead;" but another serious objection is the fact that the bobbin and flyer must be driven in such a manner as to very often produce harmful results in the roving when the machine is started. The bobbin and flyer are driven independently, as was previously mentioned, by two trains of gears. The spindles are driven directly from the main shaft through a train containing the fewer number of gears, whereas the bobbins are driven through a long train of gears, and through a cone belt working on the cones. This causes more delay in the commencement of the rotation of the bobbins than there is in that of the spindles, for the reason that there is more back lash in the gears driving the former. The spindle in thus starting ahead of the bobbin will strain the roving and very often break it. This delay in the commencement of rotation of the bobbin is also found in the "bobbin lead" arrangement, but in this instance it is not a disadvantage, since the delay only causes a little slackness to exist in the roving, which is rapidly taken up by the bobbin when it revolves at its normal speed. In the "bobbin lead," where a diminution in the speed of the bobbins takes place after each layer is completed, there is not as much strain put on the frame as with the "flyer lead" and not as much power required to run the frame as the bobbin builds. Again with flyer leading, every time an end of roving breaks, a small quantity of roving is unwound from the bobbin and is caught on the other bobbin near it, resulting in a considerable quantity of waste being made. With bobbin leading, such is not the case, since the bobbins wind the roving on to themselves and if an end breaks, the broken end will tend to cling to the side of the bobbin.

With reference to the reduction in speed, i. e., revolutions of the bobbin as it fills, it must be kept in mind that the reduction relates only to its excess speed over that of the flyer. As will be seen later, the speed of the bobbin varies inversely with its diameter, but this speed plainly refers to excess speed, since the actual speed of the bobbin can never be less than that of the flyer, for if it did there could be no winding on.

The question of winding roving on a bobbin is of such a nature as to offer exceptional opportunities for study, and a careful analysis of the subject will explain many items which at first sight appeared to be one thing, whereas a careful consideration shows them to be another. A good illustration of this would be the question of the surface speed of the bobbin. With a "bobbin lead," it is a common error to say that as the bobbins increase in diameter their revolution must decrease so as to maintain the same surface speed of bobbin at all parts of the set, this surface speed being substantially equal to the surface speed of the front rollers. There can be no dispute that the revolutions decrease, but the surface speed does not remain the same, as is thought by many. As a matter of fact, this surface speed tremendously increases, which will be shown by a practical example.

We will assume the spindles to make 1000 revolutions per minute, the bobbins to make 1104.2 revolutions when empty, and 1041 when full as will be shown; the diameter of empty bobbins to be $1\frac{3}{8}$ inch, and the diameter of full bobbin to be $3\frac{1}{2}$ inches; 450 inches of roving delivered per minute.

$1\frac{3}{8} \times \frac{22}{7}$	=	4.32	inches, circumference of empty bobbin.
$450 \div 4.32$	=	104.2	and
$1000 + 104.2$	=	1104.2	revolutions of empty bobbin per min.
$3\frac{1}{2} \times \frac{22}{7}$	=	11	inches, circumference of full bobbin.
$450 \div 11$	=	40.9	and
$1000 + 40.9$	=	say 1041	revolutions of full bobbin per minute.

From these calculations it is seen that the revolutions of the empty bobbin will be 1104.2 and that of the full bobbin will be 1041. The surface speeds of the bobbin at the beginning and end of the set respectively, would be their revolutions multiplied by their circumferences, or

$$\frac{1104.2 \times 4.32}{12} = 397.51 \text{ feet surface speed of empty bobbin.}$$

$$\frac{1041 \times 11}{12} = 954.25 \text{ feet surface speed of full bobbin.}$$

From these simple calculations we see that the surface speed of the full bobbin in a "bobbin leading" frame is almost two and a half times as great as the surface speed of the empty bobbin, although it is not an unusual thing to hear that such speed keeps the same all through the building of the set of bobbins. But it has been shown that while the revolutions of the bobbins diminish, their surface speed is very much increased, and the explanation is, that only the excess speed of the bobbins over the spindles is reduced by the movement of the cone belt, as was previously mentioned.

The explanation of how it is possible to maintain the winding on of the roving at an equal rate for all diameters of the bobbin in spite of the greatly increased surface speed of bobbins as they increase in diameter may be stated as follows: In order to wind the roving, it is necessary to take into consideration the difference in surface speeds between the eye of the presser and the point of winding on of the bobbin, this difference being equal to the surface speed of front roller, and which difference is maintained the same all through the building of the set of bobbins, because the delivery of the rolls is constant. As the bobbin increases in circumference and so has greater surface speed, as shown in the calculation, at the same time the eye of the flyer is held further from the centre and made to revolve in a greater circumference, thus increasing its surface speed at the same rate as that of the bobbin, and in this way compensation in the surface speed of the flyer eye for increase in bobbin diameter is automatically effected; so far as the fixed 1,000 revolutions of the flyers are concerned. In this way all increase in surface speed of bobbins can be ignored as regards the winding-on problem, and only the point was made that it is incorrect to say that the surface speed of the bobbins remains the same all through the set. In other words, the excess surface speed between the bobbin and flyer eye is kept constantly the same, having the surface speed of the flyer eye increase at the same rate as the bobbin.

In making any further statement in regard to winding, it will be understood that the "bobbin lead" arrangement is referred to.

We may summarize the foregoing explanation in regard to winding the roving, by saying that the bobbin must always revolve at a greater speed than the flyer. As the bobbin increases in diameter in building, this excess speed must be decreased. This decrease in the excess of the bobbin must be in the inverse ratio to the increase in diameter. For example, if an empty bobbin was $1\frac{1}{2}$ inch in diameter, when it became 3 inches in diameter or twice as large, its excess speed would have been reduced to one half of what it was at the beginning, and when the diameter increased to 4 inches, the excess would have been reduced to $\frac{3}{8}$ of its original speed, etc.

