stock is carded the clothing can be adapted to it; but where several kinds and qualities of wool are used, it is best to have the wire fine enough to handle the best quality of wool and the coarser kinds will not be injured, neither will the clothing with proper care.

Two gauges are commonly used for determining the number, or size, of wire; namely, the English, or Birmingham, and the American, or Brown & Sharpe. Table I shows the comparative sizes of the two systems. The card gauges used for determining the proximity of one roll of a card to another, such as the setting of the workers to the main cylinder, are also based on the same system as wire gauges.

The standard sizes of wire used on woolen cards are usually No. 33 wire, American gauge, for first breaker, No. 34 wire, American gauge, for second breaker, and No. 35 wire, American gauge, for finisher card. The fancy on each card is usually made one number coarser and the wire set more open. Doffers are sometimes covered with wire one number finer, while tumblers are usually clothed with coarser wire. This depends on the carder and is usually designated when ordering the cards.

3. The wire teeth are placed through the foundation by a machine that automatically cuts the wire and bends it in the form of a staple, pierces the holes in the foundation, thrusts the wire through, and then makes the knee, or forward bend. The wire is not passed straight through the foundation but at an angle opposite to that of the forward inclination of the tooth; this angle is very slight and serves to offset the bend at the knee of the tooth. This is shown in Fig. 1, which also shows the forward bend of the wire. The wire passes through the leather foundation *a* at an angle and is bent forwards again at the knee *b* until the point *c* touches the perpendicular *de*, which is drawn from the point where the wire issues from the foundation.

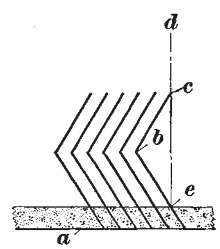


FIG. 1

The tooth should not be bent forwards past the perpendicular to any great extent; for if it is, the point will rise when the strain comes on the tooth, owing to the arc in which the tooth moves, as the wire is not held perfectly rigid, but a certain amount of play is allowed, owing to the flexible nature of the foundation and of the wire. Thus, if the tooth is inclined forwards past the perpendicular line, the strain on it when carding will raise its point and make the setting of the card closer; that is, the slight raising of the point will have the same effect as setting the rolls nearer to each other. On the other hand, if the point of the tooth just reaches the perpendicular, any strain on the tooth will have the effect of depressing the point; this will increase the distance between the rolls or make the setting more open, thus easing the strain.

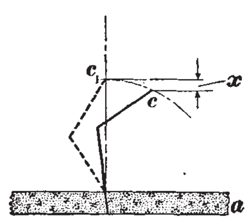


FIG. 2

In order to make this clear, reference is made to Fig. 2; if the tooth were pushed from c to c_1, its point would be raised the distance x, which in some cases might be sufficient to put it in contact with another roll. Besides, there is a tendency of the tooth to straighten at the knee, which will also have the effect of raising the point.

4. Clothing for Workers and Strippers.—Fig. 1 shows the general proportions of clothing suitable for the workers and strippers of a woolen card. It will be noticed that the distance between the knee and the foundation of the clothing is just a trifle shorter than that between the point of the tooth and the knee. This is about the right place for the forward bend of an ordinary working tooth to commence. The nearer the knee is to the point of the tooth, the stronger will be the clothing and the more tenaciously will it hold the fibers of the stock; on the other hand, the nearer the knee is to the base of the tooth or the foundation of the clothing, the more flexible will be the clothing and the more will its action resemble that of a brush.

5. Clothing for the Fancy.—Fig. 3 shows a section of a piece of card clothing such as is used for covering the fancy. The wire is longer than the ordinary tooth and more flexible, and the knee is lower, because the fancy is set into the teeth of the main cylinder and acts as a brush. The knee is often made even lower than is shown. It will be noticed that the point of the tooth of the fancy clothing in the illustration projects beyond the perpendicular. This is not a disadvantage unless the bend is extreme, for as the teeth on this roll do not engage with the wool, there is no danger of the point of the tooth being lifted, owing to the direction of rotation and surface speed of the fancy; however, if the bend at the knee is extreme, the fancy will pack the main cylinder with wool.

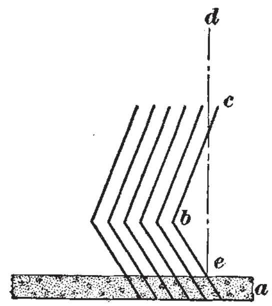


Fig. 3

Straight wire is sometimes used for the fancy, but it often has a tendency to make a large amount of flyings by throwing the wool from the cylinder, especially if the clothing is applied with considerable tension and the fancy is not speeded just right.

SHEET AND FILLET CLOTHING

6. There are, generally speaking, two varieties of card clothing—*sheet* and *fillet*, or *filleting*. The sheet clothing is manufactured in sheets 5 inches wide and as long as the width of the card on which they are to be used. Fillet clothing is made in long, continuous strips, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, or 2 inches wide; it is wound continuously around the roll to be covered.

Sheet clothing is commonly used on the main cylinders, while filleting is used for all other rolls of the card, except those covered with metallic clothing and the finisher doffers, which are covered with rings of clothing that are slipped on and spaced evenly apart. The finisher cylinder is sometimes covered with filleting, which is to be preferred. The teeth are set into sheet clothing so that their crowns—the parts of the teeth on the back side of the clothing—are *twilled;* that is, they are set in diagonal lines like a piece of twilled cloth. Sometimes sheet clothing is made *plain set*, that is, with the crown of the teeth overlapping in the same manner as bricks are laid; although this form has been extensively adopted in England, it is not generally used in America. Here most of the cards are clothed with 8-crown twilled clothing. Fillet clothing is always *rib-set;* that is, the teeth are so inserted through the foundation that the crowns form ribs on the back running lengthwise of the fillet; the teeth in

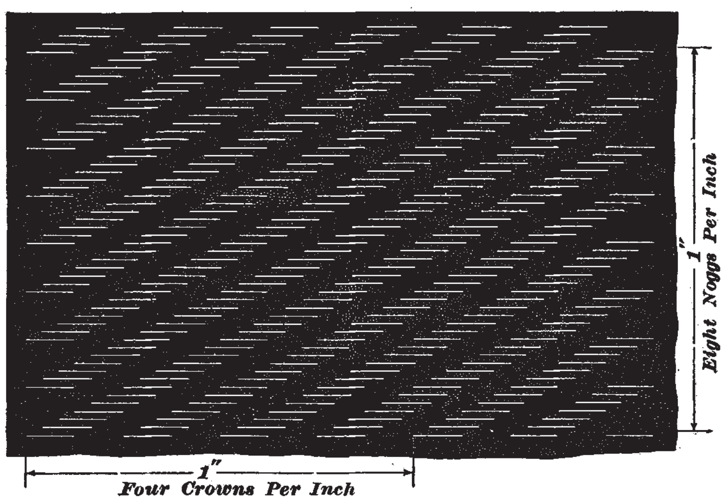


FIG. 4

rib-set clothing may be either twill set or plain set. To find the **crown** of a piece of clothing, the number of crowns, or backs, of teeth in 1 inch of two rows should be counted. Therefore, 8-crown clothing would contain 4 crowns per inch across the clothing, but there would be eight points per inch in one row on the face of the clothing, as there are two points to every crown. The piece of sheet clothing shown in Fig. 4 is 8-crown clothing, having 4 crowns per inch. Fancy clothing is more open, being usually set with 4 crowns for fillet 1½ inches wide.

7. The **nogg** is the distance between the first tooth of one line of twill and the first tooth of the next line; thus, if as in Fig. 4 the clothing has a 6-twill, there are 6 teeth per nogg. If more points per square foot are wanted, the number of noggs per inch is increased; if less points are desired, the number of noggs is reduced. The noggs run crosswise of the sheets of sheet clothing and lengthwise of the strip of fillet clothing. After either sheet or fillet clothing is applied to the card, the noggs always run around the rolls, while the crowns extend from side to side of the card.

CALCULATIONS

8. To find the number of points per square foot in card clothing:

Rule.—*Multiply the number of crowns per inch by the number of noggs per inch, by the number of teeth per nogg, by the number of points per tooth* (2), *and by the number of square inches in a square foot* (144).

EXAMPLE.—Find the number of points per square foot in the sample of card clothing shown in Fig. 4, the number of crowns per inch being 4, the number of teeth per nogg 6, and the number of noggs per inch 8.

SOLUTION.—

Number of crowns per inch . . .	4
Number of noggs per inch . . .	8
	32
Number of teeth per nogg . . .	6
	192
Number of points per tooth . . .	2
	384
Number of inches per square foot	144
	1536
	1536
	384
	55296 points per sq. ft. Ans.

When the number of points per square foot is divided by the number of noggs per inch, it will be noticed that, with

8-crown clothing (4 crowns per inch), each nogg increases the number of points per square foot by 6,912, thus: $\frac{55296}{8} = 6{,}912$. From this it will be seen that in order to find the number of points per square foot in 8-crown (4 crowns per inch) sheet clothing, it is only necessary to multiply the number of noggs per inch by 6,912.

Fig. 5 shows a piece of 1½-inch rib-set fillet that is made 8-crown, the same as sheet clothing; however, fillet clothing

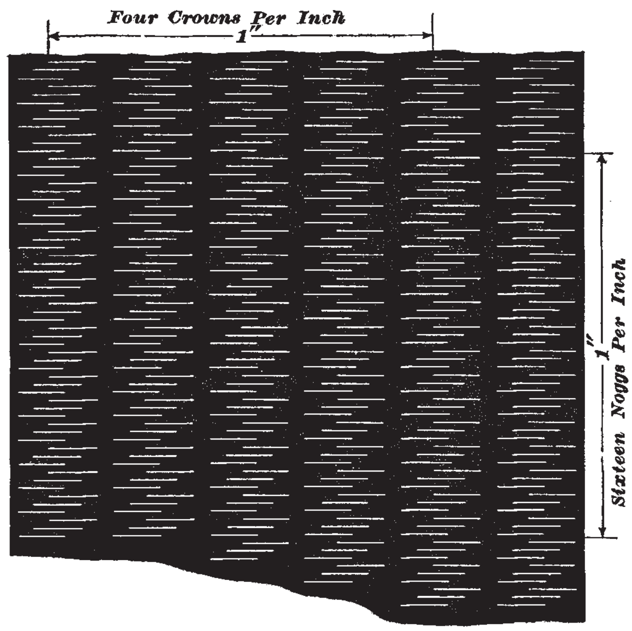


Fig. 5

is set for the same size of wire with twice the number of noggs per inch and one-half the number of teeth per nogg.

9. The rule for finding the number of points per square foot in fillet clothing is the same as for sheet clothing.

Example.—If the fillet shown in Fig. 5 has 4 crowns per inch, 16 noggs per inch, and 3 teeth per nogg, what is the number of points per square foot on the face of clothing?

SOLUTION.—

Number of crowns per inch . . .	4
Number of noggs per inch . . .	16
	64
Number of teeth per nogg . . .	3
	192
Number of points per tooth . . .	2
	384
Number of inches per square foot	144
	1536
	1536
	384
	55296 points per sq. ft. Ans.

When the number of points per square foot is divided by the number of noggs per inch, it will be noticed that each nogg in 8-crown fillet clothing increases the number of points per square foot by 3,456. From this it will be seen that in order to find the number of points per square foot in 8-crown fillet clothing it is only necessary to multiply the number of noggs per inch by 3,456.

The following tables show the number of points per square foot for different-sized wire that are regarded as the standard number for 8-crown clothing (4 crowns per inch) and orders for any number of wire are usually filled by manufacturers in accordance with them:

TABLE II

SHEETS

No. of Wire	Noggs per Inch	No. of Points per Square Foot
28	5	34,560
30	6	41,472
32	7	48,384
33	8	55,296
34	9	62,208
35	10	69,120
36	11	76,032

TABLE III

FILLETING

No. of Wire	Noggs per Inch	No. of Points per Square Foot
28	10	34,560
30	12	41,472
32	14	48,384
33	16	55,296
34	18	62,208
35	20	69,120
36	22	76,032

TABLE IV

FANCY FILLETING

No. of Wire	Noggs per Inch	No. of Points per Square Foot
28	10	23,040
30	11	25,344
32	12	27,648
33	13	29,952
34	15	34,560
35	16	36,864
36	17	39,168

CARE OF CARDS

SETTING CARDS

10. The **setting** of cards is the adjustment of one roll to another in order that each roll may have its proper action on the stock as it passes through the card. The various parts of the card are set according to the work that is being run and the condition of the stock when it comes under their action. If a card is set too open, the wool will not be properly carded or opened out; if it is set too close, especially on the first breaker card, where the wool is not so well opened as on the other cards, there is a liability of the fibers being broken or cut and the value of the spinning properties of the wool materially reduced. The setting of the first breaker should be more open than that of the second, owing to its receiving the stock in almost its natural condition and having to perform the first opening of the wool fibers; as the wool is being constantly opened the finisher may be set closer than the second breaker.

11. Gauges.—Formerly it was customary to set cards by the eye and ear alone, but owing to the fact that the light struck at varying angles on the card clothing, the settings

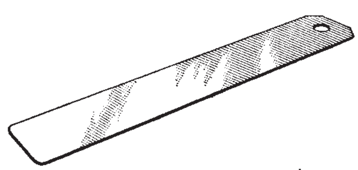


FIG. 6

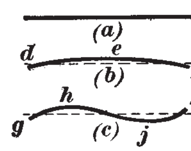


FIG. 7

were never really accurate. The setting is now accomplished by means of **gauges**, shown in Fig. 6; these are flat strips of tempered steel about $1\frac{1}{4}$ inches wide, 7 or 8 inches long, and varying in thickness according to a given standard. They should be accurate and when made by a reliable maker will be found to be of uniform thickness. The standard adopted for their thickness is the same as that used for the standard sizes of wire, so that the thickness of a No. 30 gauge is the same as the diameter of a No. 30 wire.

Although the most exact settings are obtained by means of card gauges, after being used for some time almost all gauges are found to have been bent crosswise and, instead of being perfectly flat, as shown in Fig. 7 (*a*), they become shaped as shown in Fig. 7 (*b*) and (*c*) and, consequently, touch at points *d*, *e*, and *f* in Fig. 7 (*b*) and *g*, *h*, *j*, and *k* in Fig. 7 (*c*).

While the thinner gauges, if bent in the shapes shown in Fig. 7 (*b*) and (*c*), will straighten somewhat when introduced between the rolls of the card if a tight fit is obtained, it has been found from numerous observations and tests that the thickness of the gauge is always exceeded. The thicker gauges, such as Nos. 24 or 26, when bent as shown in Fig. 7 (*b*) and (*c*), scarcely yield at all when used in setting and a large percentage of error is consequently introduced. This will cause the parts of the card to be set farther from each other than the indicated thickness of the gauge. Home-made or damaged gauges are never accurate, and should not be used except for feed-rolls or burr cylinders.

12. The points at which the distance between the rolls of the woolen card need to be adjusted, or set, are the following: Between the top and bottom feed-roll; between the burr cylinder, or licker-in, and feed-rolls; between the burr cylinder, or licker-in, and the burr guard, or licker-in fancy; between the burr cylinder, or licker-in, and the tumbler; between the tumbler and the main cylinder; between the main cylinder and the strippers; between the main cylinder and workers; between the workers and strippers; between the main cylinder and fancy; between the main cylinder and the doffer or ring doffers; between the doffer and the doffer comb. On the condenser the setting of the wipe roll to the doffers and the proximity of the rub aprons must also be regulated.

The setting of the various parts, as designated above, must necessarily vary according to conditions. The length of the fiber is one important element; the longer the fiber, the more open must be the settings. Then, again, the condition of the wool as it comes to the first breaker must be considered; if it is matted, the setting must be more open on the first two or three workers of the first breaker in order not to bend the clothing by trying to open out the stock at once. With such stock it is sometimes a good plan to set the workers progressively on the first breaker, but if the stock is well opened and lofty the card may be set close.

Although the first breaker must be set more open than the other cards, it must not be set too open, because when the wool leaves the first breaker it must be well carded, as it is on the condition of the wool, when it leaves this card, that the ultimate result of the carding largely depends. The carder, therefore, is always careful of the first breaker and sees that it turns out the stock in a lofty sliver, free from specks or neps as far as possible; otherwise, a great amount of additional care on the second breaker and finisher cards will be required.

The second breaker card is always set finer, or closer, than the first and the finisher closer than the second breaker, in order to card the stock thoroughly fiber from fiber. After each carding, the wool is more open and separated, and thus allows closer adjustments of the working parts without breaking the fibers of wool.

Before setting the card care should be taken to have all belts in place, for if the card is set with the belts off, the settings will be disturbed when they are placed in position. When setting workers and strippers, care should be taken to remove any dirt or flyings from between the bearing and the shaft, if an open bearing is used.

Only one end of a gauge is ground accurately to the indicated thickness, so that in setting the different parts of the card to each other the opposite end, which is the one with the hole in it, should be grasped and the gauge inserted between the rolls for a distance equal to barely one-half of its length. It should then be moved slowly back and forth across the card and the proximity of the rolls varied until a correct setting is obtained.

One side of the card should be set first, regulating the distance between the rolls so that the gauge will slip between them readily, neither binding nor being too loose, but simply requiring an easy but firm pressure to move it along between the rolls. Then the other side of the card should be set in the same manner.

After both sides of the card are set, the side that was adjusted first should be gone over again, as the setting of the other side of the card always disturbs the original setting more or less. On very particular work some carders go over a card several times.

AVERAGE SETTINGS

13. Setting the First Breaker.—Although the setting of the card depends largely on the stock being carded and the judgment of the carder, the following will be found to be average settings of ordinary woolen cards on from 4- to 6-run work. The adjustable bearings of the rolls of a card, except the workers and strippers, are carried on slides and are adjusted by means of screws that have circular heads with holes drilled in them. In order to turn the screw a small *set* is inserted into the hole and the screw turned, after the bolts that hold the bearings have been loosened. The adjustment screws are usually provided with check-nuts. For setting the feed-rolls of the first breaker to each other and for setting the burr cylinder to the feed-rolls and also between the burr cylinder and tumbler and between the burr cylinder and burr guard a coarse gauge, about No. 22 or 24, is generally used. This gauge is kept for this purpose and is usually an old or damaged one, as setting burr cylinders and feed-rolls injures the gauges. The setting of these parts is not so important as that of the working parts, such as the tumbler, workers, strippers, doffer, etc., to the main cylinder, which may be set with a No. 26 gauge. The doffer should be set slightly closer to the main cylinder. This may be done by pressing it tighter on the gauge when setting or by using a finer gauge. Although the fancy is usually set by ear alone, it is better to use a gauge and judge the depth of the setting by the pressure required to force it between the fancy and the main cylinder. The teeth on the fancy should dip slightly into the teeth on the main cylinder, probably about $\frac{1}{32}$ inch, although this is never measured; the fancy is set and then turned by hand, its depth being judged by the whiz it makes in rubbing through the clothing of the cylinder. The fancy usually needs adjustment after the card is running, in order to make it handle different stock successfully, being set either off or on as the occasion demands. The doffer comb should be set as close to the doffer as possible without striking.

14. Setting the Second Breaker.—The second breaker is set similar to the first except that the setting is closer, being set to about a No. 28 gauge throughout. The feed-roll stripper in the second breaker should be set quite close so as to keep the top feed-roll clear. The licker-in fancy should be set so as to dip slightly into the licker-in wire in order to keep it clean and clear from short fibers of wool.

15. Setting the Finisher Card.—The finest settings are made on the finisher card when a No. 30 gauge is used. The ring doffers of the finisher should be set very close to the main cylinder in order to strip the stock thoroughly from the cylinder. A No. 32 gauge is often employed for setting the ring doffers.

16. Setting the Condenser.—The wipe roll of the condenser is usually set to the ring doffers with about a No. 22 gauge. The teeth in the gear on the end of the wipe roll should intersect about half their depth when the wipe roll is set to the aprons. The distance between the under side of the wipe roll and the top of the bottom rub apron should be sufficient to allow the roving to clear properly, since if this distance is not great enough the vibration of the rub apron will rub the roving against the surface of the wipe roll, which does not vibrate, and thus cause the roving to be split. The wipe roll should be as close as possible to the top apron and still not touch it. These points should be carefully noted, for if either of the vibrating rub aprons come in contact with the wipe roll, twitty roving will be made.

The distance between the rub aprons on the Davis & Furber double-apron condenser is regulated by small slotted pieces of sheet iron that are slipped between the bearings of the apron rolls and the frame of the condenser. These packings are usually one of two thicknesses, $\frac{1}{16}$ inch or $\frac{1}{8}$ inch, but the $\frac{1}{8}$ inch packing is ordinarily used. For coarse wool, both packings are placed in position so that the space between the rub aprons is about $\frac{1}{32}$ inch. For medium work, the packing on the lower rub apron is removed so that the space at the front of the top and bottom rub aprons is about $\frac{5}{32}$ of an inch; this allows a slightly less rubbing action. For fine work where a less amount of rubbing action is required, both packings are removed so that a space of about $\frac{9}{32}$ inch is left between the top and bottom rub aprons at the front, while at the back part of the aprons a slight rubbing action is given. The pair of rub aprons of each deck nearest the ring doffers are generally adjusted so that there is a uniform distance or about $\frac{1}{32}$ inch between them. The throw of the eccentrics that cause the vibrations of the rub aprons should be so adjusted as to be slightly in excess of the width of the rings on the doffers. For instance, if the rings on the doffers are 1 inch in width, then the throw of the eccentrics should be adjusted so as to be about $1\frac{1}{16}$ inches.