This reduction may be shown very clearly by means of diagram Fig. 198. Say that the empty bobbin is $1\frac{1}{2}$ inch and the full bobbin to be 6 inches in diameter respectively. Consider that every layer of roving increases the diameter of the bobbin by $\frac{1}{4}$ inch. However, so as not to have too many lines in the diagram, the successive diameters of the bobbin have been given in this diagram only for every alternate increase, instead of every increase. Let A represent the bobbin, carrying one complete coil of roving, represented by the heavy black circle B; said coil representing the excess speed (gain) of the bobbin over the flyer during a certain number of revolutions of both. The number of revolutions of the spindle required in winding this length will always remain the same throughout any layer, also the length of roving delivered, so that the question simply resolves itself into: What reduction in

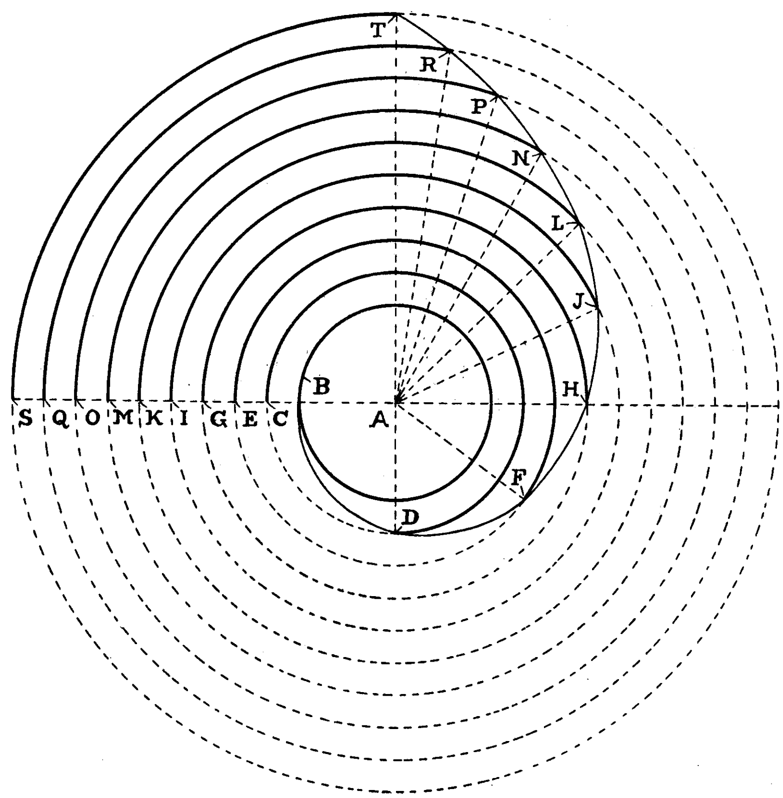

FIG. 198.

the speed of the bobbin is necessary to wind this same length of roving on during the same number of revolutions of the flyer (and spindle)? Two more layers of roving added are represented by the circle C. The same length of roving as coiled on the first coil (B) is now represented by the heavy line $C\ D$. It will be readily noticed that this length of roving does not make a complete coil around the bobbin on diameter C. The diameter of the bobbin after two more layers in turn are wound on is represented by the circle E, and the length of the first coil of roving (B)

considered in connection with it would now be equal to the length *E F*. In the same manner, every alternate layer of roving is represented by the circles *G*, *I*, *K*, *M*, *O*, *Q*, and *S* respectively, and the lengths of roving (considering the first coil (*B*) in connection with the respective circles) by the heavy lines *GH*, *IJ*, *KL*, *MN*, *OP*, *QR*, and *ST*. It will be readily seen from the diagram that only one quarter of the excess speed of the bobbin is required for the 6 inch diameter (i. e., last layer) bobbin, while a complete revolution was necessary for the $1\frac{1}{2}$ inch diameter bobbin, i. e., first layer ($1\frac{1}{2} \times 4 = 6$). The reduction in the excess speed while winding from the $1\frac{1}{2}$ inch to the 6 inch diameter is shown either by the dotted portion of each circle or by the angles which the lines connecting the ends of each heavy line to the centre make with the lines *AS*, or in other words, as previously mentioned, the reduction in the excess speed takes place in inverse proportion to the increase in the diameter of the bobbin.

The curve joining the ends of the heavy lines is used to indicate the termination of any heavy line representing the roving on any diameter between the two mentioned, and when plotted out from a horizontal line, forms the characteristic hyperbolic curve and upon which curve the outlines of the cones are based. This curve may be obtained by first laying out distances on a horizontal line from an initial point to correspond to the different layers of roving on the bobbin, as indicated by the circles in the diagram, and erecting perpendicular lines at these points having their heights to correspond to the proportion of circle occupied by its heavy line. For example, take the initial circle *B* as one inch for the first perpendicular line, then the last line would be only one quarter of an inch in height, since the heavy line only occupies one quarter of the circle. After erecting the intermediate lines, the curve is produced by connecting the ends of these lines.

Cones.—The practical application of the preceding principle of winding will now be given when designing the cones on the fly frame to give the required variation in the speed of the bobbin. It may be mentioned at this point that the outlines of the cones are not straight lines but are made curved, the top cone being made always concave, while the bottom cone is always convex, that is, the surface of the top cone curves inwardly and the bottom cone curves outwardly or bulges from an imaginary straight surface of the cone.

In designing cones certain data must be given, for instance, the diameters of the empty and full bobbins must be known, the speed of the top cone must be taken from some basis and the extreme diameters of the cones must be decided upon. For the sake of simplicity we will use, for an example, the easiest numbers with the correct proportions between them, so that to use the results in a frame, only the question of gearing will have to be looked after.

For example, the empty bobbin to be 1 inch in diameter and the full bobbin 4 inches, or the proportion between the full and empty bobbin is 4:1. From this we see that the extreme diameters of the cone drums must be arranged to reduce the excess speed of the bobbin four times during the travel of the cone belt from one end of the cones to the other. Different diameters are used by different builders, those most generally adopted being 3 or $3\frac{1}{2}$ inches for the small end, and 6 or 7 inches respectively for the large end of each cone. When the belt is on the large end of the top cone, it is driving on the small end of the bottom cone, this being the initial position, i. e., the roving is being wound on the empty bobbin; again when the belt is on the small diameter of the top cone, it is then working on the large diameter of the bottom cone. The top cone is always the driver, and for convenience we will assume it to run at a constant speed of 100 revolutions per minute. This will cause the bottom cone to be driven at 200 revolutions per minute when the belt is on the largest diameter of the top cone, since its diameter is twice as large at that point as the bottom cone; again when the belt is on the smallest end of the top cone, the bottom cone is driven at 50 revolutions per minute, or $\frac{1}{4}$ of what it was at the beginning of the set.

The speed of the bottom cone when the belt is in the centre of its length is easily calculated, since at this point the bobbin is half full or $2\frac{1}{2}$ inches in diameter. Provided the surfaces of the cones were straight, the two speeds would be the same, but not the proper speed, as will be shown by the following calculation:

The diameter of the bobbin is $2\frac{1}{2}$ inches, or $2\frac{1}{2}$ times larger than the empty bobbin, and therefore its speed must be proportionately decreased, that is, $1 \div 2\frac{1}{2} = \frac{2}{5}$ of its original speed. Or we may state it by the rule laid down, which was: The decrease in speed must take place in the inverse ratio to the increase in the diameter of the bobbin. Since the bobbin increased to $2\frac{1}{2}$ inches, the decrease in speed would be the reverse or $\frac{2}{5}$ of the original speed. Thus $\frac{2}{5}$ of $200 = 80$ revolutions, which the bottom cone must make when the belt occupies the central position on the cones. It will be seen later that the reduction in speed of the bobbin is greater during the first part of the set and becomes proportionately smaller as the diameter of the bobbin increases, which is due to the hypobolic curve outline of the cones, that is, the curve makes a quick descent for the first layers, and then becomes more gradual in curvature to the other end of its length.

Another way of making the explanation of this construction is by using an example. The constant amount of roving delivered by the front rolls determines the initial winding power of the bobbins, and for the succeeding layers the winding power has to be kept the same as for the first layer, that is, wind on the same amount from the front rolls.

For example, if the diameter of the empty bobbin is increased by $\frac{1}{8}$ of an inch, by a layer of roving, this increase may equal $\frac{1}{11}$ of that diameter, and the revolutions of the bottom cone must be reduced by $\frac{1}{11}$ of the initial speed. If $\frac{1}{8}$ of an inch is added to the diameter of a nearly full bobbin, this increase may be only $\frac{1}{33}$ part of the total diameter, so that the revolutions of the bottom cone must only be decreased by $\frac{1}{33}$ of the original speed. This unequal decrease in the speed of the bottom cone can only be made (at the same time keeping the cone belt in uniform tension) by making the top cone concave and the bottom cone convex. It was stated before that a frequently adopted diameter by machine builders for one end of the top cone was 7 inches, and the corresponding diameter of the bottom cone $3\frac{1}{2}$ inches. The sum of these diameters, i. e., $10\frac{1}{2}$ inches (or 9 inches in connection with 6 and 3 inch cones) must be the same throughout the length of the cones in order to have the cone belt always tight. To ascertain the correct outlines of the cones, the different diameters along the length of the cones must be calculated to give the required speeds to the bobbin during the set. These diameters may be worked out algebraically from the speeds necessary at that point and the sum of the diameters of the cones, from which a formula may be derived to calculate any number of diameters along the cones to produce the outline.

The formula derived is as follows:—

$$\frac{\text{speed of top cone} \times \text{sum of dias.}}{\text{speed of top cone} + \text{speed of bottom cone}} = \text{diameter of the bottom cone.}$$

It is obtained by combining two equations, one of which is that the speed of the top cone multiplied by its diameter is equal to the corresponding speed of the bottom cone multiplied by its diameter. The other is that the sum of the diameter is always the same.

Applying the formula to get the diameter of the bottom cone at the centre, we have

$$\frac{100 \times 10\frac{1}{2}}{100 + 80} = 5.83 \text{ inches diameter of the bottom cone.}$$

The corresponding diameter of the top cone would be $10\frac{1}{2} - 5.83 = 4.67$ inches. This is when the bobbin is half full.