The amount of rubbing that is imparted to the stock can be varied by altering the speeds of the eccentrics. The faster the aprons are made to traverse, the greater will be the rubbing action. Defective work is often made by the speed of the eccentrics being so slow that the ribbons of wool cannot be rubbed into roving by the rub aprons as fast as they are delivered by the wipe roll. When using a condenser with screw adjustments, both sides of the aprons should be carefully set, in order that no variation in the distance between the aprons at each end shall exist.

17. Setting Workers and Strippers.—The method of setting the workers and strippers will be readily understood by referring to the illustration of the first breaker in *Woolen Carding*, Part 1. In this illustration, the poppet heads that carry the shafts of the strippers and workers extend through sleeves attached to the arch of the card and also pass through a flange on the arch, being held in position by two check-nuts, one on each side of the flange. In order to set the worker or stripper closer to the main cylinder, the top checknut should be loosened and the bottom nut tightened. To set the worker or stripper farther from the main cylinder, the bottom nut should be loosened and the top nut tightened.

When setting workers and strippers or other rolls to a cylinder covered with sheet clothing, the cylinder should be moved so that the adjustment will take place at the center of a sheet and not on the edge, because nearly all sheets are slightly higher in the center and if the worker is set on the edge of the sheet there is some liability of contact with the highest part of the sheet. Sheets are apt to grow higher in the center as the clothing wears and is stretched by the strain during carding. This tendency is aggravated by the centrifugal force of the rapidly rotating cylinder, which tends to throw the clothing away from its center, especially if it is loose.

The sleeves through which the supports for the worker bearings pass are larger than the sleeves through which the supports for the stripper poppet heads pass and allow a lateral movement for adjusting the worker to the stripper. This movement is governed by two screws that are threaded into the sleeve and press against the support of the worker bearings. After the proper adjustment is obtained, both screws should be carefully tightened.

18. Setting the Doffer.—In setting the doffer, the fancy may be taken out in order that a clear view may be had and the distance accurately gauged all the way across. The main cylinder, as well as the doffer, should be turned into various positions and at each movement carefully tried with the gauge, so as to be perfectly sure that when the card is in operation there will be no contact between the two. It is important when setting the doffer to have the worker belt in position, for if this is neglected it may raise the doffer slightly in its bearings, and so bring the doffer too close to the main cylinder and destroy the points of both.

19. Setting the Fancy. — More trouble is usually experienced with the fancy than with any other part of a woolen card. The fancy is the only roll of the card that is set with the belt off. This is necessary, because, in setting, the fancy is made to revolve by hand and the depth of the setting judged by the sound produced by the fancy wire passing through the cylinder clothing. After it has been set and the stock is on the card, it is often necessary to change its setting, for if not properly set for a given stock, the fancy will either throw the stock out of the card or else choke up, or lap; or it may pack the main cylinder. When the fancy is throwing the stock, it is usually set too hard into the cylinder or else is speeded too fast, or the teeth may be too straight and stiff. It often laps with wool because its clothing is rough, or because its speed is too slow. When a fancy is working right, the wool is lifted to the points of the cylinder clothing uniformly and thus can be readily taken by the doffer.

The surface velocity of the fancy should only be slightly in excess of the surface velocity of the cylinder. To find the relative surface velocities of the main cylinder and fancy, turn the cylinder over once and count the rotations of the fancy; then multiply the circumference of the fancy by the number of times that it rotates to one turn of the cylinder. The circumference of the cylinder should be to this product as about 4 to 5 if the fancy is speeded right.

20. The settings previously given should not be regarded as absolute, as in woolen carding there is a wide range of variation in card setting, and as no two conditions are the same, no hard and fast rule can be laid down. Some carders set as fine as a No. 32 gauge on the first breaker, No. 33 on the second breaker, and No. 34 on the finisher card, with the ring doffers set to perhaps a No. 35 gauge. This, however, is an extreme case and is only possible when the cards are in excellent condition and the stock very fine. Other carders working on a similar grade of wool may use Nos. 28, 30, and 32 gauges. Again, cards are frequently set much more open, as, for instance, a No. 22 gauge on the first breaker, No. 26 gauge on the second breaker, and No. 28 gauge on the finisher. Much depends on the carder, the previous preparation of the stock, and the condition of the cards; a variation of a point or two in setting is of no material difference, provided that the wool is well carded. The main point to be observed is the condition of the stock as it leaves the card. Take the sliver from the first breaker and pull it apart, holding it toward the light; it can readily be seen whether the card is operating on the wool satisfactorily or whether the sliver is full of specks or neps that are not opened out. The sliver from the second breaker should be examined in the same way and if the wool is not free from specks the cards may be gone over and set closer.

The carder must use judgment in setting his cards and take into consideration the wool being worked and also the number of yarn to be spun. If the setting is too close, the wool is cut or the fiber broken; if too open, the stock is not opened and is liable to be rolled into bunches. The settings should avoid these extremes and yet be as open as possible to card the stock properly; if set finer than necessary, the treatment of the wool is more severe than is needful.

Some carders set progressively; that is, they begin with the first worker in the first breaker card, which is set open; the setting then grows finer until the ring doffers are reached. Such an adjustment might begin with a No. 22 gauge with the first worker and end with a No. 34 between the finisher cylinder and the ring doffers.

In some mills it is customary to set strippers one point finer both to the main cylinder and to the workers. Strippers are never set progressively as above explained, the progression being between the workers and the main cylinders and the main cylinders and doffers, which are the working points of the cards.

STRIPPING CARDS

21. From time to time the clothing of the cards becomes so choked and filled with short fibers, dirt, dust, shives, grease, and other matter that has been removed from the carded wool that the operation of carding is seriously affected; from this arises the necessity of cleaning, or as it is called, **stripping** the cards. Some stock contains much refuse matter and other dirt and quickly fills up the card; other stock, being comparatively clean, will allow the card to run for a much longer time without cleaning. Less cleaning is required, therefore, if the stock is prepared for the cards in the best manner and as thoroughly cleaned of foreign matter as possible.

22. **Time of Stripping.**—The first breaker needs more cleaning than the second breaker card and the second breaker needs more than the finisher, for as the wool proceeds much of the dirt is being constantly removed. Generally speaking, the first breaker should be cleaned every day; in some mills, to economize time, it is customary to clean the main cylinder and doffer one day and the whole card the next. The second breaker may be cleaned every other day, cleaning the cylinder and doffer and the whole card alternately. The finisher card may be stripped twice a week on low stock, cylinder and doffers and all through alternately, and once a week on fine stock. It may be necessary to clean the ring doffers oftener than this. It must be remembered that when the second breaker or finisher card is stopped, the production of the set is also at a standstill. With the first breaker the case is changed as, if there is a sufficient number of balls ahead to supply the second breaker creel, the production will not be checked.

If the plan of cleaning the cylinder and doffer and the whole card alternately is adopted, care should be taken not to clean two cards of a single set all through at the same time in order to avoid making a large number of thin rovings. These when made should be pulled from the jack-spool and placed in the hopper of the first breaker self-feed. Many mills clean the card all through each time, which is the best way, although the alternate plan saves much time and is fairly satisfactory.

It is necessary that the doffer should always be kept clean in order to remove the stock from the main cylinder. In England, it is customary to run a small conditioning roll, called a *dickey*, over the doffer, which keeps the doffer wire clean and in good condition.

The above statements will give some idea of the average time a card will run before cleaning, but no hard-and-fast rule for the cleaning can be laid down. It is customary in some mills to clean the cards periodically whether they require it or not, thereby making unnecessary waste or else allowing the card to run longer than it should without cleaning; a better plan is to look over the cards twice a day and have such cards or such parts as require it cleaned, thus making allowance for different kinds of stock.

23. Method of Stripping.—When the card is to be stripped the belts are thrown off and the stripping performed by means of hand cards. Two men are employed to strip a card, one working on each side of the card, in this manner the work being more advantageously accomplished. The usual method of stripping is as follows:

The belt is first thrown off from the self-feed, if the first breaker is to be cleaned, and the feed-rolls of the card disconnected by means of the small lever that throws the side shaft out of gear. The card is then allowed to run 4 or 5 minutes in order to allow it to clean itself as much as possible. The belts are then removed and the fancy taken from its bearings and placed in a rack, where the dirt is removed from it by means of a hand card or a comb. Two pieces of pipe are used in removing the fancy and the workers and strippers. These are slipped over the ends of the shaft and the roll lifted out of the card by two men without any danger of dropping it, as is otherwise liable to occur owing to the grease on its shaft. Care must always be taken when removing any roll of the card not to damage the clothing, which if bent and bruised will not properly perform its functions.

The last worker is then taken out and placed in the empty fancy box and stripped, after which it is laid either on the floor or, preferably, in a rack. The same process is then carried out with the strippers and the rest of the workers, except that, in some cases, after two workers and two strippers have been removed the rest are stripped in their positions. Sometimes after the last pair of workers and strippers—the pair nearest the fancy, which are the first cleaned—have been placed in the rack, the others are brought back to the fancy boxes and stripped and are then immediately returned to their positions. Care should be taken to replace the rolls in their original positions and not interchange the workers and strippers; their numbers are generally stamped on the shafts by the makers.

The main cylinder and doffer are necessarily stripped in their bearings, as are also the licker-in and tumbler. The licker-in fancy, feed-rolls, and feed-roll stripper should be carefully cleaned, as well as the doffer comb, each time the card is stripped. After the card has been thoroughly cleaned, the rolls should be placed back in position and the belts replaced.

The card may now be allowed to run empty for 4 or 5 minutes, in order to remove loose particles of refuse that may be resting on the surface of the clothing, after which it is a good plan to run over the settings and change such as may be found inaccurate, being careful, however, that there are no particles of waste wool or other substances under the bearings.

The card may now be put in operation and the wool allowed to enter by putting the feed-rolls in gear again, but it must be allowed to run for 4 or 5 minutes after this in order that it may become filled with wool to its utmost capacity and the sliver, or side drawing, attain its original weight before the product of the card is passed on to make roving. If this is not done the rovings made just after stripping will be thin and light and will not spin to the right number of yarn. The weight is apt to be a little light on the card for an hour or two after the stripping, but this of course is not returned to the self-feed but is spun, although perhaps the draft in the mule may have to be changed slightly to make the required number of yarn.

For stripping the ring doffers of the finisher card a special hand card of about No. 34 wire should be used; it should be used only for this purpose. Two men will keep from eight to twelve sets of cards clean, varying of course according to the stock, whether low or fine, and also according to its previous preparation.

GRINDING

24. Although **grinding,** or sharpening, the card clothing is frequently performed too often and at other times continued too long, there can be no doubt that at times the cards need grinding to replace the points of the teeth that have become worn or dull by abrasion or accident. Cards are usually ground too often where hardened and tempered wire is used; more frequent grinding is necessary on cards covered with mild wire, which is soft.

In some districts of Europe it is customary to grind the cards two or three times a month. This is wrong, for if the cards are properly set and cared for, there should be no necessity oftener than once in 3 months, and many times a card will run 6 or 8 months or even a year without grinding. More card clothing is spoiled by grinding too often and by overgrinding than work spoiled by dull cards.

Two kinds of points are obtained by grinding. The **chisel point** is the point put on the tooth by a roller emery grinder that has no traverse. This form of grinder grinds down the top of the tooth to a flat, or chisel, edge, while the traverse grinder, which grinds the tooth on each side as well as on the top, owing to the traverse of the roll, produces what is known as a **needle point.** It must be understood that the term *needle point* does not mean that the wire is pointed the same as a needle or that it is nearly so sharp. The term is simply one of distinction between the flat, or chisel, point and the more rounded point due to grinding the wire on two sides and on the top.

While it is important that the clothing shall be sharp, it is also important that the teeth shall be smooth, since any roughness of the tooth is liable to cause it to catch and break the fibers.

One of the worst things that can happen to clothing is the formation of a **hook,** or **burr, point.** This sometimes happens when the grinding is continued too long or when the grinding roll is pressed too heavily on the clothing, thus turning over the point of the tooth and making a burr on the under side. When clothing is injured in this manner, the wool is with difficulty transferred from one roll of the card to another and the fancy also lifts the stock from the main cylinder with difficulty. When grinding, it is always better to grind lightly and rapidly than to grind slowly and with heavier pressure. Heavy grinding is liable to heat the wire and draw its temper.

IMPORTANT POINTS IN GRINDING

25. The different rolls of the card need varying degrees of attention in regard to grinding; some parts of the card need to be sharper and in better condition than others, which may require only smoothness to perform their functions. The main cylinder of the card after being once ground sharp will keep in good condition for some time, especially if the fancy works properly, since if set into the teeth of the main cylinder to a reasonable depth, it will keep the points of the same smoothness and in good working order by reason of the abrasion of the teeth against each other. The main cylinder needs to be smooth and true rather than extremely sharp, as this latter condition in a measure defeats the action of the workers and of the doffer by having a tendency to hold the stock instead of allowing it to be transferred to those rolls.

The fancy is required to be perfectly true and should be smooth above all, for if the teeth are rough, it has a tendency to throw the stock from the main cylinder, thus making an increased percentage of waste in the form of flyings. Great care should be taken in grinding the fancy, and the grinding roll should only be allowed to touch it lightly, as the long, flexible teeth are liable to injury. After the fancy is ground it should be placed in the card and set well into the main cylinder, about $\frac{1}{8}$ inch. After being allowed to run into the cylinder in this manner for about $\frac{1}{2}$ hour it should be set off to its normal position and allowed to run a little longer. A hand card may be freely sprinkled with oil and held on the fancy while it is running on the main cylinder. By this means both the fancy and the main cylinder are made smooth and put in the best working order. Some fancy clothing, being made with a straight tooth with no bend at the knee, requires especial care in grinding in order that the teeth will not be bent or injured.

Workers must be kept sharp and true in order to card and open the wool, and also in order to take the stock from the main cylinder. The worker should always have a sharper point than the cylinder for this reason. In England, it is customary to set the strippers into the workers until a slight whizzing sound, caused by the contact of the teeth, is heard. The object of this is to keep the worker wire in good condition, the rubbing action of the stripper being to sharpen and smooth the worker. When grinding workers, care should be taken to avoid forming a burr on the wire, the tendency being to overgrind the roll while endeavoring to obtain as sharp a point as possible.

The strippers are simply conveyers of the wool from the workers to the main cylinder and should be kept smooth rather than sharp. Strippers are usually $2\frac{1}{2}$ or 3 inches in diameter and owing to this small diameter, the teeth are spread apart more by being projected from a surface bent around so small a circle. This makes it necessary to exercise

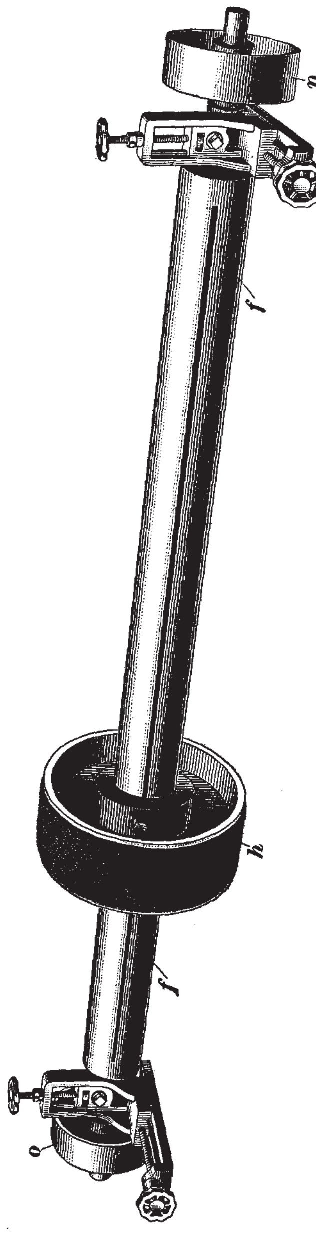


Fig. 8

some care in grinding or the teeth will be bent out of shape.

The doffer is one of the most important parts of the card and should always be kept sharp and in good condition. It should always be smooth as well as sharp and the nearer it is set to the cylinder, the better it will work, provided that there is no contact between the two. The doffer should be sharper than the main cylinder in order readily to take the wool from the latter.

Before grinding, the card should be thoroughly cleaned and all places where the clothing is damaged should be remedied. The bent teeth are raised into position by means of a small steel blade provided for the purpose, or with a jack-knife.

TRAVERSE GRINDER

26. The main cylinder and doffer should be ground at the same time and without being removed from the card, which may be accomplished by means of a **traverse grinder;** the one shown in Fig. 8 is known as the Roy traverse grinder.

Fig. 9, which is a section of this grinder, shows that it consists primarily of a steel shell *f*, on which a sliding, or traversing, grinding wheel *h* is mounted.

Attached to this wheel is a slotted **T** piece *a* that extends through a slot cut the entire length of the shell and, by means of a dog *b* attached to the chain *k*, imparts the traversing motion to the wheel. The dog *b* is really a stud link, since it forms one part, or link, of the chain. The chain is driven by means of the pulley *p*, known as the *traversing pulley*, which is attached to a journal *j* that passes through a sleeve formed in one piece with the head of the shell. Attached to this journal is a bevel gear *e* that drives a gear *d* driving another gear, to which is attached the driving sprocket *c*, around which the chain passes. At the other end of the shell is a flange binder pulley *r* around which the chain passes and which may be adjusted by means of an adjusting screw *n*, in order to take up the slack of the chain when it stretches. A rotary

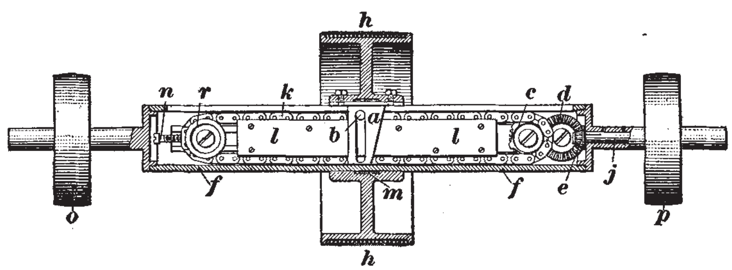


FIG. 9

motion is imparted to the grinding wheel by means of the pulley *o*, which is attached to a shaft forged in a solid piece with the other head of the shell. This pulley imparts motion to the shell; and as the **T** piece projects through the slot in the shell, the motion is also imparted to the grinding wheel. A steel plate *l* guides the chain.

The *grinding wheel* is an iron pulley covered with twine and afterwards having coarse emery glued on it. Special emery fillet is sometimes used for covering grinding wheels and rolls. Covering emery rolls should not be attempted in the mill unless emery fillet is employed, as the work must be perfect and the roll true; otherwise, the grinding will be imperfect. The emery should always be coarse, in order to allow the particles to project into the clothing and to grind the sides of the teeth as well as the top. Grinding wheels are made up to 13 inches in diameter and the larger the wheel within reasonable limits, the better work it will do. In order that the grinding wheel may slide easily on the shell, a chamber *m* is cut around the inside of its hub and a felt washer inserted; this being saturated with oil lubricates the shell as the grinding wheel slides back and forth. The shells for traverse grinders are made 4 or 5 inches in diameter. The 5-inch shell is to be preferred, since the greater the diameter, the less is the tendency of the shell to spring and consequently to make the grinding uneven.

27. Speed.—The traversing pulley *p*, Figs. 8 and 9, should always be driven more slowly than the driving pulley as, both being driven in the same direction, there would be no traverse of the grinding wheel if the speeds of both pulleys were equal. The revolutions of the bevel gear *e* that drives the traverse chain is equal to the revolutions of the driving pulley *o* minus the revolutions of the traversing pulley *p*. In order to make the grinding wheel traverse faster, the speed of the traversing pulley is reduced.

The speed at which grinders are driven varies considerably with different carders, but the following table gives the average speed of the grinding wheel and the number of times that it traverses across the card per minute. The table is made for different widths of cards.

TABLE V

Width of Card or Traverse of Grinder Wheel Inches	Revolutions per Minute of Grinder Wheel	Number of Times Across the Card per Minute
36	375	15
40	365	14
48	340	12
60	300	10
72	275	8

28. Adjusting Device.—After a traverse grinder has been used for some time, the grinding wheel and shell become so worn that the grinding wheel is loose and perfect grinding is difficult to attain. In order to remedy this defect and to afford a method of easily adjusting the size of the hole in the hub of the grinding wheel to the diameter of the shell, the hole in the grinding wheel in the latest machines is bored tapered instead of straight. A tapered, split bushing with a chamber for the felt oiler is inserted into the tapered hole in the grinding wheel; a collar is then screwed on each side of the hub of the wheel up to the bushing. By loosening collar at the small end of the bushing and tightening the one at the large end, the bushing is pressed into the hub of the wheel and, being split and tapered, is contracted around the shell until a proper fit is obtained.

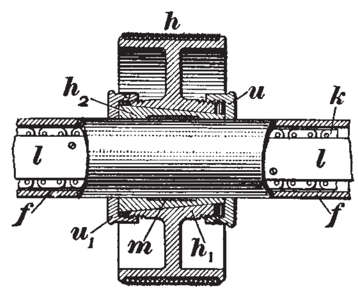


FIG. 10

This device is not shown in Fig. 9, being placed only on the latest models, but it is shown in Fig. 10; h_1 is the hub of the grinding wheel, which is bored tapered, while h_2 is the tapered bushing that fits into h_1 and is held in position and adjusted by means of the threaded collars u, u_1. To tighten the grinding wheel, thus giving less play on the shell, loosen collar u and tighten u_1; loosening u_1 and tightening u has the opposite effect.

29. Operation.—The method of grinding the main cylinder and doffer at the same time by means of the traverse grinder just described is as follows: Referring to Fig. 8, it will be seen that the journals of the shell are carried in adjustable bearings, which may be moved in two directions by means of screws provided with hand wheels, allowing the grinding roll to be set both to the main cylinder and also to the doffer. The doffer, however, is usually set to the grinding wheel instead of the wheel being set to the doffer. The bearings of the traverse grinder are bolted to the fancy brackets when grinding the main cylinder and doffer, the fancy and last worker being removed and placed in a rack in order to allow room for the grinding wheel. Usually, however, the workers and smaller rolls of the card are being ground on the grinding frame (which will be dealt with later) while the main cylinder and doffer are being ground.

When grinding the main cylinder its direction of rotation is reversed, in order to grind against the backs of the teeth. When the card is driven with an open belt, the direction of rotation of the main cylinder may be reversed by crossing the belt, but if the card is driven by a cross-belt, the belt will have to be taken up by means of holes punched in it, and run open. Often an extra belt is provided for driving the cards while grinding cylinders. The doffer should run in its usual direction, but its speed should be increased by putting a pulley on its shaft and driving it from the main-cylinder shaft.

The grinder may be driven from pulleys fastened to the third stripper shaft of the card. A pulley may be placed on each end of the stripper shaft, one for driving the shell and another smaller one for the traversing motion of the grinder. The stripper may be driven from a belt directly from the flange on the main cylinder. Before placing the grinder on the fancy brackets, the doffer should be moved from the main cylinder about 2 inches. The grinder may then be set to the main cylinder until a whizzing sound, caused by the contact of the emery with the clothing, is heard. Each side should be carefully adjusted so that the wire will not be overground on one side. After the grinder has been adjusted to the main cylinder the doffer may be adjusted to the grinder, using the same precautions as before, in order to grind the doffer even.

The doffer should always have the preference over the cylinder and should always be sharper; however, the grinder should not press too hard on the wire or a hook will be formed on the under side. It is better to set the grinder light at first and after the grinding has been going on for an hour set it down a little heavier. The grinding of the cylinder and doffer usually takes from 4 to 8 hours. The wire is tested at intervals to see if it is sharp enough, by means of the thumb, which is pressed against the point. It is also a good plan to examine the wire with a magnifying or pick glass to determine whether the point of the tooth is ground to the proper shape and also to be sure that the point is not turned over and the wire hooked.

It is always best when grinding to stop a little short of the sharpest point possible rather than to put a burr point on the wire. Smoothness should be sought more than sharpness. In case the wire becomes hooked, the defect may be remedied to a certain extent by *facing* the wire or by using a burnishing brush, which is a roll covered with straight clothing set loosely in the foundation. This roll is set to run into the clothing and removes the burr. Facing is a dangerous operation and often results in the ruin of the clothing. The operation consists of running the grinding roll against the points of the clothing and should be done very lightly, only allowing the grinder barely to touch; otherwise, the clothing will be damaged. It is best never to run a grinding roll in this manner.

The traverse of the grinding wheel should preferably be long enough to carry it clear of the clothing on each side. This prevents all possibility of the clothing being ground at the ends of the cylinders more than in the center, which sometimes happens when the motion of the grinding wheel is reversed before it has cleared the clothing, as it then remains in contact with the sides of the clothing for a longer time than with the other parts.

30. Some grinders instead of being driven by means of a chain have a traversing motion imparted to them by means of a reciprocating screw; that is, a screw provided with right-hand and left-hand threads that are joined at each end. In the groove, fits a fork, or traveler, having a stem through the slot in the outer shell in which the screw turns. By means of the stem the grinding wheel is not only rotated by the shell, but a traversing motion is imparted to it by the screw. The fork changes from one thread to the other and reverses the motion of the grinding wheel at each side.

TRAVERSE GRINDING FRAMES

31. The workers, strippers, fancies, and tumblers are not ground in their positions, as are the main cylinder and doffer of the card, but are removed and taken to a machine called a **grinding frame.** This machine, shown in Fig. 11, consists of an iron frame on which is mounted, on suitable bearings, a traverse grinding wheel *h* identical with the one employed in grinding the cylinder and doffer. The grinding frame is arranged to grind two rolls at one time, one on each side of the traversing grinding wheel, the rolls being placed in **V**-shaped notches in the slides *c* that rest on the top of the frame. These slides are adjustable, by means of screws, to the grinding wheel, thus allowing the rolls being ground to be adjusted to the same. The screws are provided with hand wheels *d* for easily adjusting the rolls and also with check-nuts for locking them when once the rolls have been set. Pulleys, setscrewed to the shafts of the rolls to be ground, are driven by means of a belt from the bottom shaft of the grinding frame. The grinding wheel is also driven from the bottom shaft of the frame by two belts, one of which drives the traversing motion of the grinding wheel while the other imparts a rotating motion to it. When putting on the belts before grinding, care should be taken before the rolls are set up to the wheel to see that the directions of rotation are such that the grinding wheel will grind the backs of the teeth on each roll.

Referring to Fig. 11, it will be seen that an adjustable stand *f* also carries slides with **V**-shaped notches; this is for the purpose of grinding shorter rolls that do not have shafts long enough to rest in the bearings on each side of the machine. Inside of the frame of the grinder there is a small emery-covered roll *g* for grinding hand cards; this is driven from the main or bottom shaft.

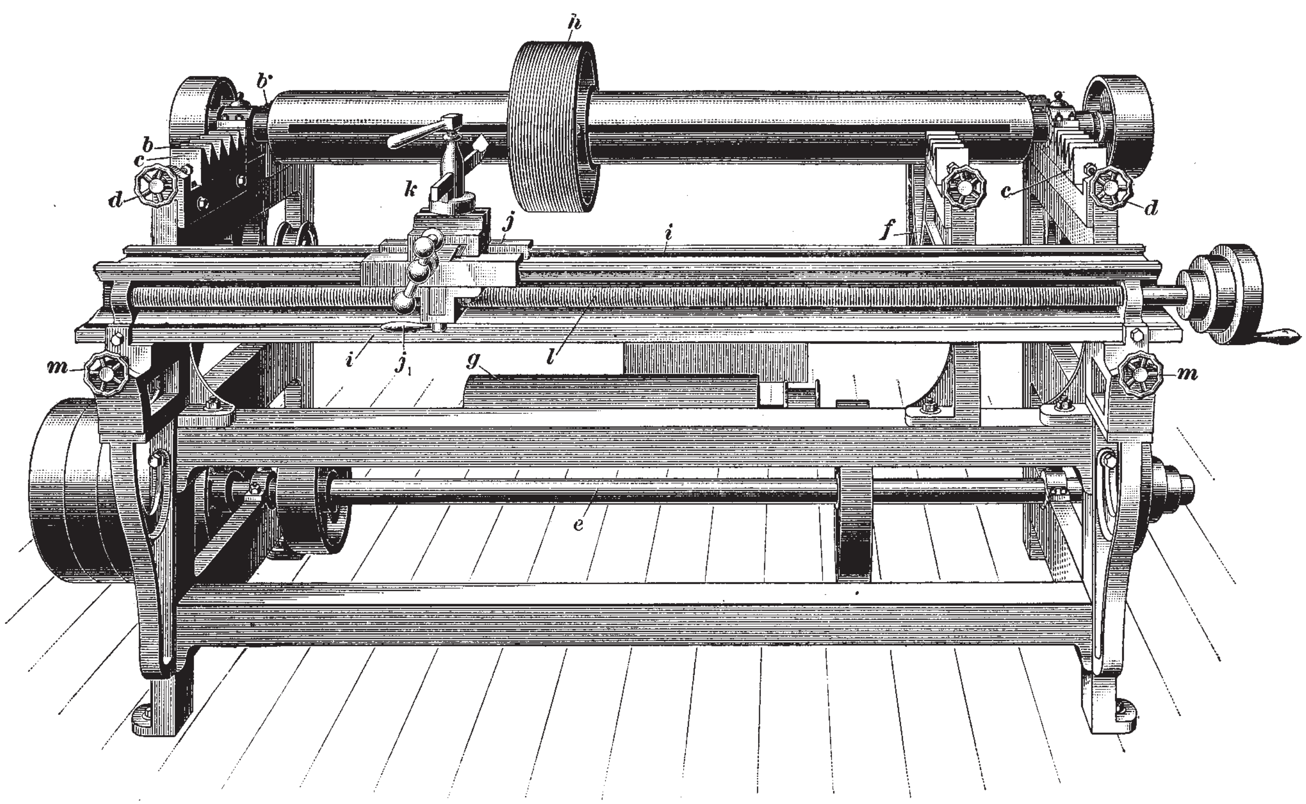


FIG. 11

The grinding of the smaller rolls of the card takes 3 to 4 hours. Great care should be taken when grinding strippers not to injure the wire because, owing to the small diameter of the stripper, the wire stands more open on it than on the larger rolls. The workers should have the most grinding of the smaller rolls of the card, as they need a sharp point for taking the wool from the main cylinder as well as for the actual carding.

The fancy should not require much grinding, as its friction with the main cylinder should keep it in good condition. Many carders do not grind the fancy at all, claiming that as the fancy does not engage with the wool perfect smoothness is better than sharpness. The point produced on any roll by wear is always smoother than that obtained by grinding. If the fancy is ground it should be ground very lightly and only for a short time, so as not to jam or disarrange the long teeth of the roll. After grinding, it is a good plan to allow the fancy to run into the cylinder of the card for about ½ hour, being set up hard at first and afterwards being moved off to its normal position. This will take off any roughness left by the emery. When grinding the tumbler perfect smoothness is desired rather than extreme sharpness.

32. Grinding Metallic Rolls.—Occasionally the burr cylinder of the first breaker card or the metallic feed-rolls need grinding and sometimes the burr cylinders of the burr picker are brought to the card room for grinding. The grinding of these rolls is a difficult task and should never be attempted until the roll is considerably worn, as at best they can only be improved and not rendered as good as new. Metallic burr rolls may be ground on the traverse grinding frame, but the *solid emery* or *carborundum* wheel should be used instead of the iron grinding wheel covered with emery. The grinding frames are supplied with solid wheels if so desired. When grinding metallic rolls the grinding wheel should always revolve against the point of the teeth. This is the opposite way from which the rolls covered with card clothing revolve, but it is necessary in order to prevent the metallic wire from becoming hooked. The burr cylinder should be made to revolve very slowly, say not more than 10 turns per minute, and the grinder pressed very lightly against it. The grinding being very light, it takes more time, and 2 days are sometimes spent in grinding a single roll. Sometimes a file is fixed in the turning post of the grinder and allowed to bear on the surface of the roll. The roll is then revolved toward the file at the rate of from 250 to 300 revolutions per minute. If burr cylinders are worn very badly, they are placed in a lathe and turned down.

When grinding any metallic roll great care should be taken not to heat it, which is very apt to be done and may affect the trueness of the cylinder. Small rolls, like feed-rolls, are very difficult to sharpen and more satisfactory results can be obtained by filing them by hand.

After the burr cylinder is ground sufficiently to feel sharp to the hand, although it cannot be made to feel as sharp as card clothing, means must be taken for smoothing it up. The grinding always leaves a metallic roll rough and the teeth more or less burred, or hooked. One way to smooth a metallic roll after grinding is to reverse its direction of rotation and hold the end of a soft pine board against it until notches are worn by the teeth. The end of the board may be moistened with oil and sprinkled with powdered emery, which will smooth the teeth and remove any rough edges, leaving the roll smooth and in good condition.

ROLLER GRINDING FRAME

33. The grinding frame shown in Fig. 11 contains a narrow traversing grinding wheel, but Fig. 12 shows a grinding frame known as the **roller grinder,** which is preferred by some carders. This grinder is identical with the traverse-wheel grinding frame with the exception of the wheel, or roll, *h* for grinding, which extends entirely across the frame, grinding the entire surface of the worker or other roll at once. Rolls can be ground in less time with a roller grinder, but are more liable to be ground in stripes or

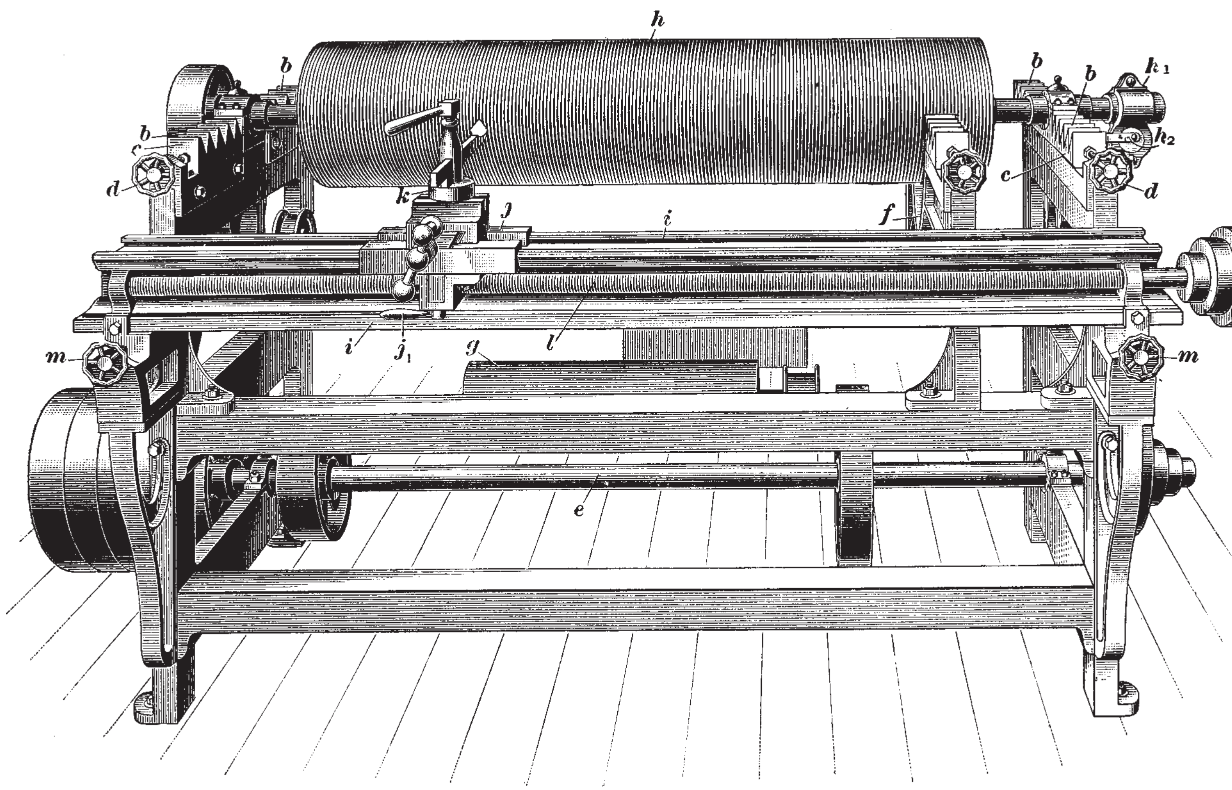


Fig. 12

unevenly. To prevent this the roller grinder has a slight traverse of about 2 inches. This is accomplished by giving the roller a reciprocating motion by means of the device shown on the right-hand side of the grinding-roll shaft. This consists of a worm on the shaft, which meshes with a worm-gear, both being contained in the casing h_1, Fig. 12. On the side of the worm-gear is a crankpin that is connected to the stationary bearing of the grinding-roll shaft by means of rod h_2. When the grinding-roll shaft revolves, the worm-gear is turned and the crankpin, working against the arm attached to the stationary bearing, moves the whole casing, and also the grinding roll, by means of collars on the shaft. A roller grinder is also made for grinding cylinders and doffers.

TRUING WOODEN CYLINDERS

34. Often when wooden rolls are used in a card it will be found that they are not true when the card is being set or when the roll is being ground. In this case the rolls should not be evened up by grinding, as this will make some of the teeth shorter than others and make good carding difficult. The only remedy is to take off the clothing and turn down the roll. This is done on a grinding frame, except in the case of the main cylinder, which is trued by fastening the turning lathe to the frame of the card, the doffer being removed. After the clothing has been taken off from the roll that is to be trued, the roll is placed in the grinding frame. In the case of large rolls, as for instance a doffer, it is sometimes necessary to remove the grinding wheel in order to make room.

It will be noticed, Figs. 11 and 12, that the turning lathe is fastened to the front of the grinding frame and consists of a rest *i* on which there is a movable slide *j* carrying a tool post *k*, in which the turning knife is fastened. The slide is controlled by a screw *l* running the width of the frame, which is either turned by hand by means of a handle or preferably driven by means of a belt and two three-step pulleys, one on the screw shaft and the other on the bottom shaft of the grinding frame, as seen at the right of the frame. A small handle j_1, under the slide, allows it to be disengaged from the screw after the latter has been moved entirely across the width of the roll that is being trued. The slide is then moved back by hand and the handle underneath turned in, which allows the screw to act and the slide to make another traverse.

The whole turning lathe may be adjusted to the roll that is being trued by means of hand wheels *m* on each side of the machine, which operate screws provided with check-nuts for fastening the lathe in any desired position. Small adjustments of the turning knife may be made by means of a crank that operates the tool post. Care should be taken to have the rest perfectly parallel with the shaft of the roll to be trued. The turning knife passes through a slot in the turning post and is so arranged that it may be set and securely fastened at any angle. When turning, or truing, the point of contact of the turning knife with the cylinder should be on a level with or slightly above the axis of the latter.

When truing the main cylinder of the card it often becomes necessary to place blocks under the turning lathe in order to raise it high enough. The doffer being removed, the turning lathe is placed in its position resting on the end of the card frame. If it is not desired to place blocks under the lathe, the turning knife should be set so as to come in contact with the cylinder at the proper angle.

It is better to take off several small, or thin, shavings from the cylinder rather than to attempt too thick a shaving. Before putting the knife to the cylinder, the latter should be scraped by holding on it the edge of a piece of board or an old piece of sheet-iron or steel with a straight edge; this removes any grease or dirt that may be on it which would dull the knife.

In order to make a smooth surface, the turning knife must be sharp and the cylinder should revolve against its edge. When removing sheets from a cylinder before truing it, care should be taken, if the heads of the tacks are broken off, not to leave the latter protruding in the wood, where they will come in contact with and ruin the turning knife. It is better to drive the slide that carries the knife with a belt rather than to attempt to turn it by hand, as more uniform results will then be obtained. If it is desired to operate the slide by hand, it is best to disengage it from the screw entirely and move it across the face of the cylinder with a firm, uniform pressure. The turning lathe should always be in line with the axis of the main cylinder. If the latter is level, as it should be, the turning lathe may be leveled also; but otherwise it is a good plan to sight the shaft of the cylinder over the lathe rest.

After the cylinder has been trued and its surface made to run perfectly, a sheet of sandpaper tacked on a block of wood may be lightly passed over the surface finally to smooth it before replacing the clothing. If there are small knot holes in the cylinder they must be filled with putty, slightly warmed beeswax, or a wooden plug, before the clothing is put on; otherwise, the teeth over them will be pushed through the foundation of the clothing and be lower than the rest.

In turning the smaller rolls of the card, the same rules apply as with the main cylinder, except that they are trued in the grinding frame. Iron cylinders and doffers never have to be trued if properly used, but if sprung through any accident, they should be turned down in the machine shop.

CLOTHING CARDS

COVERING WITH SHEET CLOTHING

35. Whenever old clothing is replaced with new, or after cylinders have been trued, there arises the necessity of recovering the cards, this may be done with one of three coverings—sheets, fillet, or rings. The **sheet clothing,** as has been previously stated, consists of sheets 5 inches wide and as long as the width of the card. They are used on the main cylinders of the first and second breakers, and in order to prevent their blistering, or raising, in the center, they should be applied with considerable tension and be securely fastened in place with long tacks, 12-ounce tacks being suitable for this purpose. Tacks made without any web on the under side of the head, which would be liable to cut the foundation, are provided for attaching card clothing to the cards.

The cylinder should first be marked off with a pencil so that each sheet will be placed in the proper position and parallel to the axis of the main cylinder. This marking is usually done after the cylinder is turned down and with the turning lathe in position. With the cylinder turning, a mark is first made with a pencil $\frac{3}{4}$ inch from each edge. Then the circumference of the cylinder is divided on one of these lines, with a pair of dividers, into as many parts as there are sheets. If the main cylinder is 48 inches in diameter it is customary to apply twenty-four sheets, a certain amount of space being necessary between the sheets for tacking; this means that twenty-four equal divisions will be made around the cylinder. Then using the turning rest, which is parallel to the axis of the main cylinder, as a rest, a line is marked across the card at each of the points spaced off with the dividers. The turning lathe is then removed from the card and the sheets of clothing applied. The tacks should first be stuck into each sheet about $\frac{7}{8}$ inch apart and $\frac{1}{4}$ inch from the wire. The upper edge of the sheet is then placed on one of the lines drawn across the main cylinder and the tacks driven in. A clamp, Fig. 13, is then attached to the lower edge of the sheet and a strap passed through the link of the clamp and attached to a ratchet, by which the sheet of clothing can be stretched. The ends of the sheets should always be stretched first and firmly tacked, after which the middle portion of the sheet may be stretched and tacked.

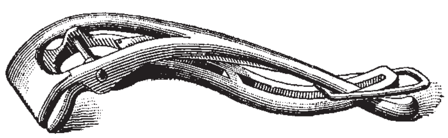


Fig. 13

While the tension is being applied to the sheet, the main cylinder must be prevented from turning. This may be accomplished by means of a bar of iron propped against the bolts on the inside of the cylinder and resting on the floor. After the first sheet is tacked on, the lower edge should be trimmed to the pencil line and the operation repeated.