The length of the cones is usually 30 inches, and in order to get their outlines as accurately as possible, the diameters will be calculated for every layer wound on the bobbin, considering that the bobbin increased $\frac{1}{4}$ inch for every layer added. Beginning with one inch and progressing by $\frac{1}{4}$ inch, we obtain 13 diameters including the full diameter of 4 inches. The cones will therefore have to be divided up into 13 equal points including the ends of the cones. The speeds and diameters of the cones, required for the diameters of the bobbin, are given in the following table:

Dia. of Bobbin.	Inverse Ratio of Bobbin.	Speeds of Bottom Cone.	Dia. of Top Cone.	Dia. of Bottom Cone.
1	1	$1 \times 200 = 200$	7.0	3.5
$1\frac{1}{4}$	$\frac{4}{5}$	$\frac{4}{5} \times 200 = 160$	6.46	4.03
$1\frac{1}{2}$	$\frac{2}{3}$	$\frac{2}{3} \times 200 = 133.33$	6.0	4.5
$1\frac{3}{4}$	$\frac{4}{7}$	$\frac{4}{7} \times 200 = 114.28$	5.6	4.9
2	$\frac{1}{2}$	$\frac{1}{2} \times 200 = 100$	5.25	5.25
$2\frac{1}{4}$	$\frac{4}{9}$	$\frac{4}{9} \times 200 = 88.88$	5.0	5.5
$2\frac{1}{2}$	$\frac{2}{5}$	$\frac{2}{5} \times 200 = 80$	4.67	5.83
$2\frac{3}{4}$	$\frac{4}{11}$	$\frac{4}{11} \times 200 = 72.72$	4.42	6.07
3	$\frac{1}{3}$	$\frac{1}{3} \times 200 = 66.66$	4.2	6.3
$3\frac{1}{4}$	$\frac{4}{13}$	$\frac{4}{13} \times 200 = 61.5$	4.0	6.5
$3\frac{1}{2}$	$\frac{2}{7}$	$\frac{2}{7} \times 200 = 57.14$	3.82	6.68
$3\frac{3}{4}$	$\frac{4}{15}$	$\frac{4}{15} \times 200 = 53.33$	3.66	6.84
4	$\frac{1}{4}$	$\frac{1}{4} \times 200 = 50$	3.5	7.0

It will be remembered that the top cone revolves at a constant rate of 100 revolutions per minute and in order to arrive at the different diameters of the cones, the proper substitutions must be made in the formula previously given.

The layout of a pair of cones from the data found in the table is shown in Fig. 199, also a diagram of a bobbin at the left hand side showing the successive layers of roving which make up the bobbin; the diagram of the bobbin being drawn enlarged to that of the pair of cones.

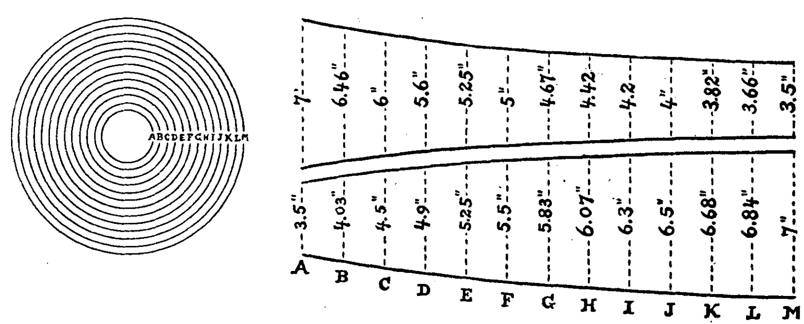

FIG. 199.

While the first layer *A* is being wound on the bobbin, the cone belt is driving the bottom cone at the point *A*. When that layer is completed, the belt is moved to the position *B* and the second layer *B* of roving is commenced to be wound on the bobbin, the speed of the bobbin having been properly reduced by the reduction of the speed of the bottom cone. Thus the cone belt is moved the same amount along the cones after the completion of each layer of roving represented by the circles *C*, *D*, *E*, *F*, *G*, *I*, *J*, *K*, *L* and *M* respectively, the different diameters being indicated on the diagram.

There are other methods of laying out cones, which however are more or less based on the method explained, no perceptible advantage being gained by their use.

Differential Motion.—The method of applying the change of speed to the bobbins from the cones is shown by referring to illustration Fig. 200, which is a diagram of the gearing of a fly frame, showing how the different parts are driven. The frame is driven by means of a belt to the pulley *A* fast on the main shaft *B* of the machine; *A'* being the loose pulley. Secured on this main or jack shaft *B*, as it is sometimes called, is a bevel gear *C* which forms a part of the differential motion as composed of gears *C*, *D*, *E*, *F* and *G*. Considering at present that gear *D*, which carries the studs for the two bevel gears *E* and *F*, is stationary, then these two bevels simply act as intermediates and drive the bevel gear *G*. Secured on the same collar with the bevel gear *G* is a tooth gear *H*, which through an intermediate *I* drives tooth gear *J* on the end of the bobbin driving shaft *K*, which carries a number of skew bevel gears (one of which *L* is shown in diagram) to correspond to half the number of the bobbins (i. e., one line of bobbins in frame) and which gears drive the respective bobbins through their respective bevel gears *M*, the top sides of which are made with projections to engage with notches on the bottoms of the bobbins in order to positively hold them. The other row or line of bobbins are driven similarly through a shaft with skew bevels, as for the line of bobbins just explained, on it, said shaft being driven from the first bobbin shaft *K*.

With this gearing alone, the bobbins receive, as near as possible, the same number of revolutions per minute as the spindles, and as no winding is done with this system of gearing alone, it does not have to be changed in speed. The gearing and cones which give the excess speed to the bobbins is traced from the main shaft *B*, which carries at its end a twist change gear *N*, and this gear through an intermediate *O*, drives gear *P* on the top cone shaft *Q*. The top cone *R* drives the bottom cone *R'* through belt R^2, said bottom cone *R'* having at the end of its shaft a tooth gear *S*, which drives a tooth gear *T* molded with another tooth gear *T'*, and this gear in turn drives the spider shaft *U* through tooth gear *V*. On the other end of the spider shaft *U* is a tooth gear *W*, which drives the gear *D* of the differential motion, this gear *D* being sometimes known as the sun wheel. The rotation of this gear *D* is transmitted through the differential motion to the bevel gear *G*, and from there to the bobbins through the gearing already explained; in this manner giving the necessary excess speed to the bobbins for winding on the roving.

There are several makes of differential motions, which we will take up individually and explain, and when a thorough understanding of the

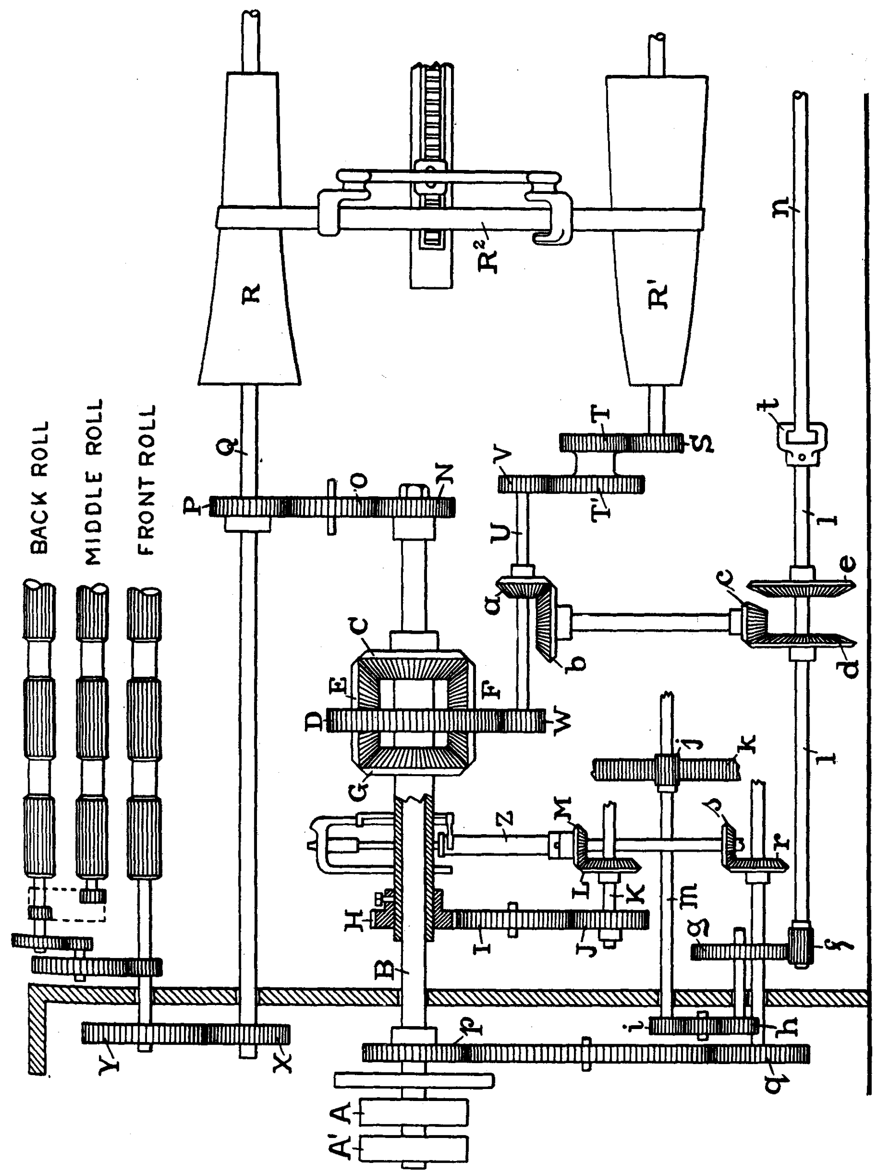

Fig. 200

principle underlying their construction is necessary in order to fully comprehend explanations given.

We have seen that the bobbins are driven by two trains of gearing, one from the main shaft and the other from the cones, and it is to effect the combination of these two drives into a single drive and at the same time allow of the variation in the speed of the cone drive, that the differential motion is used.

A differential motion, or epicyclic train of gearing, consists in introducing gears on movable centres into a regular train of gears

One of the simplest forms of differential motion is shown in diagram Fig. 201, which will very clearly show the character of this system of gearing. The motion consists of two gears *A* and *B*, in mesh with each other, the number of teeth in the two gears being the same in this

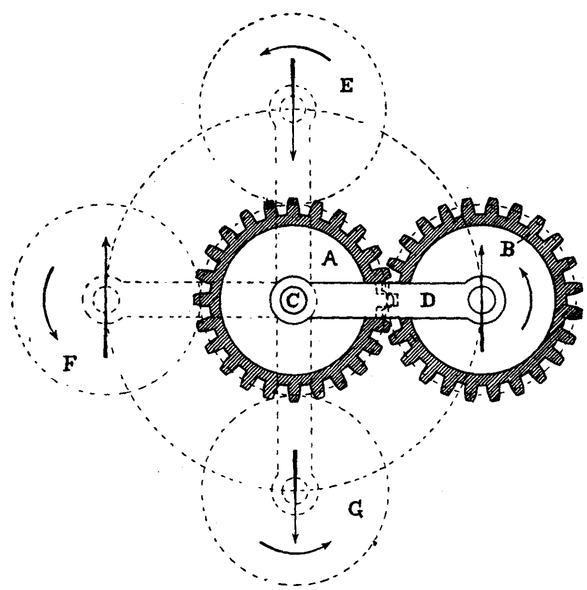

Fig. 201.

instance. The gear *A* is fixed in bearings on a regular shaft *C*, while the outer gear *B* is on a small stud, carried by the arm *D*, said arm being pivoted at one end on the shaft *C*, thus allowing a bodily movement of the gear *B* around the gear *A*. If the arm *D* be considered as fixed and the gear *A* given one revolution, the two gears are then a simple train and consequently the gear *B* is given one revolution in the opposite direction to that of *A*. Now consider that the arm *D* is moved about its pivot at the shaft *C*, in this instance being given a complete revolution about said pivot, and the gear *A* is held stationary with the gear B in mesh with it. The gear B will thus naturally receive motion from two sources, that is, it will revolve bodily around the gear A and also it will revolve about its own axis, and consequently receive two complete revolutions while the arm D only makes one. The reason for this is, that one revolution is gotten from being in mesh with the gear A and the other revolution is obtained from the revolution of the arm D.