When stretching the last sheet, it will be necessary to place a block of wood in the space between the sheets on the first and second sheets tacked on for the clamp to rest on so that it will not injure the clothing. After all the sheets are on, the ends of each sheet should be drawn out and a single tack put in each. If the card clothing is sufficiently stretched and well tacked it will not blister. Iron cylinders have parallel rows of holes drilled in their surfaces and tapered, hardwood plugs driven into the holes. The tacks are driven into these plugs when the clothing is applied.

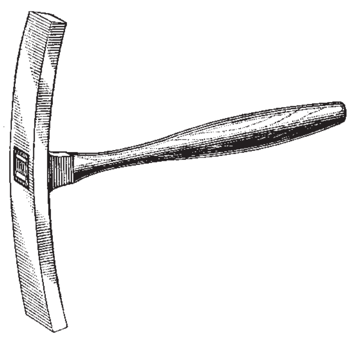


FIG. 14

The hammer used for driving the tacks when sheet clothing is being applied is of a peculiar shape, as shown in Fig. 14; the head is 8 or 10 inches long and the face of the hammer $\frac{1}{4}$ in. × 1 in. This shape is adapted for driving the tacks without jamming the card clothing.

COVERING WITH FILLET

36. Fillet Winding Frame.—The rolls of the card that are not covered with sheet clothing, metallic wire, or rings are covered with fillet, which is applied by various means, the object being to wind the fillet with sufficient tension to prevent its becoming slack.

Fig. 15 shows a machine for doing this. The desired length of fillet for any given roll is found (as will be explained later) and one end tacked to the large drum *f*, around which it is wound; the other end of the fillet is then tapered and tacked to the roll *e*, which is to be covered, and which is turned by means of the crank-handle *d* and gears *c*, *b*.

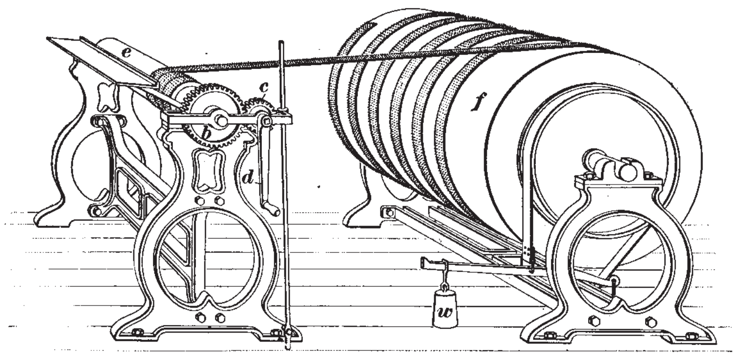


FIG. 15

The desired tension is obtained by means of an adjustable weight *w* placed on a lever, to which a strap passing around

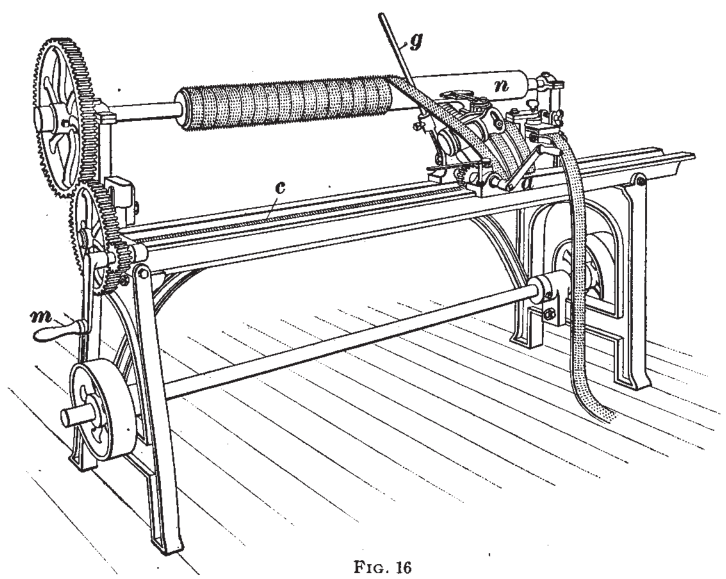


FIG. 16

a flange on the drum *f* is attached. By moving the weight, any amount of friction may be placed on the drum and, consequently, any amount of tension on the fillet that is desired may be obtained. When the end of the roll is reached, the fillet should be carefully secured and then trimmed off flush with the end of the roll. The taper at each end is necessitated by the fact that the fillet is wound on spirally and the taper must therefore coincide with the pitch of the spiral.

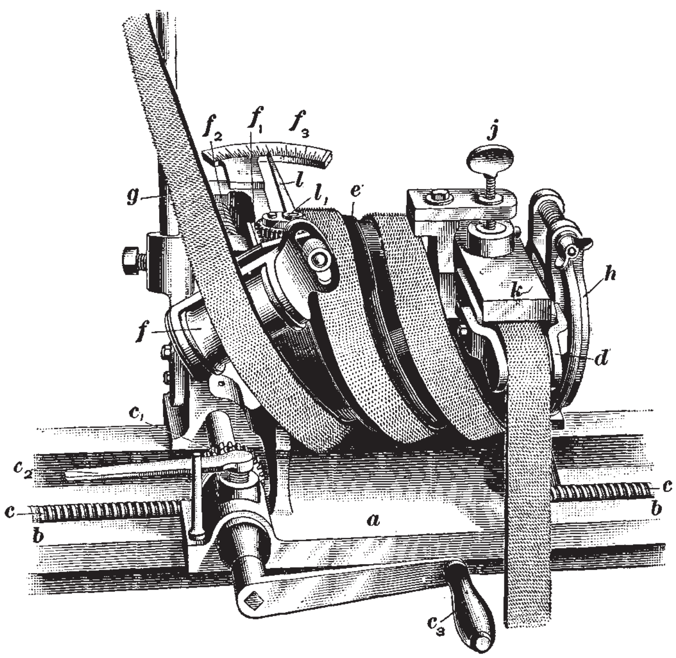


Fig. 17

37. Fig. 16 shows a fillet winding frame similar to the one described except that it is equipped with a patent drum for regulating the tension of the fillet as it is placed on the cylinder. An enlarged view of it is shown in Fig. 17, where it will be seen that it consists of a carriage *a* that slides on a bed *b*. Sufficient motion is imparted to the carriage by means of a screw *c* to guide the spirals of fillet close up to each other. The fillet when being wound is usually placed in a basket, from which the end is taken and passed through the trough *d* to what is known as the *cone drum e*, around which it is wrapped three times. The fillet emerges over the roller *f* and is guided on the roll to be wound by the rod *g*.

The tension is obtained in the following manner: The drum *e*, which revolves as the fillet passes over it, is made in three sections—the first 6½ inches, the second 7 inches, and the third 7½ inches in diameter. The part with the largest diameter is covered with leather so that this portion of the drum and the fillet revolve together; and as it requires a greater length of fillet to cover this surface than it does to cover either of the smaller sections, the fillet is drawn over these at a greater speed than that at which their surfaces revolve. The friction between the fillet and the drum produces the tension on the former, the amount of which may be regulated by the brake *h* on the drum shaft and also by a thumbscrew *j* that presses the die *k* down on the fillet, which is drawn over a spring cushion.

About 200 pounds tension may be obtained by means of the brake *h* alone, the rest being obtained by means of the thumbscrew *j*. The fillet must always be passed through the trough so that the teeth will point in the opposite direction to its motion; otherwise, they will be injured. For main cylinders wound with 2-inch fillet a tension of 275 pounds is about right; smaller rolls require less tension as does also narrower fillet. Doffers may have fillet applied with about 175 pounds tension, while 125 pounds is sufficient for workers. The amount of tension with which the fillet is being wound in this machine is indicated by a finger *l* on the dial f_3. This is accomplished by arranging the roll *f* to press against a strong coil spring f_2, connection being made with a rack f_1 and pinion l_1 so that the motion of the roll when acted on by the tension of the fillet is communicated to the finger and indicated on the dial.

The frame shown in Fig. 16 is also used for truing wooden rolls, in which case the fillet winding device is removed and a turning lathe substituted. In this case the frame is driven by a belt, but when winding fillet, motion is imparted to the roll to be wound and to the winding device by means of the crank *m*.

In using this machine it is essential that for each revolution of the roll *n* the carriage shall move along the bed a distance corresponding to the width of the fillet. This is sometimes accomplished by gearing the screw that imparts the traverse motion to the carriage from the roll that is being covered, the train of gears being so arranged that 1 tooth of the change gear moves the carriage $\frac{1}{32}$ inch to each revolution of the roll. From this it will be seen that $1\frac{1}{2}$-inch fillet will require a 48-tooth gear and 2-inch fillet a 64-tooth gear. In actual practice, however, a 49-tooth gear is used for $1\frac{1}{2}$-inch and a 66-tooth gear for 2-inch fillet, since the fillet is wider than the nominal width and measures $1\frac{17}{32}$ inches and $2\frac{1}{16}$ inches, respectively.

After large rolls are covered with fillet they should be allowed to stand for 3 or 4 hours in order that the fillet may become adjusted and then it should be tacked crosswise of the cylinder. When covering with card clothing, if the roll is not reversible end for end, care must be taken to have the teeth of the clothing pointing in the right direction. As a rule, the workers, strippers, tumblers, and fancies are covered with $1\frac{1}{2}$-inch fillet, while the doffer is clothed with 2-inch fillet, as is also the finisher cylinder when it is clothed with fillet.

Before winding on the fillet some carders paint the surface of the cylinder or roll, but this is not done so much at the present day. The usual custom is to brush the cylinder with linseed oil just before the fillet is wound on. This prevents the backs of the teeth from rusting and also prevents cracks from opening in the cylinders. Iron cylinders, of course, do not need this treatment.

38. The following rule is used to find the length of filleting required to cover a given roll:

Rule.—*Multiply the diameter of the roll by its length, in inches, and by 3.1416 and divide by the width of the filleting multiplied by 12 to reduce the answer to feet.*

A little allowance must be made for tapering the ends of the fillet at the start and finish and also to leave enough to keep the tension when finally tacking the clothing to the rolls.

EXAMPLE 1.—What length of 2-inch filleting is required on a 48-inch card to cover a 24-inch doffer?

SOLUTION.— $\frac{24 \text{ in.} \times 48 \text{ in.} \times 3.1416}{2 \text{ in.} \times 12 \text{ in.}} = 150.796$ ft. Ans.

EXAMPLE 2.—What length of $1\frac{1}{2}$-inch filleting is required to cover a 10-inch fancy on a 60-inch card?

SOLUTION.— $\frac{10 \text{ in.} \times 60 \text{ in.} \times 3.1416}{1.5 \text{ in.} \times 12 \text{ in.}} = 104.72$ ft. Ans.

COVERING RING DOFFERS

39. Many carders have difficulty in clothing ring doffers, the rings being made endless and of a slightly smaller diameter than the doffer in order to fit it tightly. The following method of application, however, will be found to accomplish the purpose and not to injure the rings: The doffer should be taken out of the card and placed on end on a box, its shaft passing through a hole bored in the latter. To help in getting the rings on, a wooden cone may be made about 6 inches long, with its lower end of the same diameter as the doffer. Through its center a hole is made, which allows it to be placed on the doffer shaft. The rings may now be placed over the cone and pushed down about an inch over the doffer. A square board 3 or 4 inches wider than the diameter of the doffer should be obtained and a round hole slightly larger than the diameter of the doffer cut into it. This can be slipped over the doffer and the rings readily forced into place without bruising the leather by pounding. After all the rings are on the doffer it may be taken to the grinder and the rings, which are at varying distances apart, easily adjusted by means of a screwdriver or small stick. With the doffer revolving toward the operator but against the back of the teeth, the screwdriver should be pressed against the side of the leather part of the ring, which may thus be slid in any desired direction.

Before doing this, however, a gauge should be made for spacing the rings in order that the divisions between them may be made equal. This gauge consists of a stick as long as the width of the card and marked with as many divisions as there are rings, the latter to be spaced equally over a distance equal to the width of the clothing on the main cylinder. The waste-end ring, which is wider than the others, should be placed on the end of the top doffer farthest from the stripper belt and on the end of the bottom doffer nearest the stripper belt. Some carders place the top waste-end ring on the side of the card on which the longer side of the Apperly feed is.

The method of marking off a gauge stick for a 48-inch card with two waste ends and 48 rings on a double-doffer card is as follows: First the waste-end rings should be made $1\frac{1}{2}$ inches wide. This leaves 45 inches (48 inches − 3 inches) in which to place 48 rings. If the rings on the top and bottom doffers were all the same size, they would then be $\frac{45}{48}$ or $\frac{15}{16}$ inch wide, but the top rings must be narrower; therefore, the gauge stick must be marked so as to space twenty-four $\frac{14}{16}$-inch rings 1 inch apart on the top doffer, while the bottom doffer will have twenty-four 1-inch rings $\frac{14}{16}$ inch apart.

When the gauge is made for the right number of rings equally spaced, the doffer should be fastened with collars in the grinder so that it will have no lateral motion, or play, and the gauge placed in front of it about $\frac{1}{4}$ inch from the wire. The rings may now be moved with the screwdriver until they coincide with the divisions marked on the gauge. The bottom doffer is treated in the same manner and when both doffers are spaced, the rings of the top doffer should just fit into the spaces of the bottom doffer and the ends of the doffers should be flush.

40. Strips of leather, as free from grease and dirt as possible, are prepared as wide as the space between the leather part of the rings and glued or tacked in with the ends butting together. Filleting with the wires removed is frequently used for this purpose. These strips should not be cut too wide or the rings will be forced from their positions; but, on the other hand, they should fit snugly so that the rings will be held firmly in position when the card is in operation.

Another method of securing the rings that is sometimes used is as follows: Having adjusted the rings in their correct positions, a cop of cotton yarn should be procured and with the doffer in the grinding frame and the teeth of the rings revolving against the point, the thread should be touched to the outside ring, to which it will instantly cling. The thread is then guided neatly back and forth between the rings, one layer of cotton being wound over another until the same thickness as the leather foundation of the ring is obtained; then the thread is quickly crossed over to the next space, and so on continuously to the end. When finished, the doffer is stopped and with a small brush and a thin glue solution the cotton is saturated, the crossings from one space to another first being cut and the ends of the cotton thread tied together. The grinding may be commenced at once and the packing will dry as the grinding proceeds. This makes a solid, compact filling with no danger of the rings becoming displaced. If desired, strips of leather may be tacked over the cotton filling, just touching the wires of the rings.

CARDING SURFACE

41. The following rule is used to find the number of square feet of carding surface on a cylinder covered with sheet clothing:

Rule.—*Multiply the length of the sheets (width of card) by the width of the sheets (5 inches) and by the total number of sheets on the cylinder and divide the product by the number of square inches in 1 square foot (144).*

EXAMPLE.—On the main cylinder of a 48-inch first breaker card there are 24 sheets of card clothing; how many square feet of carding surface has the cylinder?

SOLUTION.— $\frac{48 \text{ in.} \times 5 \text{ in.} \times 24}{144} = 40$ sq. ft. Ans.

42. To find the number of square feet of carding surface on a cylinder or roll covered with filleting:

Rule.—*Multiply the diameter of the cylinder, in inches, by 3.1416 and by its length, in inches, and divide the product thus obtained by the number of square inches in 1 square foot (144).*

NOTE.—To find the exact surface area of a given cylinder at the points of the clothing, add $\frac{3}{4}$ inch to its diameter.

EXAMPLE.—How many square feet of carding surface on a 7-inch worker, the card being 48 inches wide?

SOLUTION.—

$$\frac{7\frac{3}{4} \text{ in.} \times 3.1416 \times 48 \text{ in.}}{144} = 8.115 \text{ sq. ft. Ans.}$$

43. The following tables show the amount of clothing required for a set of 48-inch cards, the finisher main cylinder being covered with filleting. The reference to angular wire refers to the angular, or diamond-point, wire with which the lickers-in and feed-rolls of the second breaker and finisher cards are covered, this wire being stronger and coarser than the ordinary card clothing wire. Lickers-in may be garnetted with licker-in wire.

TABLE VI

FIRST BREAKER

No.	Cylinders	Dimensions Inches	Length Feet	Width Inches	Square Feet
24	Sheets (main cyl.)	5 × 48			40.00
6	Workers	7 × 48	61	1½	43.98
6	Strippers	3 × 48	27	1½	18.84
1	Doffer	24 × 48	156	2	25.13
1	Fancy	10 × 48	87	1½	10.47
1	Tumbler	9 × 48	78	1½	9.42
1	Burr cylinder	7 × 48	Metallic		7.33
2	Feed-rolls	2 × 48	Metallic		4.18
					159.35

TABLE VII
SECOND BREAKER

No.	Cylinders	Dimensions Inches	Length Feet	Width Inches	Square Feet
24	Sheets (main cyl.)	5 × 48			40.00
6	Workers	7 × 48	61	1½	43.98
6	Strippers	3 × 48	27	1½	18.84
1	Doffer	24 × 48	156	2	25.13
1	Fancy	10 × 48	87	1½	10.47
1	Tumbler	9 × 48	78	1½	9.42
1	Licker-in	5½ × 48	48	1½ angular	5.75
1	Licker-in fancy	3 × 48	27	1½	3.14
1	Feed-roll stripper	1¾ × 48	24	1 angular	1.83
2	Feed-rolls	1¾ × 48	24	1 angular	3.66
					162.22

TABLE VIII
FINISHER

No.	Cylinders	Dimensions Inches	Length Feet	Width Inches	Square Feet
1	Cylinder	48 × 48	312	2	50.26
5	Workers	7 × 48	61	1½	36.65
5	Strippers	3 × 48	27	1½	15.70
1	Fancy	10 × 48	87	1½	10.47
1	Tumbler	9 × 48	78	1½	9.42
1	Licker-in	5½ × 48	48	1½ angular	5.75
1	Licker-in fancy	3 × 48	27	1½	3.14
1	Feed-roll stripper	1¾ × 48	24	1 angular	1.83
2	Feed-rolls	1¾ × 48	24	1 angular	3.66
48	Rings (doffers)	12 × 48			12.56
					149.44

The lengths given in these tables for fillet clothing are long enough to allow for tapering the fillet on each end of the cylinder. The total carding surface of the entire set of cards is approximately 471 square feet; this is the surface of the rolls before they are covered. The surface of the teeth of the card clothing itself would be slightly in excess of this.

POINTS IN MANAGEMENT

44. In the management of card rooms many points must be watched, but the following results should always be attained: (1) The production of good work; (2) as large a production as is consistent with the quality of work required; (3) economy in avoiding unnecessary waste and keeping down the expense of wages, power, supplies, etc.; (4) the maintenance of the machinery in good condition.

With reference to the first point, it may be said that this is judged by the appearance of the roving and by the resulting yarn. If the rovings are round and full, free from *twits* and imperfections, and of the right weight, the carder may feel satisfied that any imperfection of the resulting yarn is not due to the carding. A **twit** is a thin place in the roving, or yarn, that looks as though the roving were partly broken. Where twits occur in the roving, bunches and thick places are also apt to occur. If the roving is twitty, the yarn will also be full of thin places. Twitty roving causes much trouble in card rooms; it is produced in many ways. Sometimes the twits are caused as far back as the scouring, since if the wool is scoured with too hot liquor the grease seems to be driven into the fiber, rendering it stiff and wiry. Wool rendered harsh in the drying will also make twitty roving, unless carefully oiled and carded. Sometimes the clothing on the finisher-card cylinder grows slack and blisters through usage; this is a cause of twits that is only remedied by taking the clothing from the cylinder, recovering it, and afterwards grinding to a true surface. A poorly working licker-in on the finisher is also apt to cause twits; the licker-in should always take the wool evenly in small bunches and not in large flakes or uneven bunches. Twitty roving is often caused by trying to spin fine yarn out of wool that is only fit for spinning coarse yarn. Sometimes a poorly working fancy will cause twits, especially if it is inclined to *choke* with wool, when it is often called a *lapping fancy*. Any defect in the doffer rings of the finisher doffers is sure to cause a defect in roving. These rings should be carefully attended to and kept in good condition; they should always be smooth and have a point that is sharper than the cylinder of the finisher. If the wipe roll, which strips the ribbons of carded wool from the rings, is driven too fast or if not set properly with regard to the rings, twitty roving is liable to result. Twits are also sometimes caused by too much draft between the aprons of the condenser and sometimes by poor or dirty aprons. Sometimes the rovings are not rubbed solid enough and so are liable to be weak in places. Twits are often caused by too high speed of the cards, especially of the ring doffers. If one fiber receives more oil than another, that fiber has a different action; and when one part of the batch of wool is over-oiled and another part is not sufficiently lubricated, twitty and uneven roving will often result.

Great care should be taken to bring the stock from the first breaker in good condition, as on the character of the carding done by the first breaker the resulting roving will largely depend. The side drawing from the first breaker card should be frequently examined for neps and vegetable matter. The sliver should be round and full from the first and second breakers and the rovings from the finisher card should be round and perfect, without having been rubbed too much. All little points that tend to deteriorate the quality of the work should be carefully attended to and the cards stripped when necessary; that is, when they become so filled with dirt as to clog the clothing and prevent the wire from acting freely on the stock as it passes through the card.

The economizing of production can be obtained by limiting as much as possible the time allowed for stripping, grinding, or setting the cards and also by not allowing the rest of the set to be stopped any longer than is necessary while stripping or grinding one card. The production may be increased by speeding up the whole card or by increasing the speed of the doffer and the feed-rolls by changing the small gear that drives the large gear on the doffer shaft. Cards should never be speeded so fast as to make a large percentage of flyings, as these not only increase the amount of waste, but settle on the card and make it more difficult to clean, besides having a tendency to work into the bearings and around the shaft, collecting in lumps that are sometimes caught and carried into the card, rendering the roving uneven. Too much stock should not be forced through the card by speeding up the doffer, nor should the sliver be made too heavy. The quality of the work in woolen carding should rarely be sacrificed for production.