It may be a question in some minds as to how the gear B can make two revolutions when it has the same number of teeth as the gear A with which it is in mesh and under ordinary circumstances would only make one revolution, but this point can be made clear by a little analysis of the motion. Consider first the question of the revolution of the gear B about its own axis. It was stated that the gear A in this instance was stationary, therefore as the arm D carries the gear B around, different teeth of the two gears will come successively into mesh with each other and by this meshing, the teeth of gear B assume different positions in relation to the gear A, or in other words, the gear B revolves on its own axis due to the meshing with the stationary gear A. Provided the gear A was loose on the shaft C, as the gear B was carried around by arm D, the teeth of the two gears which were in mesh would remain in contact, and hence the gear A would receive an axial revolution while the gear B would receive no revolution about its own axis. Therefore we have found that when the gear A is stationary and the gear B is carried around in mesh with it, the latter is given a revolution about its own axis. Now as to the revolution given to the gear B by its bodily movement, we can see that it does receive this revolution by considering that there is no gear A at present and only the arm D carrying the gear B is used. By giving this arm D one revolution, it will consequently carry the gear B around with it, which will give it a complete revolution. To show this in the diagram, the dotted circles E, F and G are given to represent the gear B at each quarter of the revolution, and the straight arrows (in the centre of the circles) show the changes in position which the gear takes up at each quarter of a revolution, considering the direction of the straight arrow in B as the starting point. It will be seen that this bodily revolution of the gear is made without reference to its revolution about its own axis, and will be made just the same when it is in gear with the wheel A which gives it the axial revolution. Thus it is that we get the two revolutions of the gear while the arm D is moved once around its pivot C. The curved arrows shown in circles B, E, F and G indicate the positions which the gear takes up at the quarters of revolution of the arm D, that is, including its axial and bodily revolutions. When the arm D has made a quarter of a revolution, the gear has made one half of a revolution, as indicated by the opposite direction of the straight arrow in circle E from its original position in gear B; again when the arm D has made one half of a revolution, the gear has made a whole revolution (see straight arrows in B and F) and by the time the arm reaches its original position, the gear thus has made two complete revolutions.

The revolutions of the gear *B* cannot be used in practical work without other gearing, to transmit them to axial rotation entirely, and for convenience, in practice, bevel gears are used. The simplest form of differential motion finds its use in the construction of the ordinary hand yarn reel, a diagram of such a gearing being shown in Fig. 202. In the reel, the gear *A* is fastened to a horizontal shaft *B*, and drives a bevel

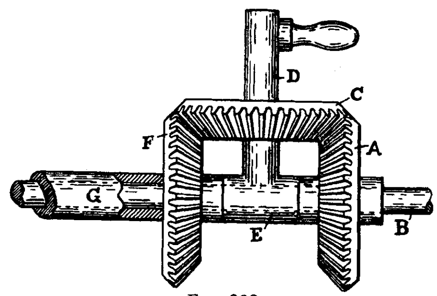

FIG. 202.

gear *C* which is loose on the arm *D*, this arm having a collar *E* at its lower end, which fits loosely on the shaft *B*. The gear *C* drives a bevel *F* which is on a loose collar *G*, on the other end of which is secured the reel (not shown). When the arm *D* is rotated by its handle, for every revolution the bevel *F* is revolved twice, or in other words the reel revolves twice as fast as the handle.

The gears in the explanation thus far given have all been considered with the same number of teeth in them for simplicity, but any numbers may be substituted without altering the principle on which they are figured, although the answer of course will be different to suit the changes made in the number of teeth.

For example, say the gear *A* in Fig. 201 contains 50 teeth, while the gear *B* contains 20 teeth. With gear *A* stationary, when the arm *D* makes a revolution, gear *B* will make $\frac{50}{20}$ axial revolutions and one bodily revolution, or $\frac{50}{20} + 1 = 1\frac{50}{20} = 3\frac{1}{2}$ revolutions. It will be seen later that a great variety in the number of gears used may be had and also in their disposition in relation to each other. Simple carriers may also be introduced, which is a common occurrence, and in which case they do not affect the value of the train except to change the direction of rotation.

When it comes to figuring out a differential motion, a variety of methods may be used, some based on the analysis or simply following out the action of each gear, while other methods make use of certain formula to arrive at the final result. In differentials where several motions are used, the motions of the gears must be found in relation to each other, or we must ascertain the "relative" motion of the gears; by which we mean, if a gear is revolving at a certain speed in one direction and another gear is revolving at a definite speed in the same or opposite direction, what is the speed of the first gear with reference to the second? This is simply one example to illustrate "relative" motion, because any combination of motions may be had and the question of relative motion would still be present, or one gear may be stationary while the other revolved and still have relative motion. For example, suppose the gear *A* in diagram Fig. 201 is stationary, then although it has no absolute motion in relation to the other stationary parts, yet when compared with the movable arm *D*, it has a "relative" motion and which is opposite to the absolute direction of said arm *D*.