As a rule, two men or boys will care for from four to six sets of cards with a creel feed at the second breaker and an Apperly feed for the finisher card. Two men will strip from eight to twelve sets of cards. The labor cost of a card room varies according to the price of labor in the locality in which the mill is located, the class of work, and other conditions.

As little waste as possible should be made and all soft and clean waste should be run through the cards again. A good deal of the waste around the card may be dusted, run through the picker, and then worked over. Greasy waste should not be allowed to accumulate in piles or in bins, and water should never be put on greasy waste. Under these conditions there is great danger of spontaneous combustion and a serious fire.

The care of machinery requires that the cards shall be frequently cleaned and oiled. Cards should be wiped down with a piece of waste every night, the flyings removed and also the waste on the floor gathered up. Every week the cards should be thoroughly cleaned and the card room swept. The cards should be carefully cleaned after every stripping, and all dirt and waste removed from the bearings. After cards have been ground they should be cleaned and the wire brushed out with a strong bristle brush.

Machinery, in order to be kept in the best condition, requires frequent oiling. All fast-running parts of the card, such as the strippers, main-cylinder, fancy, tumbler, and licker-in bearings should be oiled twice a day. The workers do not need to be oiled oftener than once in 2 or 3 days and sometimes not more than once in a week. The main-cylinder and fancy bearings should be packed with tallow, having a small hole in the center so that it will allow the oil to run directly on the shafts and provide a reserve of lubrication that will melt in case of a hot bearing. If tallow cannot be obtained, small pieces of waste should be placed in the bearings and soaked with heavy oil. The doffer-comb driving mechanism is run in oil and should be examined once in 2 weeks to see if there is sufficient oil in the reservoir, or casing.

All belts on the card should be examined once a week, especially the stripper belt, and all broken or worn lacings should be replaced. The belts should be cleaned every time the cards are stripped and, when dry, they should be oiled with castor oil. When the parts of the card are disturbed in any way, they should be carefully gone over again in order to detect any variation in the setting.

ELECTRICITY IN THE CARD ROOM

45. Any animal fiber, especially wool or silk, is liable to become charged with electricity, owing to friction combined with a dry state of the fiber and of the atmosphere. The place where the most difficulty with electricity is experienced in woolen carding is at the condenser, where the rubbing action of the aprons, or rolls, tends to charge the rovings with static or frictional electricity, which causes them to cling to the aprons and to the iron parts of the card frame and spool stand, thus becoming broken and winding around the rubs. When a roving breaks and is not immediately replaced, a blank space is left in the spool, making it imperfect. Sometimes when very dry or harsh stock is being carded, it becomes almost impossible to run the cards, owing to the electricity, which is more troublesome in dry weather than in damp and in winter than in summer.

The card room should always be fitted with a humidifying plant in order to keep the air moist and thus reduce the electric charges as much as possible, but even then there is often difficulty with the rovings. The longer the throw, or the traverse, of the condenser aprons and the closer together they are set, the more difficulty there is; the electrification may often be reduced by setting the aprons farther apart and decreasing the traverse, only allowing enough rubbing action to condense the rovings into a round thread.

A remedy that is sometimes used with good results for the prevention of electric charges is soap, which, when added to the emulsion when the wool is being oiled, seems to render the wool soft and less liable to become electrified. About 2 pounds of soap to 100 pounds of wool is generally sufficient to prevent electrification and also to render the stock moist and silky in feeling, enabling the yarn to be spun into a round, lofty thread. Alum has been found to reduce the liability to electrical effects and is usually dissolved in the water used for the emulsion for oiling in about the proportion of $\frac{1}{2}$ pound of alum to 100 pounds of stock.

The use of steam is sometimes resorted to in order to prevent electric charges from being produced, although steam is expensive to use for this purpose. The method is to run a steam pipe under the floor of the card room on a line with the condensers. Holes are bored at the end of each condenser and the pipe under the floor tapped with a $\frac{1}{2}$-inch pipe, which should extend across the condenser $2\frac{1}{2}$ inches below the lower rovings and plumb with the rear of the rub aprons. This pipe should be perforated with small holes 2 or 3 inches apart and should have a valve attached so that the steam may be turned on or off as desired. There will be no trouble with electrification if the steam is turned on before starting the cards. No more steam should be turned on than is absolutely necessary, or the aprons will stretch or become otherwise injured; and it should be shut off the moment the finisher card is stopped. It should not be used unless the presence of electric charges is very evident as, if too much is used, the wire of the finisher card may become rusted.

WEIGHT OF ROVING

46. In order that a woolen yarn may have a definite size, or **run**, that is, a certain number of yards per pound, it is necessary that the roving, or roping, from the cards shall be of a given, uniform weight. It is, therefore, one of the duties of the carder to make the rovings of such weight that they may be spun into the required run of yarn with a reasonable draft in the spinning.

The draft that can be given on the mule depends on the quality of wool used and the size of the yarn being spun. If the wool is of good quality and is not spun too fine, a half draft in the mule is reasonable; that is, if the draw of the carriage is 72 inches, then 36 inches of roving will be let out before the delivery rolls of the mule stop. If a low grade of stock is being spun, it may be necessary to let out 40 or more inches of roving before stopping the delivery rolls. If the mules are running on half draft, that is, letting out 36 inches of roving and drafting it into 72 inches of yarn, the roving must be brought from the card just twice the weight of the required yarn.

It is not customary actually to figure the weight of the roving by the amount of wool fed to the card, as the weight of stock fed is an unknown quantity; though the Bramwell feed supplies the wool to the card uniformly by weight, this weight is not usually known or taken into account. The point is to bring from the first breaker a sliver that will allow a suitable gear on the second breaker to give the required weight of the roving from the finisher. For instance, if the card is taking off 48 ends, the side drawing from the first breaker should weigh from 200 to 220 grains per yard if it is desired to make 4-run yarn. For a 40-inch card, carding for 4-run yarn and taking off 40 ends from the finisher, the side drawing from the first breaker may weigh from 180 to 190 grains per yard. These weights give sufficient leeway for changing the gear on the doffer shaft of the second breaker until the rovings from the finisher are of the right size.

47. Finding Required Size of Roving.—The size of the roving, as has been previously explained, depends on the number of yarn to be spun and on the draft of the roving in spinning. The latter depends on the character of the stock and also on how near to the limit of its capabilities it is being spun; low stock will stand less draft than sound wool with good spinning properties. The size of the roving necessary to spin a given yarn is to the amount of roving let out by the delivery rolls of the mule as the number of yarn spun is to the draw of the carriage; therefore, the following rule is necessary to find the size of roving that should be made on the card for a given size, or run, of yarn, the draft in the mule in spinning being known:

Rule.—*Multiply the length of roving, expressed in inches, delivered by the rolls on the mule by the size, or run, of the yarn to be spun and divide by the draw of the carriage, in inches* (72). *The answer will be the size of roving required to spin the run desired with the draft given.*

EXAMPLE.—Suppose that it is desired to spin $5\frac{1}{2}$-run yarn and that the stock will allow 36 inches delivery of roving to be drawn out to 72 inches of yarn of the desired size. Of what weight should the roving be brought from the card?

SOLUTION.— $\frac{36 \text{ in.} \times 5.5 \text{ run}}{72 \text{ in.}} = 2\frac{3}{4}\text{-run}$. Ans.

48. Changing Size of Roving.—The carder, having found the required run of the roving, must now take steps to procure the right size and to have all the rovings uniform. It must be remembered that changing the gear on the doffer shaft of the finisher does not change the weight of the roving when the finisher card is fed continuously from the second breaker; this gear simply changes the character of the feeding of the Apperly feed. If the slivers are crowded on the feed-apron and do not lie smoothly, a larger gear on the finisher doffer shaft will drive the feed-apron faster and, consequently, spread out the slivers on the apron, rendering them less closely packed. The weight of the roving is generally changed by means of the gear on the doffer shaft of the second breaker; this is the best place, although it may be readily changed on the first breaker. The weight of the sliver from the first breaker and, consequently, the weight of the roving may be changed by the gear on the doffer shaft; a larger gear produces a heavier sliver, as it speeds up the feed-rolls of the card and also makes the dumping arrangement and feed-apron of the Bramwell feed, which is geared from the feed-rolls, work more rapidly. It may also be changed by changing the gear on the feed-rolls, which drives the dumping arrangement and feed-apron. The oftener the self-feed dumps, the heavier is the side drawing from the card.

Alterations in the weight of the first breaker sliver may also be made by changing the amount of wool deposited in the weighing pan of the self-feed. More wool is placed in the pan, or scales, if the weight that balances the pan is moved toward the extremity of the lever, or away from the pan. This is apparent, since more wool is required to overbalance the scale, and the elevating and stripping aprons are not stopped until the scale is overbalanced, the scale being the governing element.

49. Sizing Roving.—In order to find the size or run of the roving that a card is producing, it is necessary to measure a certain length and either find the size by means of a run scale or find the weight by means of a grain scale and then figure the run. If it is necessary to use a grain scale, it is convenient to have a table with the weight and size of a given length figured out. Sometimes 50 yards of yarn is measured and sometimes only 20 yards. Whatever the length, however, it is usually measured by means of a stick either 1 or ½ yard in length and 3 or 4 inches in width, around which a number of rovings are carefully wound until the length desired is obtained. Sometimes instead of using a stick for measuring the yarn, marks are made on a post or on the wall exactly 1 yard or ½ yard apart. The required number of rovings is placed even with the top mark and allowed to hang loosely; they are then broken off squarely at the bottom mark. This insures an even and uniform length being weighed each time, as the tension is always the same. It is somewhat difficult in winding the rovings around a stick always to keep the same tension, and if this is not done a considerable error may be brought into the calculation, since the length weighed may vary in different cases.

50. The top and bottom spools of the condenser are always weighed separately and also spun separately, either on different mules or on separate sides of the same mule, it being possible to have different drafts on different sides of a woolen mule, thus allowing the same size of yarn to be spun even if there is some variation in the size of the roving.

The necessity for keeping the top and bottom spools, or all three spools in a three-deck condenser, separate, arises from the fact that it is impossible to set the doffers to the main cylinder absolutely the same. Then again the top ring doffer makes the first stripping from the main cylinder of the card, while the bottom doffer takes what is left on the cylinder. Although the rings of the top doffer are made narrower than those of the bottom doffer and its speed may be changed, there is a tendency for rovings on one spool to be heavier or lighter than those on the other. This necessitates making separate weighings from the top and bottom spools. If there is much difference in the weight of the rovings from the top and bottom doffers, the speed of the top doffer should be changed slightly; increasing its speed makes the rovings from the top doffer lighter, and decreasing it makes them heavier.

If the mules are running on half draft, it is customary instead of weighing 50 yards of roving to weigh 25 yards. This, of course, makes the reading of the run scale identical with the ultimate size of the yarn when it is spun, as the mule draws the roving out to twice its original length.

WOOLEN SPINNING

INTRODUCTION

1. The stock, after having been carded and converted into roving of a suitable size, is ready to be spun into yarn of the required run or cut. This involves two principal operations; namely, the drafting, which is a drawing out, or attenuation, of the roving, and the twisting, which, in reality, is the process that forms the roving into yarn. In addition, the yarn thus formed must be wound on suitable bobbins or formed into cops. These operations may be said to constitute the process of *spinning*.

The spinning of yarn from fibers of wool is one of the oldest textile arts known to history and in ancient times was performed by first drawing and twisting the thread by hand and afterwards winding the yarn thus formed on a round piece of wood 18 or 20 inches long. This constituted the first spinning and the piece of wood was the first bobbin, or spindle. The first advance in spinning was the one-thread spinning wheel, which consisted of a large wheel mounted in a frame and carrying a driving band or cord for imparting a rotary motion to the spindle, which was also carried in bearings in the frame. After this came the Hargreaves spinning jenny, which was really an adaptation of the one-thread spinning wheel to spin more than one bobbin of yarn. The next advance was the Crompton mule, which was in reality a hand jack. Following this, Roberts made the mule self-acting and introduced the quadrant for winding the yarn on the bobbins. From these, the present *woolen mule* has been evolved.

Before wool can be spun into yarn, it must be carded and converted into rovings, which, being wound on jack-spools, are placed on the mule; the roving is then unwound from the jack-spools, drafted, twisted, and wound in cops or on bobbins. In order that the resulting yarn may be as nearly perfect as it can be made, the rovings must be as free as possible from twits and bunches and also from foreign substances, such as broken burrs and other minute particles of vegetable matter; they should be round and firm, uniform in structure, and of such a size that the required number of yarn may be spun without an excessive attenuation, or drafting, of the roving during the spinning. As a rule, the longer the fiber, or the better the grade of stock, the greater is the draft that can be given in the spinning; short stock requires more roving to be delivered by the delivery rolls of the mule for every stretch of yarn. Low stock with from 50 to 75 per cent. of waste or shoddy mixed with it also necessitates less draft in spinning; the carder, therefore, must make the roving correspondingly lighter in weight to produce the required yarn. Certain wools also have much better spinning properties than others, owing to their fineness, elasticity, waviness, serrations, and other characteristics that determine the value of wools for different classes of goods. Such stock will spin much better and stand more draft than poorer material.

2. Quality of Roving.—There are, generally speaking, three kinds of roving spun into woolen yarn: (1) Roving made from inferior stock or from stock that is barely capable of spinning to the desired run; (2) roving that has been cut, rolled, or otherwise affected by poor carding; (3) roving that has been properly handled in all the previous processes and that will spin superior yarn.

Regarding the first class of roving little can be said, as it is so plainly inferior and the stock from which it is carded so short, broken, and generally unsuitable, that only uneven yarns irregular in structure and lacking in elasticity and strength can be made from it.

The second class is generally caused by carelessness. It is ordinarily expected that with a good grade of stock the product of the cards will, in spinning, be drawn out to twice the original length, thus greatly assisting in the removal of any possible lumps, bunches, or general irregularities. Good even roving can be easily drawn out to this length, or even more, but poor uneven roving, or that made from low stock, cannot.

The uneven bunches in roving of this class are a great hindrance in producing even yarn and require careful setting of the mule. The twist runs into the thin places in the roving first and twists them hard, thus forming twits in the yarn. At the same time there is a tendency of the mule to regulate uneven roving to a large extent, because as the thin places become twisted hard first they will not be drafted, or drawn out, while the bunches remaining soft are drawn out until they are nearly as small as the thin places, when the twist will commence to run into them. The spindles of the mule are turning all the time that the carriage is being drawn out and a certain amount of twist is put into the roving before the delivery rolls stop and the drafting action commences. Therefore, if the roving to be spun into yarn is full of bunches, it is a good plan to have the carriage come out slowly at first; this puts the twist into the thin places quickly and allows more time for the soft bunches to be evened up by the drafting. However, if roving contains very many large, uneven bunches, it is impossible to produce a perfectly even yarn, although the unevenness may be largely reduced in the spinning.

The third class of roving includes that which is well carded from good, even, sound wools and a round, even roving made. The mule will draw such roving to twice its original length, and even more, with very little trouble.

3. Operation of Spinning.—By the term **spinning** is meant a process that may be divided into three operations as follows: (1) The drafting of the roving, in order to reduce its diameter and increase its length until the desired size of yarn is obtained. (2) The twisting of the attenuated roving, in order to give the yarn sufficient strength to be woven; on woolen mules this is partly combined with the first operation mentioned, namely, drafting. (3) The winding of the yarn prepared by the previous operations on bobbins or in cops in suitable form for the succeeding operations of weaving or spooling.

THE MULE

ELEMENTARY PARTS

4. The machine used in woolen spinning for accomplishing the above results is, owing to its hybrid nature, known as a **mule;** and on account of its practically automatic action is called a **self-acting mule.** It may be divided into two parts, each being equally essential in performing the objects named in the formation of the woolen thread; namely, the *head*, or *headstock*, which receives the driving power and from which all the motions of the mule originate, either directly or indirectly, and which is stationary and connected to the delivery rolls for delivering the roving; and the *carriage*, which bears the spindles that perform the functions of drafting and twisting the roving into yarn and then winding it on bobbins placed thereon, and which is movable.

In order that the principle of spinning and the fundamental action of the mule may be understood, the essential movements of the machine will be described first without reference to the complicated mechanisms that produce the various motions.

5. Referring to Fig. 1*, the jack-spool a, on which the roving to be spun is wound, is placed on a rotating drum a_1,

*The same letters of reference are used in all the illustrations of the woolen mule where the same parts are shown. This will be found a great aid in reading the illustrations and in becoming familiar with the machine. Figs. 4 and 5 are illustrations of the front and rear of the machine and should be frequently referred to in order that separate mechanisms may be associated, wherever possible, with the whole machine.

which turns the spool and unwinds the roving, allowing it to be passed through the stationary guide a_2 to the delivery rolls a_3, a_4, a_5. Thence the roving passes directly to the spindle c_7 and is wound on a bobbin c_8 placed on it; that is, after the roving has been drafted and twisted into yarn.

The delivery rolls of the mule are composed of three parts; the two bottom rolls a_4, a_5 are driven from the head-stock, while the top roll a_3 is made in sections, each consisting of two bosses that rest on the bottom rolls. The bosses may be removed in order to replace rovings that become broken between the delivery rolls and the jack-spool.

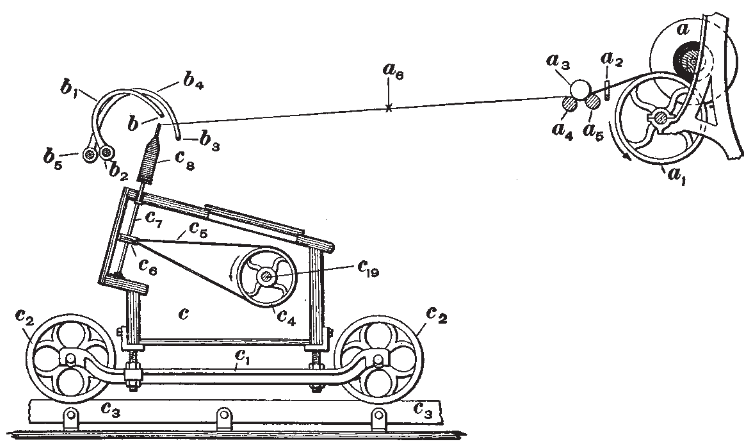


FIG. 1

Although only one spindle and one bobbin are shown, it must be remembered that each mule often contains as many as 280 or 300, and sometimes as many as 400.

The spindle c_7 is carried in two bearings—a bottom, or step, bearing and a top, or bolster, bearing. Between the bolster and the footstep, there is fixed on the spindle a small, grooved pulley c_6, called a *whorl*, that has an endless spindle band c_5 passed around it. This spindle band also passes around a tin cylinder c_4, called a *drum*, which supplies the motive power for turning the spindles by means of the spindle bands. The drum runs the full length of the carriage, each spindle having a separate band that passes around its whorl and around the drum. The spindle is not absolutely vertical, but is inclined at an angle toward the delivery rolls. The spindles and drum are borne in a frame, or carriage, c, that is carried by transverse supports c_1 in the ends of which are bearings for the carriage wheels c_2. The latter run on iron rails c_3, so that if power is applied to the carriage it can readily be moved to or from the delivery rolls.

The yarn passes under a wire b fixed in the *sickle* b_1, which oscillates with the shaft b_2; this wire is known as the *faller wire*, or more definitely, the *winding faller*. Its object is to guide the yarn on to the bobbins during the operation of winding. The yarn also passes above the wire b_3 that is attached to the sickle b_4, the sickle, in turn, being fastened to the shaft b_5. This is known as the *counter*, or *tension*, *faller* and is for the purpose of keeping tension on the yarn during the winding in order to prevent kinks and soft-wound bobbins.

6. Converting the Roving Into Yarn.—The method by which this mechanism produces yarn is as follows: The carriage is brought close to the delivery rolls, so that the points of the spindles are within a short distance of the point of contact between the delivery rolls where the yarn is delivered. As the delivery rolls combined with the drum a_1 begin to deliver the roving, the carriage simultaneously commences to recede from the rolls at practically the same speed as that at which the roving is delivered, and the spindles begin to rotate. When the spindles reach the point a_6, the position of which depends on the draft of the roving, the delivery rolls and the spool drums stop, but the carriage continues to recede until the points of the spindles are about 72 inches from the delivery rolls. By this means the roving is drafted, or drawn out, to twice its original length or thereabouts.

As these operations are taking place the twist is being put into the yarn by the rotating spindles; this is accomplished by the slipping of each turn of yarn over the end of the bobbin and spindle, which is due to the inclination of the latter; Fig. 2

illustrates this point. If the spindle were vertical and the point of delivery at the rolls a_3, a_4, a_5 level with any point on the bobbin c_8, the yarn would tend to be wound on the bobbin at that point when the spindle was put in motion. The spindle, however, is set at an angle and the point of delivery is slightly above the top of the bobbin; thus, when the spindle rotates, the yarn rises on the bobbin in a series of spiral coils, the tendency of the thread being to assume a position at right angles to the spindle, which would be at the point a_7, provided that the spindle and bobbin were long enough.

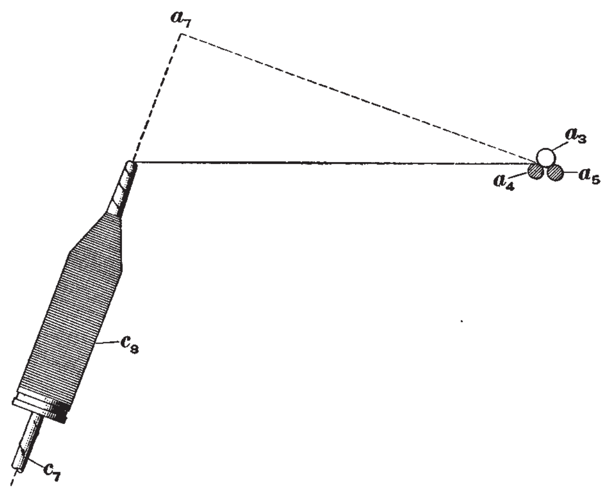


FIG. 2

The tendency of the yarn to rise continues until the top of the bobbin is reached, when the yarn slips over the end of the bobbin, thus putting in one turn of twist. As the spindle continues its rotation, each coil of yarn rises and slips over the end of the bobbin, thus putting as many turns of twist into the yarn as there are revolutions of the spindle.

It is the combined drafting and twisting action of the woolen mule that gives to the woolen thread its distinctive woolen formation, or covered appearance. In spinning other yarns, the roving is first drafted to the required size by means of two or more pairs of rolls, each successive pair running at an increased speed, and then twisted into yarn, the operations of drafting and twisting being entirely separate; in other words, the yarns are *roll drawn*. Woolen yarn, however, is drafted and twisted at one and the same time; the yarn being spoken of as *spindle drawn*, because the spindle draws the roving to the required size, while in the other case this is accomplished by means of rolls.

When the carriage reaches the end of its stretch—when the spindles are at their greatest distance from the rolls—it is stopped and is held while more twist is put into the yarn; the full amount of twist is not put in while the carriage is coming out, because if it were the yarn could not be drawn

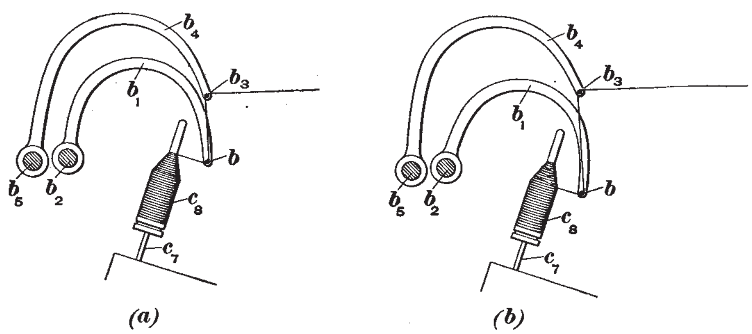


Fig. 3

out, but would break instead, since the twist gives the yarn strength and prevents the individual fibers from being drawn past each other as is necessary in order that the roving may be drafted. This extra twist is sometimes put in by means of an accelerated motion.

At the completion of the twisting motion, the spindle is stopped and reversed for a few turns, so that the few coils of yarn between the top of the bobbin (which is flush with the top of the spindle) and the yarn already spun, are unwound. This operation is technically known as *backing-off;* as it takes place the faller *b*, Fig. 1, descends and assumes a position for guiding the yarn on to the bobbin, while the counter faller b_3 ascends so as to obtain the requisite tension of the stretch of yarn for winding it on to the bobbin and to prevent the formation of kinks. The position of the winding and counter fallers after the backing-off takes place and just as the stretch of yarn is ready to be wound on the bobbin is shown in Fig. 3 (*a*).

Immediately after the backing-off is completed, the *drawing-in* of the carriage is commenced and the spindles are revolved in their normal direction so as to wind the yarn on to the bobbin as it is released by the inward run of the carriage. As this takes place the winding faller *b* first descends quickly to the position shown in Fig. 3 (*b*) and then rises slowly until it again assumes the position shown in Fig. 3 (*a*). The result of this is that the yarn is first wound on the bobbin in a series of coarsely pitched descending coils and then in a series of finely pitched ascending coils. Thus each stretch of yarn is wound on the bobbin in two layers, the coarsely pitched layer giving the bobbin strength and solidity and the finely pitched layer serving to place the remainder of the yarn in the stretch on the bobbin. This motion of the winding faller is regulated by what is known as the *builder rail*.

When the inward run of the carriage is completed, the winding operations cease; the winding faller and counter faller assume their normal positions clear of the yarn, Fig. 1, and the parts are again adjusted to begin the work of drafting and twisting. The complete outward and inward run of the carriage is technically called a *draw*.

7. The **driving** of the principal parts of the mule may be briefly stated as follows: The roving motion, i. e., the motion for the delivery of the roving, is driven by bevel gears and a cross-shaft from the headstock of the mule. The drum in the carriage, which imparts motion to the spindles, is driven by means of an endless rope, called the *rim band*, from grooved pulleys on the main shaft. The rim band, however, only drives the spindles while the carriage is coming out and while twist is being put into the yarn by the accelerated speed; when the yarn is being wound on the bobbin, the spindles are driven by the motion of the carriage, which unwinds a chain called the *quadrant chain* from a

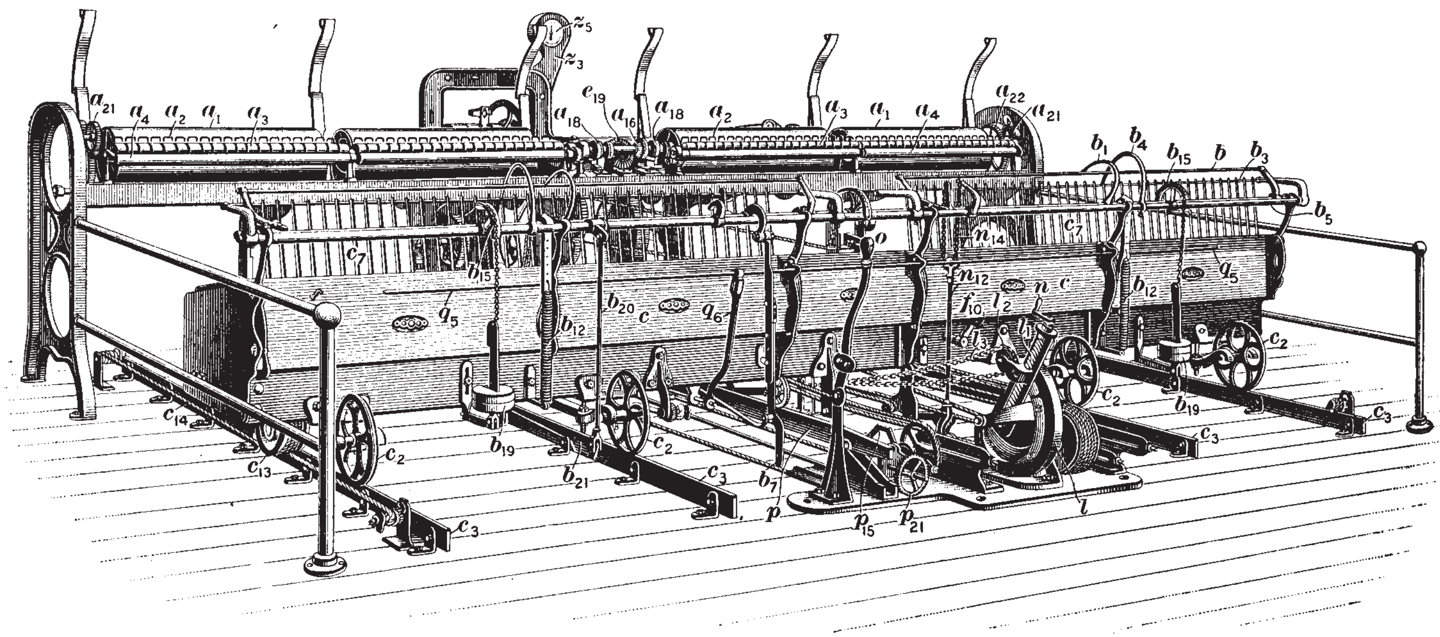


Fig. 4

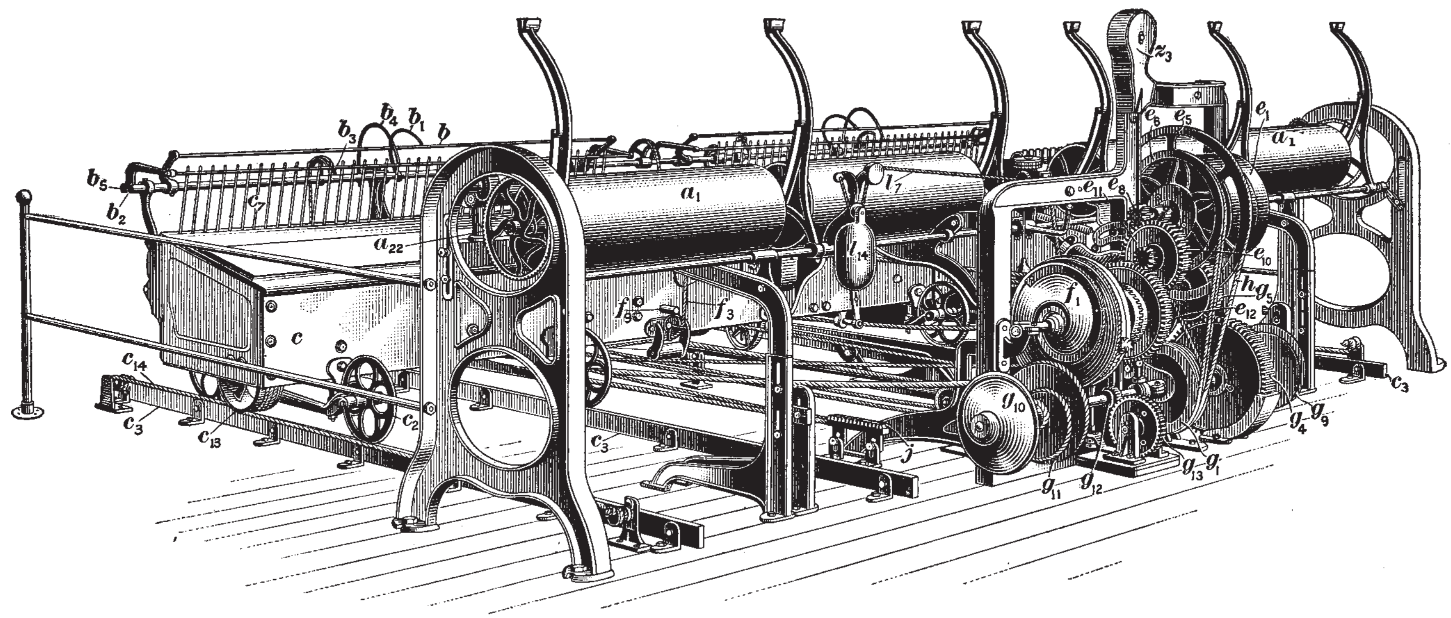
chain drum connected to the shaft of the drum that drives the spindles. The carriage is drawn out by means of a scroll on the drawing-out shaft of the headstock and is drawn in by means of two scrolls on the drawing-in shaft.

DETAILS OF CONSTRUCTION AND OPERATION OF THE MULE

8. Classification of Operations.—The brief description given enables the movements of the woolen mule to be classified as follows: (1) delivery of roving, (2) drafting and twisting, (3) backing-off, (4) winding, (5) reengagement. It is somewhat difficult to understand the movements of the various parts of the mule at different periods because of the fact that at one time a certain portion of the mechanism may be performing a certain function, while at another time it may be performing a totally different one, both the velocity and direction of its motion being changed. Each of the essential mechanisms of the mule will now be described in detail, and in studying these descriptions reference should be made not only to the illustrations of these various mechanisms, but also to other illustrations in which they may be incidentally shown, and also to Figs. 4 and 5, which show the positions of many of these parts and their relation to the mule as a whole.

9. Headstock.—As has been said, the mule consists of two parts, from one of which, the **headstock**, all other parts receive their motion. The sectional view shown in Fig. 6 illustrates the method of transmitting the power to the various mechanisms.

The main shaft e receives and transmits the motive power by means of which the various operations are performed, and is for this purpose provided with four pulleys e_1, e_2, e_3, e_4. These pulleys are commonly spoken of, in their respective order, as the first, or loose, pulley; the second, or drawing-in, pulley; the third, or drawing-out, pulley; and the fourth, or accelerated-speed, pulley. In addition, the main shaft also carries two grooved pulleys e_5, e_6 and three gears e_7, e_8, e_9.



b
b1
b3
b4
b5
b2
c7
c
c14
c3
c13
c2
a22
a1
f9
f3
l7
l14
z3
e6
e5
e1
a1
e11
e8
e10
h g5
e12
f1
g10
g11
g12
g13
g1
g4
g9
c3
j

Fig. 5

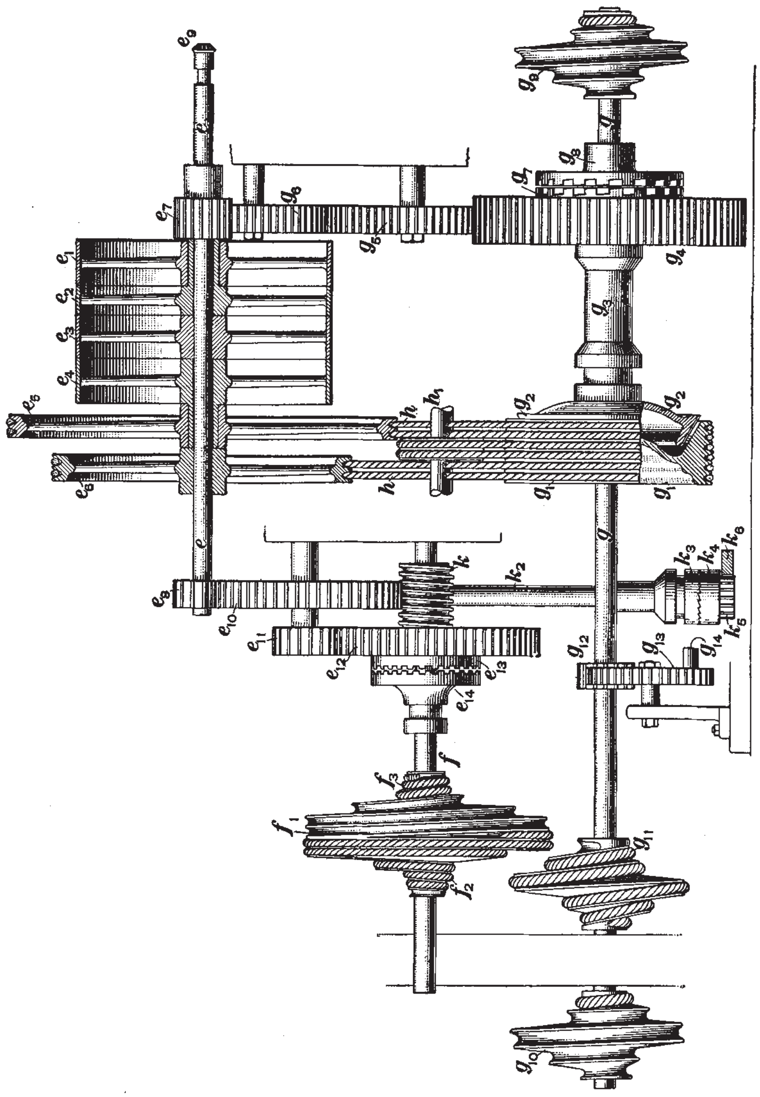


FIG. 6

The drawing-out pulley e_3, grooved pulley e_6, and gears e_8, e_9 are keyed to the shaft; the others are loose. The pulley e_2 is provided with a sleeve, on which the pulley e_1 runs loose but to which the gear e_7 is fastened; the grooved pulley e_5 is keyed to the sleeve of the pulley e_4. As a result of this arrangement, the pulley e_1 acts simply as a loose pulley and furnishes a resting place for the driving belt when motion is not being imparted to any part of the mule; the pulley e_2 imparts motion to the gear e_7; the pulley e_3, to the gears e_8, e_9 and the grooved pulley e_6; and the pulley e_4, to the grooved pulley e_5. It should also be noted that when the driving belt is on e_4 the pulley e_5 will drive the shaft e and, consequently, the gears e_8, e_9, by means of the rim band h, which passes around the grooved pulleys e_5, g_1, e_6; in this case e_6 is the follower and e_5 the driver. When the mule is not in operation the driving belt runs on the loose pulley e_1, from which it may be moved to the pulleys e_2, e_3, e_4 by means of a belt lever.

ROVING MOTION

10. At the commencement of the spinning operation, the carriage is in near the headstock so that the spindles are close to the delivery rolls, and as the mule is started, two motions are brought into play; namely, the *roving motion*, for delivering the roving, and the *drawing-out motion*, which causes the carriage to recede from the delivery rolls. The roving motion here described is so arranged that the delivery rolls and spool drums on one side of the mule may be stopped independently of those on the other side, thus allowing yarns of two sizes to be spun on the same mule, or allowing the same size yarn to be spun from two different run rovings. For this reason this motion is known as a *double roving motion*. The driving belt at the start is shifted from the loose pulley e_1 to the third pulley e_3, Fig. 6, and the power transmitted to the gear e_{12} through gears e_8, e_{10}, e_{11}. From the gear e_{12}, motion is communicated to the delivery rolls of the mule through gears e_{15}, e_{16}, and e_{17} and e_{19} on the cross-shaft e_{18}, as shown in Fig. 7.

Fig. 8 is a plan view of this double roving motion, while Fig. 9 is a side elevation of one side of the same mechanism, representing Fig. 8 as it will appear when looked at in the direction of the arrow. The bevel gear e_{19} meshes with another bevel gear a_{16}, which, together with the halves a_{15} of two toothed clutches, is fastened to a sleeve a_{13} that is loose

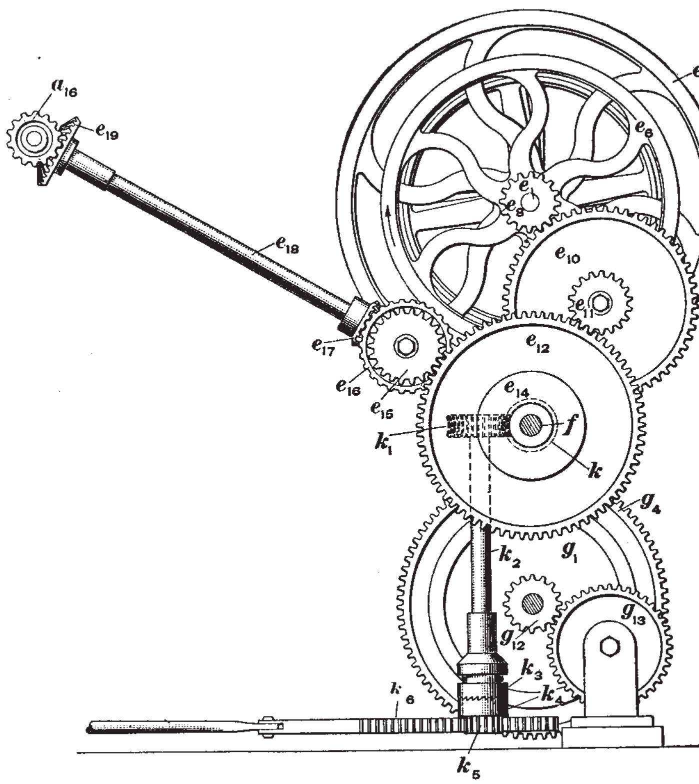


Fig. 7

on the shaft of the rear bottom delivery roll a_5. When these clutches are out of contact, as shown in Fig. 8, no motion is imparted to the delivery rolls of the mule, but when the parts a_{14} are moved in contact with the parts a_{15}, by the yoke levers d_2, the motion of the gear a_{16} is imparted to the rear delivery roll a_5 and also through the gears a_9, a_{10}, a_8, to the