Relative motion is not confined to gearing alone, and a good example of this relative motion is found in the case of a train. A person on the moving train is given the impression that objects outside are moving in the opposite direction at a speed equal to that of the train, but while there is no "absolute" motion of the objects, yet there is a "relative" motion between them and the train, which is a similar motion to that found in the differential motion. This illustration may be carried further by considering two trains on parallel tracks, running in the same direction, but at different speeds, and again running in opposite directions. The relative speed of either train is obtained by subtracting the speed of one train from the one from which the relative speed is to be taken. A minus quantity simply indicates an opposite direction to the plus sign, which is always understood when no other sign is present.

The relative speeds of gears in the differential are obtained by the same rule, and thus the "relative" speed of the gear *A* with reference to the arm *D* in Fig. 201, equals the speed of itself minus the speed of said arm *D*. The relative speed of gear *B* with reference to arm *D* is obtained by subtracting the speed of said arm *D* from that of the gear *B*.

This gives the basis for the formula derived, which is gotten by substituting letters for the different items.

We will call the gear *A* the first wheel in the train of gears and consider that it makes "**m**" revolutions per minute.

The last gear *B* will make "**n**" revolutions per minute.

The arm *D* will make "**a**" revolutions per minute.

Let "**e**" equal the value of the train of gears; that is, the number of revolutions which the last gear is capable of transmitting. This value "**e**" of the train is obtained by dividing the relative speed of the gear *B* or last wheel by the relative speed of the gear *A* or first wheel.

From the rule given, to find the relative speed of the gear, we have:

For the gear *A*, relative speed $= \mathbf{m} - \mathbf{a}$ revolutions;

For gear *B*, relative speed $= \mathbf{n} - \mathbf{a}$ revolutions.

Therefore the value of the train would be expressed thus:

$$\mathbf{e} = \frac{\mathbf{n} - \mathbf{a}}{\mathbf{m} - \mathbf{a}}$$

This formula may be expressed in different forms, convenient to the data at hand; as for instance, say we have the values of "**e**", "**n**", and "**a**" and wish to find the value of "**m**", then:

$$\mathbf{m} = \frac{\mathbf{e\,a} + \mathbf{n} - \mathbf{a}}{\mathbf{e}}$$

If "**e**", "**m**" and "**a**" are given, and we want to find the value of "**n**", we have:

$$\mathbf{n} = \mathbf{a} + \mathbf{e\,m} - \mathbf{e\,a}$$

When "**e**", "**m**" and "**n**" are given and we wish to find the value of "**a**", we have:

$$\mathbf{a} = \frac{\mathbf{n} - \mathbf{e\,m}}{1 - \mathbf{e}}$$

It was mentioned in connection with the gearing for the yarn reel Fig. 202, that the gear *F* made two revolutions while the arm *D* carrying the bevel *C* made one revolution, which may be also proved by substituting the proper numbers in the formula.

For example, say that the number of teeth in the gears are the same, as previously stated, the gear *A* is fixed and the arm *D* is given one revolution.

Since the gears are equal, the value of "**e**" = 1, because one divided by the other equals 1. The gear *A* is stationary so that its number of revolutions "**m**" = 0; the arm *D* has one revolution, or "**a**" = 1, then the question is to find the number of revolutions of the gear *F* or "**n**".

It may be mentioned at this point that when the last gear revolved in the same direction as the first gear, the value of the train or "**e**" is always positive or plus, and when it is opposite in direction from the first gear, the value of "**e**" is negative or minus. In this case of the reel, the directions are opposite and therefore "**e**" = — 1.

From the formula we found:

$$\mathbf{n} = \mathbf{a} + \mathbf{e\,m} - \mathbf{e\,a}$$

Now substituting the values of the letters, we have:

$$\mathbf{n} = 1 + (-1 \times 0) - (-1 \times 1)$$

$= 1 - 0 + 1 = 2$, or the gear *F* makes two revolutions under the conditions named.

Any other conditions may be taken and by using the proper formula for the quantity desired, it may be calculated in a similar manner as the example just taken. We will now take up the different styles of differential motions, and make the calculations for them.

Holdsworth's Differential.—This motion was invented by Aza Arnold, of Providence, R. I., in 1823, and is shown in detail in Fig. 203, the same motion having been previously given in connection with the diagram of gearing in Fig. 200. It is also known as the "Sun and Planet" motion, "Compound," or "Jack in the Box," these names being given to it from the character of the motion, it being used in connection with the fly frames as built by the Saco and Pettee Machine Shop, the Lowell Machine Shop and the Providence Machine Co. Referring to the illustration Fig. 203, *A* indicates the main shaft of the machine, to which is secured a bevel gear *B* by means of a set screw. This gear *B* drives the bevel gears *C* and *D* which are on studs as secured on the inside of the gear *E*, or sun wheel as it is sometimes called. This sun

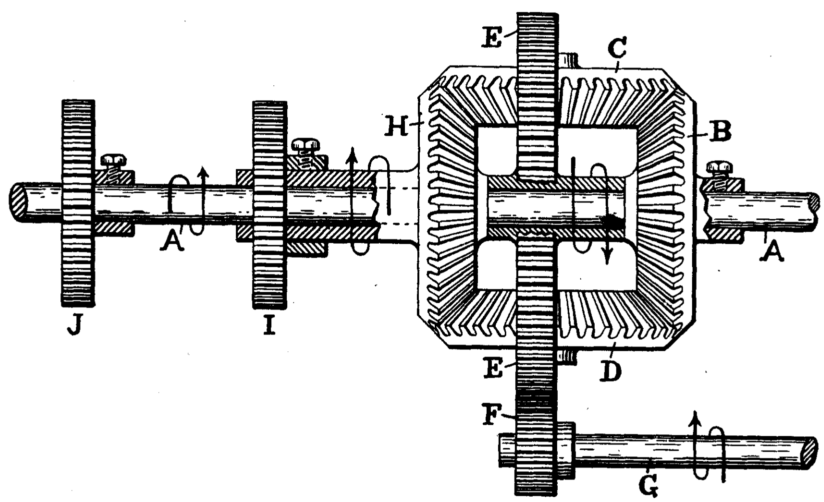

FIG. 203.