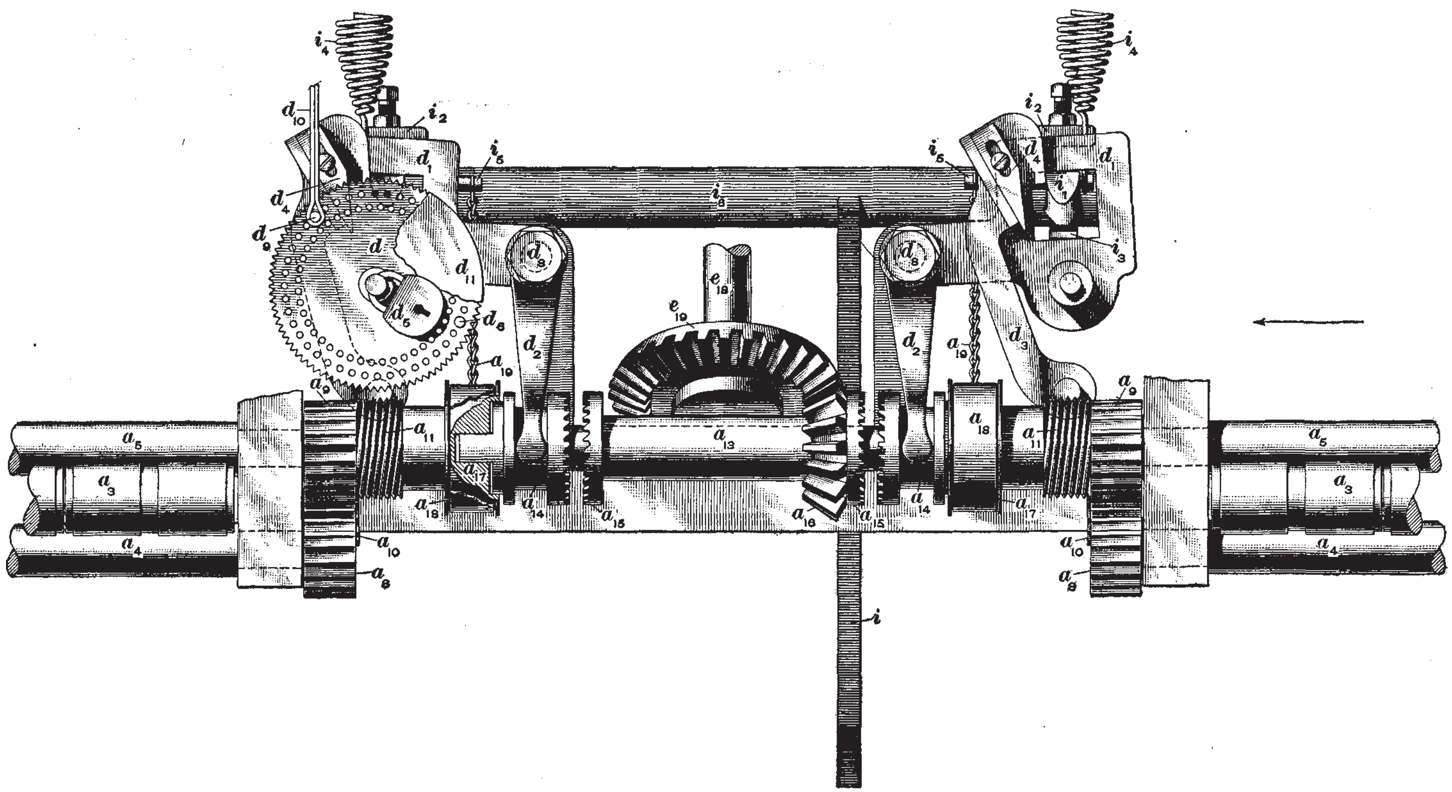


FIG. 8

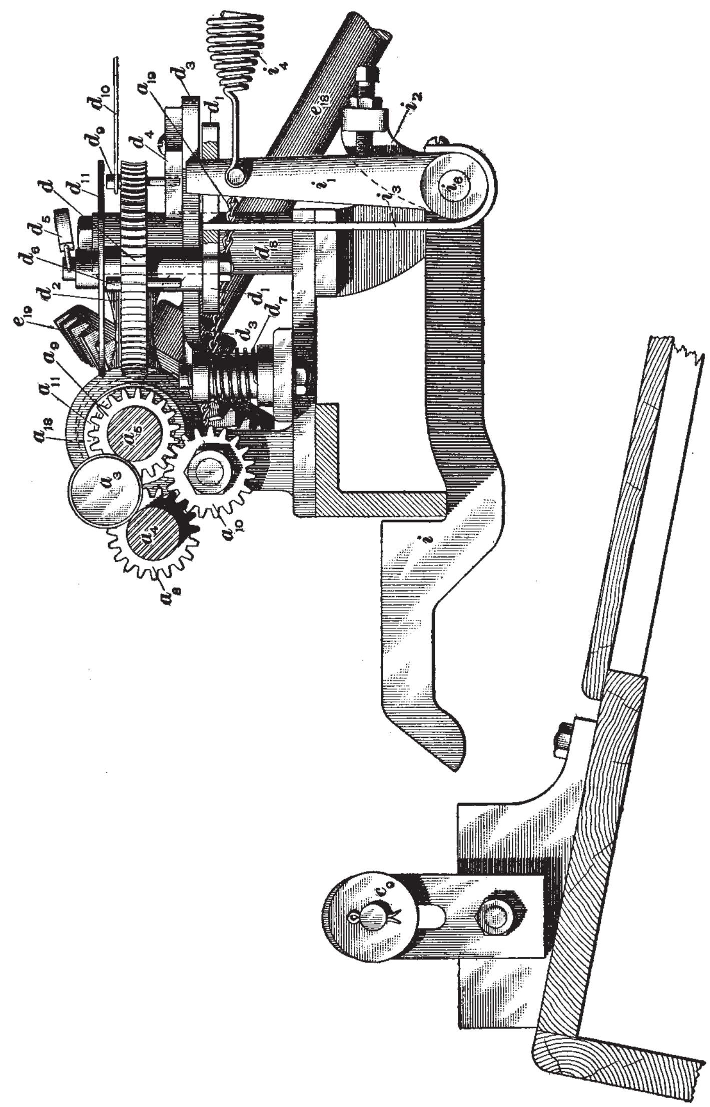


Fig. 9

front delivery roll. The halves a_{14} of the clutches have two projections extending into slots in the brake bosses a_{17}, so that although they are free to be moved along the shaft so

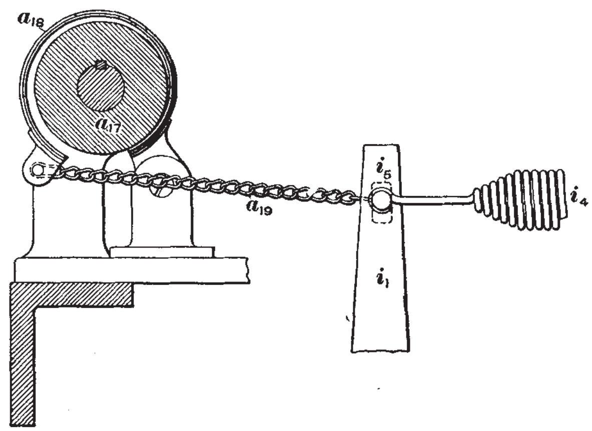


FIG. 10

as to engage with a_{15}, they will impart motion to a_6 when so engaged. The top roll a_3, which consists of loose bosses,

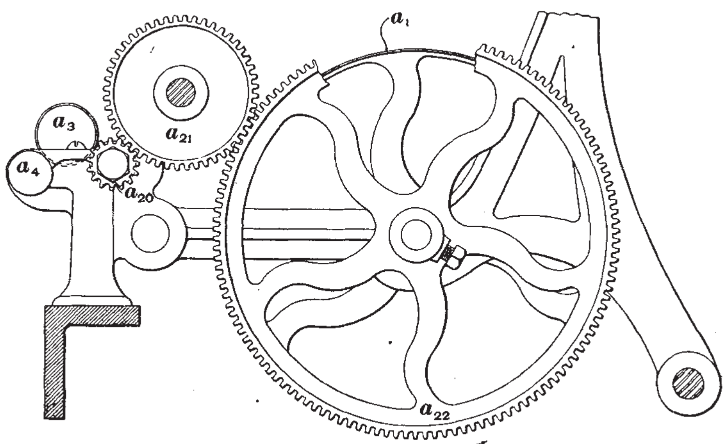


FIG. 11

is not driven positively, but receives its motion from the two bottom delivery rolls, on which it rests, being thus rotated only by frictional contact with the bottom rolls. The spool drums, which carry the spools of roving and unwind it as it is taken by the delivery rolls, are geared from the shaft of the rear delivery roll at each end of the machine. As shown in Fig. 11, a gear a_{20} drives an intermediate gear a_{21} that in turn imparts motion to the gear a_{22} and spool drums a_1. The gear a_{20} is a change gear and may be changed in size if in any case the spool drums unwind the roving faster or more slowly than it is taken by the delivery rolls. The motion of the delivery rolls is of necessity intermittent, since the roving is delivered during only a portion of the time that the carriage is receding from them; this is necessary so that the drafting of the roving may take place in order to reduce its size and produce yarn of the required run.

11. The motion of the delivery rolls and spool drums may be checked by means of the *roving stop-motion*, Figs. 8 and 9, at any point, so that any desired length of roving may be delivered for each draw of the mule. The point at which the delivery rolls stop, and consequently the length of roving delivered, is regulated by means of a roving-pin gear for each side of the mule; the pin gear d for the left-hand side is shown in Fig. 8, while the other is removed in order to show the mechanism of the stop-motion more clearly. The yokes d_2, which operate the sliding portions a_{14} of the delivery-roll clutches, and the castings d_1, which carry the roving-pin gears, are rigidly fastened together, and are fulcrumed at d_8; thus, if motion is imparted to them the clutches will be thrown in contact and the roving-pin gears moved forwards so as to mesh with the worms a_{11}, which are fastened to the shaft of the rear delivery rolls a_5. This is accomplished each time that the carriage comes in to the delivery rolls by means of a roll c_9, Fig. 9, that presses down a lever i cast in one piece with the shaft i_6. The motion of this shaft is imparted to the finger i_1 and a strong, flat spring i_3 by means of the casting i_2, which is cast in one piece with the shaft i_6 and carries a setscrew by means of which the finger i_1 may be adjusted. As the spring i_3 moves forwards, it moves the casting d_1 and yoke d_2 around the fulcrum d_8, thus forcing and holding together the parts a_{14}, a_{15} of the delivery-roll clutch, and also holding the roving-pin gear in contact with the worm a_{11}. As the finger i_1 is moved it is caught and held against the tension of the spring i_4 by a dog d_3 that is constantly pressed against it by means of a coil spring d_7 on the stud on which it is fulcrumed. Motion being imparted to the gear a_{16} as described, the delivery rolls and also the roving-pin gears are rotated. This motion continues until a pin d_6 placed in a hole in the roving-pin gear comes in contact with a wedge-shaped piece of steel d_4 screwed to the dog d_3. When the pin strikes this wedge, the dog is forced from contact with the finger i_1 and a strong spring i_4 attached to the finger pulls it backwards, thus moving the casting d_1 and yoke d_2 and disengaging the delivery-roll clutches and roving-pin gears, so that the motive power is withdrawn.

12. In order that the delivery rolls may stop instantly when the power is withdrawn, friction brakes are applied at the same time, thus checking any momentum that the rolls may have and also firmly locking them in place until they are ready to deliver the roving for another draw of the carriage. These brakes are shown in Figs. 8 and 9 and also, in detail, in Fig. 10. A boss a_{17} that is fastened to the shaft of the rear delivery roll is encircled by a friction strap a_{18}, one end of which is fastened to the framework of the mule, while the other is attached, by means of a short length of chain a_{19}, to the stud i_5 on the finger i_1; thus, as the finger i_1 is pulled backwards by the spring i_4 to disengage the roving motion, it also tightens the chain a_{19} and applies the brake to the delivery rolls.

A strap d_{10} is fastened by a pin d_9 to the roving-pin gear and is carried back over a small pulley. At the end of this strap is attached a weight that revolves the pin gear in the opposite direction as soon as it is released from the worm, thus bringing it back to its initial position, with the pin d_9 resting against the back of the wedge d_4.

In order to prevent tampering with the roving-pin gears, a circular plate d_{11}, partly shown on one side in Fig. 8, is placed over them and fastened with a small padlock d_5. With this plate in position it is impossible for the pin d_6 to be moved from one hole to another or be accidentally displaced.

13. Each roving-pin gear contains two rows of holes with 44 holes in a row. Those in the outside row are known as *full holes*, while those in the inside row, as each is placed between 2 holes of the outside row, are known as *half holes*, since it is possible by their use to obtain an adjustment of the length of roving delivered equal to one-half that obtained by moving the pin 1 hole in the outside row. The setting of the pin d_6 so as to deliver any desired length of roving before the delivery rolls of the mule stop is determined by the fact that for each full hole in the roving gear $2\frac{1}{2}$ inches of roving is delivered, while for each half hole $1\frac{1}{4}$ inches is delivered; that is, by changing the pin from a full hole to an intermediate half hole or from a half hole to the next full hole the length of roving delivered is varied $1\frac{1}{4}$ inches. This may be easily proved by figuring from the diameter of the delivery rolls, as follows: The diameter of the delivery rolls is $1\frac{3}{16}$ inches; therefore, their circumference is $1\frac{3}{16}$ inches $\times 3.1416 = 3.73$ inches. The worm a_{11} is triple-threaded, and consequently moves the roving gear 3 teeth to each revolution of the delivery roll. The roving gear contains 88 teeth and 44 full holes; therefore, 2 teeth in the gear are equal to 1 full hole, and 1 full hole is equal to two-thirds of a revolution of the delivery roll; that is, two-thirds of 3.73 inches, or practically $2\frac{1}{2}$ inches. A half hole of course is equal to one-half of $2\frac{1}{2}$ inches, or $1\frac{1}{4}$ inches.

Knowing the length of roving controlled by each hole in the roving gear, the number of holes to be allowed can be easily ascertained after the desired length of roving to be delivered has been found. For instance, suppose that 40 inches of a certain run roving must be delivered to spin yarn of a required run and it is desired to ascertain how many holes to allow in the roving-pin gear to deliver this amount of roving. All that is necessary is to divide 40 by $2\frac{1}{2}$, which will give 16 holes as the number to allow. With soft roving, however, it is very difficult to figure exactly how many holes will be necessary, but the above method will approximately give the correct result, and then if the yarn spun is too light or too heavy, the pin can be changed a half hole or a full hole, etc., as may be required. If it is desired to change the roving-pin gear so as to spin yarn of different run from the same run roving, or so as to spin the same run yarn from a different run roving, the number of holes to allow may be found by proportion. For instance, suppose that with a certain run roving 18 holes give $2\frac{1}{2}$-run yarn and it is desired to spin 3-run yarn. Letting x represent the number of holes that must be allowed, the proportion is $3 : 2\frac{1}{2} = 18 : x$; x is therefore 15, and 15 holes must consequently be allowed in the roving gear to spin 3-run yarn from that particular run roving. For another example, suppose that with an allowance of 20 holes in the roving gear a mule is spinning a certain run yarn from $2\frac{1}{2}$-run roving and that it is desired to spin the same run yarn from 2-run roving. The number of holes to allow in the roving gear to accomplish this may be found by the following proportion: $2\frac{1}{2} : 2 = 20 : x$; x is therefore 16—the number of holes required.

DRAWING-OUT MOTION

14. The **drawing-out motion** is in operation at the same time that the roving motion is delivering the roving, and causes the carriage to recede from the delivery rolls so as to draft and twist the roving into yarn. The driving belt during this period is in contact with the third pulley and imparting motion to the gear e_{12}, Fig. 6. Attached to the gear e_{12} is one-half e_{13} of a toothed clutch; the other half e_{14} may slide along a key on the shaft f so as to engage with e_{13}, in which case motion will be imparted to the shaft f and to the draft scroll f_1 fastened to it. The draft scroll is made with two separate and opposite scrolls, to one of which the rope f_2 is attached, as shown in Fig. 12. This rope, or

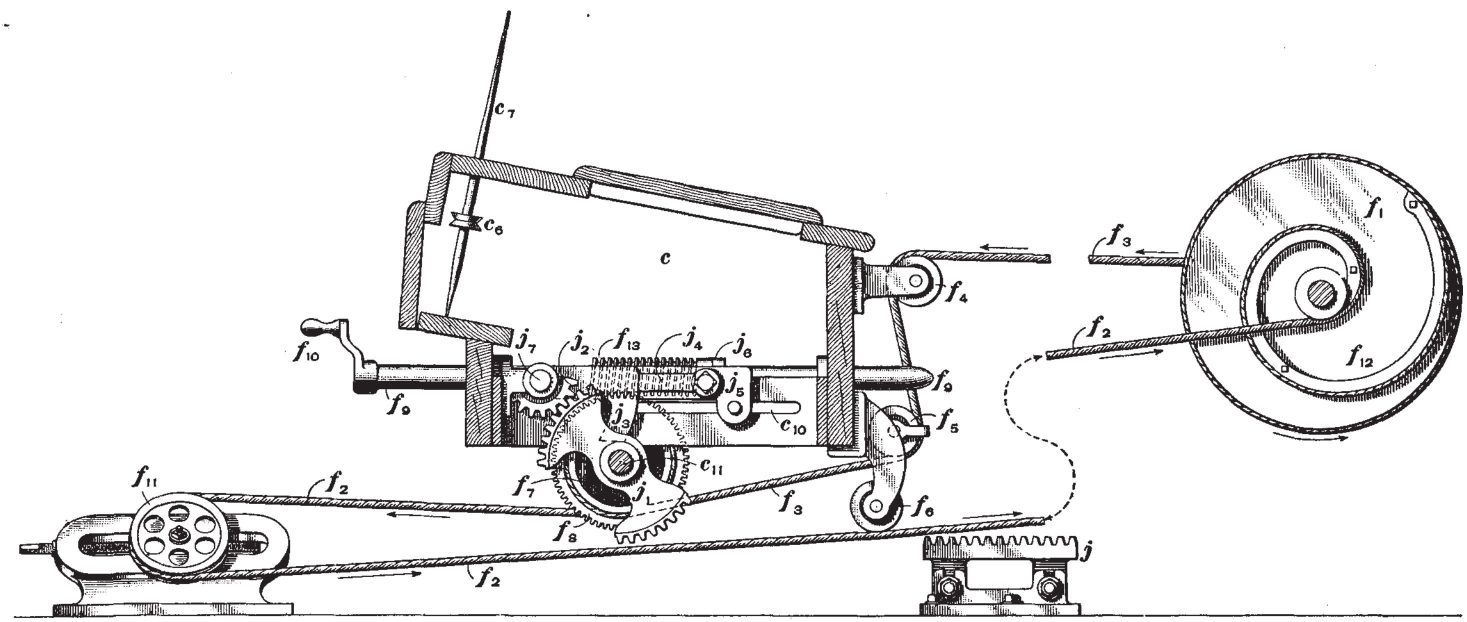

c7
c6
c
f3
f1
f4
f2
f12
f10
j7
j2
f13
j4
j6
j5
f9
f9
c10
f5
j3
f11
f2
c11
f7
j1
f3
f6
f8
j
f2

Fig. 12

band, as it is called, passes from the scroll around a binder pulley f_{11} and is attached to the carriage. As the middle part of the rope f_2 is omitted, a dotted arrow has been inserted to indicate the connections between the two ends. The binder pulley is movable in a slotted casting attached to the floor and is adjusted by means of a screw, to which a crank-handle may be attached for the purpose of tightening the band. Another rope f_3 is attached to the other scroll and is also attached to the carriage. These ropes are so connected with the scrolls that when the rope on one scroll is winding up, it is unwinding on the other. The result is that when one scroll is full, as the front one in Fig. 12, the other is empty. In Fig. 6 also the scroll f_1 has been shown in this condition. The diameters of the active parts in both scrolls, however, are always equal; otherwise, one of the ropes f_2 or f_3 would at certain times either be slack or too tight. Therefore, when the rope f_2 is winding up on the small diameter of its scroll, the rope f_3 is unwinding from the small diameter of the other scroll, and vice versa. The greater the diameter of the active part of the scroll, the greater will be the speed of the rope and, consequently, that of the carriage. When the carriage is being drawn out, the band f_2 is being wound up on the scroll and, as it passes over the binder pulley f_{11} and is attached to the carriage, it is this band that really draws out the carriage. The other band f_3 on the draft scroll has no real function in connection with actually drawing out the carriage, but simply furnishes a positive connection between the draft scroll and the carriage. This prevents any liability of the momentum of the carriage carrying it forwards faster than it is drawn out by the draft scroll and rope f_2; prevents the draft scroll from overrunning when the carriage comes in again; and also enables the position of the draft scroll to be changed, as will be explained later.

15. In order fully to appreciate the method adopted for drawing out the carriage by means of a draft scroll, it is well to understand the reason for its adoption. In the first place, the carriage moves out very fast in the first part of its motion, in order to keep pace with the delivery of roving by the delivery rolls of the mule. When the delivery of roving stops, the speed of the carriage is immediately checked, and spinning, or the combined drafting and twisting of the roving, commences. Such an action is necessary for the carriage, since, if it commenced the draw by moving slowly, there would be so much twist put into the roving at the start, before it was drafted, or drawn out, at all, that it would be impossible afterwards to draw it to the required size of yarn. The variable speed thus necessitated is provided for by the draft scroll.

When the mule is started, the rope f_2 is on the large diameter of the scroll, at its center, and the carriage is thus given the speed necessary for keeping the delivery of roving at the required tension. As the delivery of roving is stopped, however, the drawing-out band commences to be wound down on the smaller part of the scroll, so that the speed of the carriage is gradually checked, thus allowing for the drafting and twisting of the roving. The carriage runs very slowly when near the end of its outward movement. The point at which the speed of the carriage is slowed by allowing the drawing-out band to wind on the smaller part of the scroll is controlled by the position of the scroll, which is regulated to suit different conditions of stock and roving.

16. The band f_2, Fig. 12, after passing around the binder pulley f_{11} is attached to a drum f_7, which is loose on the shaft c_{11}. The band f_3 passes over guide pulleys f_4, f_5 attached to the carriage, and is also fastened to the same drum as the band f_2, but is wound on it in the opposite direction. In the center of the drum f_7 is a worm-gear f_8 that engages with a worm f_{13} fastened to a shaft f_9. This worm may be turned by means of the crank f_{10}, which will rotate the drum f_7, winding up the band f_2, and unwinding the band f_3, or vice versa. This changes the position of the draft scroll relative to that of the carriage. It is sometimes desirable to do this, in order to adapt the drafting, or the speed of the carriage during the earlier part of its movement, to the particular stock in hand. For instance, if roving that will not admit of much drafting is being spun and an extra amount of roving is being delivered, it will be desirable to turn the drum f_7 in such a direction that the band f_2 will start to wind on the draft scroll in such a position that a greater length of time will be required before it commences to wind down on the low part of the scroll, thereby making the carriage move rapidly for a greater distance at the start. This has the effect of allowing less twist to run into the roving before the drafting of the roving into yarn commences. This means of adjustment is only used, however, where a small change in the speed of the carriage is desired. The position of the draft scroll may be changed while the carriage is coming out or while the accelerated speed is in operation, but should not be changed while the carriage is in and the clutch e_{13}, e_{14}, Fig. 6, locked, as this puts an extra strain on either band f_2 or f_3 while the other becomes slack; this is apt to strip the teeth from the worm-gear f_8.