wheel *E* (corresponding to the arm *D* in Fig. 201) is loosely collared on the shaft *A*, so that it may receive rotation independent of the main shaft *A*, from the gear *F* as secured on the shaft *G*, which is driven through gearing from the bottom cone of the machine. It will be understood that the bevels *C* and *D* are free to rotate about their own axis, apart from any bodily revolutions which they may receive from the rotation of the sun wheel *E*. The gears *C* and *D* are also in mesh with a bevel *H*, which is on a collar, loose on the shaft *A*, said collar also carrying a gear *I*, which, through proper gearing, drives the bobbins. The gear *B* which is fast on the shaft *A* is used to drive the bobbins at a speed to correspond to that of the spindles which are driven from the main shaft also, through the gear *J* and the other gearing previously explained, while the excess speed, and which must come through the cones, is transmitted through the rotation of the sun wheel *E*; and it is the combination of these two motions which will be worked out in a practical manner.

When the sun wheel *E* is held stationary and the gear *B* is revolved in a positive direction, the gear *H* is caused to revolve in the opposite direction to said gear *B*, a feature which is easily traced from the illustration. By revolving the sun wheel *E*, the speed of the gear *H* may also be increased or decreased, according to the direction of rotation of said sun wheel *E*, by means of the gears *C* and *D*. It is only necessary to use one of these gears for transmitting the motion, but the other is used to counterbalance the weight of the first gear.

The amount of variation given to gear *H* may be seen by a few examples.

Say the gear *B* on the main shaft *A* is given "**m**" = 400 revolutions per minute, and the sun wheel is given "**a**" = 400 = the same number of revolutions, in the same direction; then to find the number of revolutions "**n**" which the gear *H* will receive, we have:

$$\begin{aligned} \mathbf{n} &= \mathbf{a} + \mathbf{e\,m} - \mathbf{e\,a} \\ &= 400 + (-1 \times 400) - (-1 \times 400) \\ &= 400 - 400 + 400 \\ &= 400 \text{ revolutions.} \end{aligned}$$

Hence all three gears would revolve at the same speed and in the same direction, just as if the teeth were locked to each other.

We have thus seen what would occur if the sun wheel were stationary, that is, gear *H* would make the same number of revolutions as *B*, but in the opposite or minus direction.

Now say that the sun wheel is revolved at half the speed of the gear *B*, then from simple reasoning, taking the two speeds just found into consideration, the gear *H* should remain stationary or have 0 revolutions.

$$\begin{aligned} \mathbf{n} &= \mathbf{a} + \mathbf{e\,m} - \mathbf{e\,a} \\ &= 200 + (-1 \times 400) - (-1 \times 200) \\ &= 200 - 400 + 200 \\ &= 0 \text{ revolutions.} \end{aligned}$$

By giving the sun wheel one half the number of revolutions of gear *B* in the same direction, the gear *H* will be driven in the same direction but at a decreased speed, and by giving said sun wheel less than half the number of revolutions of *B*, we drive the gear *H* in the opposite direction at a decreased speed.

These speeds would of course be impracticable in the fly frame, since it would put too much work on the cones and prevent the gear *B* from performing the work for which it was intended. This trouble is gotten over very easily by simply revolving the sun wheel *E* in the "opposite" direction to the gear B, and while the gear H will be driven in the opposite direction from B it will make no difference except to cause a slight increase in friction between the shaft and collar.

Say that the sun wheel is given as 400 revolutions in the opposite direction from gear B, then we have:

$$\mathbf{n} = \mathbf{a} + \mathbf{e\,m} - \mathbf{e\,a}$$
$$= -400 + (-1 \times 400) - (-1 \times -400)$$
$$= -400 - 400 - 400$$

$= -1200$ revolutions, in which case the minus sign indicates the opposite or minus direction. A number like that would be too large for the purpose of winding, and is only given to show how the speed may be increased by simply reversing the direction of rotation of the sun wheel.

By giving the sun wheel the least amount of motion in the opposite direction from B, the gear H will be driven at a speed of over 400 revolutions and which is the condition desired for winding, as will be seen later. In making the calculation for the differential motion, the cone gear is the unknown quantity, since the proper winding of the roving depends upon the speed of the sun wheel and which is driven through the cone gear, so that we first have to find how fast the sun wheel must revolve, in order to wind properly, and then we calculate the correct cone gear to give the desired number of revolutions to the sun wheel. It is only necessary to take into consideration the conditions for beginning the bobbin, since the cones will take care of the bobbin after it is begun correctly.

For the purpose of calculating, we will refer again to diagram Fig. 200, in connection with the following data:

Diameter front roll = $1\frac{3}{16}$ inches.
Diameter empty bobbin = $1\frac{9}{16}$ inches.
Diameter top cone (at beginning of set) = 6 inches.
Diameter of bottom cone (at beginning of set) = 3 inches.
Speed of main shaft (B) = 350 revolutions per minute.

We will first find the length of roving delivered per minute by the front roll. Starting from the main shaft, we have:

$$\frac{350 \times N \times X \times 1\frac{3}{16} \times 3.1416}{P \times Y}$$ and substituting gearing in connection with our diagram thus: N = 32, P = 39, X = 71 and Y = 130, we have:

$$\frac{350 \times 32 \times 71 \times 1\frac{3}{16} \times 3.1416}{39 \times 130} = 585.13 \text{ inches per minute.}$$