The small roll f_6, supported by brackets fastened to the frame of the carriage, prevents the drawing-out band from chafing on the carriage when it is in.

The part of the draft scroll where the drawing-out band winds down on to a smaller diameter, and where the speed of the carriage is thus checked, is composed of a flat, malleable-iron spiral, or wing, f_{12} that is bolted or screwed to the side of the scroll, so that it can be removed and a wing of different shape substituted, to accommodate the speed of the carriage to any particular stock. The draft scroll is the only scroll that needs removable wings, as this scroll controls the motion of the carriage while the yarn is being spun, during which the character of the resulting yarn and the ease with which it is spun is largely dependent on the motion of the carriage.

17. The drum f_7 is made in halves that are provided with toothed ends, which lock them together after the manner of a toothed clutch; a coil spring on the shaft c_{11} presses the halves together and thus keeps them locked. Cast in one piece with the half on which the band f_5 is wound is the worm-gear f_8. The object of this arrangement is to allow an adjustment, in addition to the movable sheave f_{11}, for taking up the slack of the drawing-out bands as they stretch through wear. If the sheave f_{11} has been moved as far as possible and the drawing-out bands are still slack, the sheave may be moved back, so as to slacken the bands as much as possible, and then the two halves of the drum f_7 separated and the shaft f_9 rotated by the handle f_{10} until all the slack is taken out of the bands; this still allows a full length of travel of the sheave f_{11} for further adjustment of the tension of the drawing-out bands should they continue to stretch.

DWELL MOTION

18. The object of the **dwell motion** is to afford relief to the roving as the carriage starts away from the delivery rolls, since there is a tendency for the carriage slightly to strain the roving at this point, owing to the fact that it tends to start rather abruptly on its outward journey. As no twist has as yet been inserted in the roving, it is also more liable to be strained at this time than at any other. The dwell motion, therefore, is an important mechanism, especially if the roving is soft and tender, since it prevents twits and unevenness in the yarn that would otherwise be unavoidable except with very strong roving. This relief is given the rovings by causing the carriage to dwell for an instant before attaining its maximum speed, which necessarily occurs during the first part of its motion away from the delivery rolls. The dwell motion is shown in detail in Fig. 13, but, as shown in Fig. 12, is really a part of the drawing-out motion.

In Fig. 13, the various parts of the dwell motion are shown in the positions that they assume when the carriage is drawn in, just previous to its outward journey. The shaft f_9 is free to move for a limited distance in the direction of its axis; that is, it may be thrust forwards or backwards, carrying with it the worm f_{13} and thereby imparting a slight motion to the worm-gear f_8 and drum f_7. The effect of this motion therefore is the same as though the crank f_{10} were turned, with the exception that the effect is not permanent, as will be explained. A rack j is fastened to the floor in such a position that as the carriage reaches the end of its inward motion and approaches the delivery rolls it is engaged by a segment gear j_1 that is loose on the shaft c_{11}. As this segment gear engages with the rack the motion of the carriage imparts a movement to it that is transmitted to the segment gear j_2 and shaft j_7, to which j_2 is fastened. An

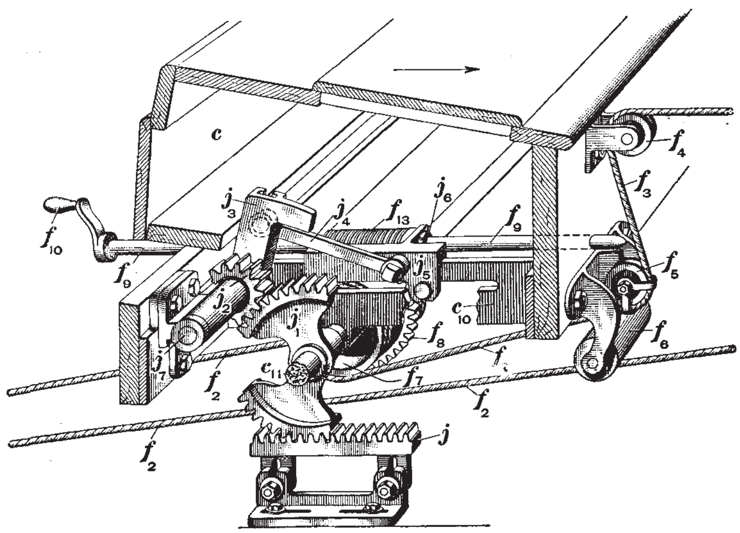


FIG. 13

arm j_3 is also attached to the shaft j_7 and is connected by a link j_4 to a slide j_5 that is free to move in a longitudinal direction on a girt c_{10} extending from the front to the back of the carriage frame. This slide is connected to the shaft f_9 by an extended arm fitting between the worm f_{13} and a collar j_6 setscrewed to the shaft. The effect of the motion imparted to the segment gear j_2 is to turn the shaft j_7 and raise the arm j_3, as shown in Fig. 13, which results in the connecting link j_4 drawing the slide j_5 and, therefore, the shaft f_9 and worm f_{13} forwards, or toward the front of the carriage. This imparts a slight motion to the worm-gear f_8 and drum f_7, and thus winds up a short length of the band f_2 and likewise unwinds some of the band f_3. Normally, that is, when the carriage is away from the delivery rolls and the segment gear j_1 disengaged from the rack j, the arm j_3 is lowered and, as it rests on the link j_4 just below the dead center, it locks the shaft f_9 in its backward position; that is, in a position thrust away from the front of the carriage.

The way in which this mechanism imparts an initial dwell to the carriage is as follows: When the carriage is drawn in, the segment gear j_1 engages the rack and moves the drum f_7, raising the arm j_3, as shown in Fig. 13. As the carriage starts on its outward motion the draft scroll commences to wind up the rope f_2, but instead of drawing out the carriage, the initial movement of the rope f_2 turns the drum f_7, thus forcing the worm f_{13}, shaft f_9, and slide j_5 from the front of the carriage, drawing down the link j_4 and arm j_3 to their locked positions, and, through the segment gear j_2, imparting a motion to the segment gear j_1 in the opposite direction to that imparted by the rack j. The result of this is that the movement of the segment gear against the stationary rack imparts a slow movement to the carriage until the arm j_3 is lowered to its locked position and the segment gear is clear of the rack, whereupon the full speed will be imparted to the carriage by the draft scroll in the ordinary manner. All this movement is accomplished in a comparatively short time, but it allows just sufficient dwell at the start of the outward movement of the carriage to prevent any undue strain on the roving. More or less dwell may be given by raising or lowering the connecting link j_4 in the slotted casting j_3, which allows more or less thrust to the shaft f_9 and worm f_{13} and, consequently, a greater or less movement to the drum f_7.

SQUARING BANDS

19. It is impossible to construct the carriage of the mule so that it will be perfectly rigid, on account of its great length; consequently, since it is driven in the center only, there is a tendency for the carriage to warp so that the spindles will not form a line parallel to the delivery rolls. This tendency, which exists when the carriage is being drawn in as well as when it is being drawn out, is overcome by means of squaring bands. Several drums, one of which, c_{13}, is shown in Fig. 4, are keyed to a shaft that is carried in bearings just beneath the carriage and extends its whole length. The number of drums placed on this shaft depends on the length of the carriage, but generally there are three, one at each end and one in the center. A rope, or band, c_{14}, Fig. 4, is wrapped several times around each drum to prevent any slipping; one end of the band is fastened to a casting bolted to the floor at the front of the mule, while the other is fastened to a similar casting at the back of the mule.

As a result of this arrangement, whenever the carriage moves, the motion of any one portion is immediately transmitted by the shaft to each drum and squaring band, so that all parts of the carriage will move in unison. In order to work properly the squaring bands must be kept tight; this may readily be accomplished by means of ratchets and pawls attached to the castings to which the bands are fastened.

DRIVING OF SPINDLES

20. During the time that the carriage is receding from the delivery rolls, and also while the twist is being placed in the yarn by the accelerated speed, the spindles are being turned by a rope h, known as a **rim band,** which is driven by means of the two grooved pulleys e_5, e_6, Figs. 6, 7, 14, and 15, on the main shaft e. The spindles are, of course, turning all the time that the carriage is being drawn out, being driven in this case by the smaller grooved pulley e_6, which is fast on the main shaft e, as is also the third

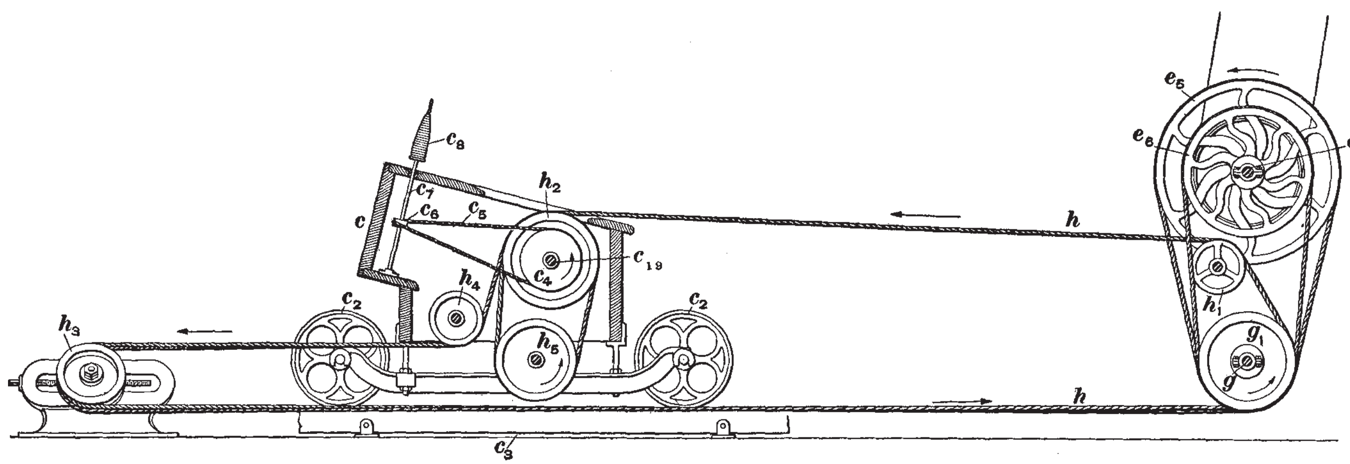


FIG. 14

pulley e_3, to which the belt is at that time furnishing the power for drawing out the carriage. While the rim band is driven by the smaller grooved pulley e_6, the larger grooved pulley e_5 is simply a follower; but when the carriage is drawn out to its full extent, the driving belt is shifted from the third

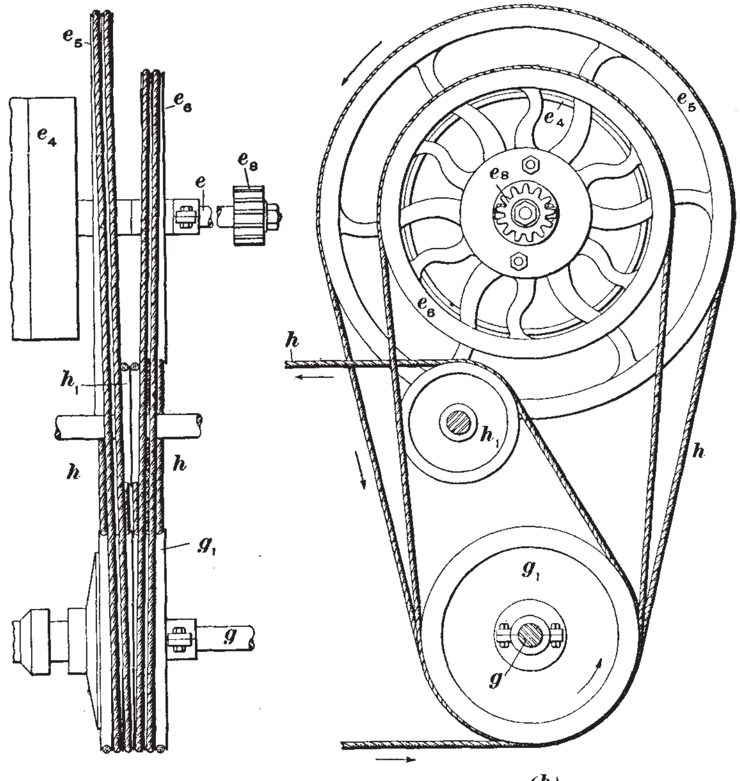


FIG. 15

to the fourth driven pulley e_4, and the rim band is driven by the larger grooved pulley e_5, the smaller grooved pulley e_6 being a follower. In this case motion is imparted to the main shaft e by e_6, since e_4 and e_5 are both loose on the shaft. When the larger grooved pulley is the driver, the spindles are driven at a higher velocity than when the smaller grooved pulley is the driver; this is called the **accelerated speed** and is for the purpose of saving time in putting in the requisite amount of twist after the yarn is drafted. The rim band in this mule is carried through the machine twice, and is known as a *double rim band*. Besides the grooved pulleys on the main shaft, the rim band is passed around a grooved pulley g_1 on the drawing-in shaft g, by means of which the direction of rotation of the spindles is reversed when the carriage backs off. It is also passed around the guide pulleys h_1, h_4, h_5, Fig. 14, around the grooved pulley h_2 on the drum shaft of the carriage, by means of which the motion is communicated to the spindles, and around a binder pulley h_3 that may be moved in a slotted stand attached to the floor for the purpose of adjusting the tension of the band.

21. The driving pulleys e_5, e_6, Fig. 6, on the main shaft are each made in different sizes, so that almost any speed of the spindles may be obtained without altering the speed of any other part of the machine. The slow-speed, or smaller, grooved pulley e_6 is made 11, 12, 13, 14, 15, 16, 17, 18, or 19 inches in diameter, while the fast-speed pulley e_5 is usually made 19, 21, or 22 inches in diameter. The grooved pulley h_2 on the center, or cylinder, shaft of the carriage is 10 inches in diameter. The spindle-band cylinder c_4, Fig. 14, is usually about $6\frac{1}{4}$ inches in diameter and the whorl c_6 on the spindle, 1 inch.

22. In order to find the speed of the spindles, therefore, the following rules are necessary.

To find the speed of the spindles when the driving belt is on the third pulley:

Rule I.—*Multiply the revolutions per minute of the main shaft by the diameter of the smaller grooved pulley and by the diameter of the spindle-band cylinder; divide the result thus obtained by the product of the diameter of the driven grooved pulley on the cylinder shaft and the diameter of the whorl on the spindle.*

EXAMPLE 1.—The main shaft e, Fig. 14, makes 320 revolutions per minute and the smaller grooved pulley e_6 is 18 inches in diameter; the driven grooved pulley h_2 on the cylinder shaft in the carriage is 10 inches in diameter; the cylinder c_4 is $6\frac{1}{4}$ inches; and the whorl c_6 on the spindle is 1 inch in diameter. What are the revolutions per minute when the driving belt is on the third pulley?

SOLUTION.— $\frac{320 \times 18 \times 6\frac{1}{4}}{10 \times 1} = 3{,}600$ rev. per min. of spindles.

To find the revolutions per minute when the belt is on the fourth pulley and twist is being put in the yarn by the accelerated speed:

Rule II.—*Multiply the revolutions per minute of the main shaft by the diameter of the larger grooved pulley and by the diameter of the spindle-band cylinder; divide the result thus obtained by the diameter of the driven grooved pulley on the cylinder shaft multiplied by the diameter of the whorl on the spindle.*

EXAMPLE 2.—What would be the accelerated speed of the spindles in the mule given in example 1, if the larger grooved pulley e_6 were 22 inches in diameter?

SOLUTION.— $\frac{320 \times 22 \times 6\frac{1}{4}}{10 \times 1} = 4{,}400$ rev. per min. of spindles.

In the case of example 1, the spindles would revolve from 1 to 2 per cent. more slowly than figured, owing to the carriage and the rim band traveling in the same direction. This does not happen when the accelerated speed is on, because the carriage is drawn out to the full extent before the belt is shifted on to the fourth pulley. However, in a machine of so complicated a nature as the mule, there is more or less slippage and loss of power, and it is therefore customary to deduct 5 per cent. from the foregoing results in each case, in order to approximate the actual speed of the spindles. This also allows for the fact that the diameter of the whorl and drum should be taken at points representing their effective diameters; that is, for more accurate calculations the thickness of the spindle band should be added to the diameter of both the tin drum and the spindle whorl.

23. Since the rim band is a continuous band running through the machine twice, in different grooves on the same pulleys, it must necessarily be crossed at some point, in order to bring it back to its starting place. If the band were not crossed it would necessitate the use of two bands running side by side and having two splicings, whereas the crossing of the band makes only a single splice necessary. The rim band is crossed, as shown at Fig. 14, between the binder pulley h_3 and the grooved pulley g_1 on the drawing-in shaft.

The band runs in the direction indicated by the arrows on Fig. 14 during the slow speed of the spindles; that is, while it is driven by the pulley e_6, and also while the spindles are being driven at an accelerated speed by the large grooved pulley e_5. During the backing-off of the spindles, however, the rim band is driven by the grooved pulley g_1 on the drawing-in shaft and its direction reversed, in order to reverse the motion of the spindles and wind the yarn down the bobbin previous to winding the stretch of yarn on it.

Fig. 15 (*a*) is a view of the rim band as it appears from the front, or carriage, side of the mule, showing the method of passing the band around the driving pulleys, and Fig. 15 (*b*) is a side view of same. The part of the rope that passes from the right-hand groove of the pulley h_3, Fig. 14, passes to the left-hand groove of the pulley g_1, Fig. 15 (*a*). From this pulley the rope passes around the larger grooved pulley e_5, then back around g_1, then around e_5, then around g_1, until it finally passes over the grooved guide pulley h_1 to the carriage. The other part of the rope, which is in the left-hand groove of the pulley h_3, Fig. 14, passes to the right-hand groove of the pulley g_1, Fig. 15 (*a*), and then around the pulley e_6 in the same manner as the rope on the other side was passed around e_5, both parts of the rope emerging together over the pulley h_1 between the ropes passing from e_5 and e_6 to g_1.

Occasionally the rim band will fly from the pulleys, especially if it is run too slack. When replacing it, first be sure that it is crossed; then, commencing on the outside grooves of the pulley g_1 on the drawing-in shaft, pass the ropes around e_5, e_6, constantly working toward the center from each side until the ropes finally come together over the guide pulley h_1.

EASING-UP MOTION

24. The **easing-up motion** is in operation during the time which the accelerated speed is putting the twist into the yarn. When twist is put into yarn, the yarn grows shorter in length, or, as the effect is technically designated, the yarn *takes up*. Thus, while the accelerated speed is rapidly putting twist into the stretch of yarn, there must be some method of moving the carriage inward slightly, in order to accommodate the twist and ease the tension that the twist generates between the spindles and the delivery rolls. This necessary easing, or drawing in, of the carriage is performed by the easing-up motion, which, as shown in Figs. 6 and 7, derives its motion primarily from the drawing-out gear e_8, which in this case receives motion from the pulley e_4 that is fastened to the pulley e_5 but is loose on the shaft e; the motion is transmitted by means of the rim band h from the pulley e_5 to e_6. The gear e_8 through the gears e_{10}, e_{11}, e_{12}, and clutch

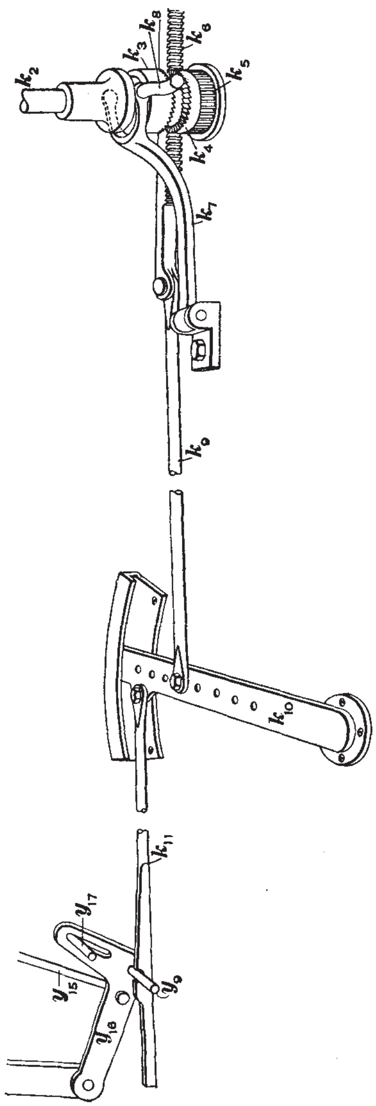


FIG. 16

e_{13}, e_{14} drives the shaft f, on which is fastened the worm k, which meshes with the worm-gear k_1, fast to the upright shaft k_2.

Referring to Fig. 16, the upper part k_3 of a clutch is keyed to the upright shaft k_2, but is movable on the shaft, so that it may be disengaged from the lower half k_4 when the easing-up motion is not in operation. A pinion k_5 that is fast to the lower half of the easing-up clutch meshes with a rack k_6. The two halves of the clutch are allowed to come in contact by the release of the yoke k_7 that controls k_3; this is effected by the removal of the support of the pin k_8 that is attached to the yoke, as will be explained later. The rack k_6 is connected with a rod k_9 that is connected with a lever k_{10} pivoted to the floor. Attached to the outer end of this lever is another rod k_{11}, which connects with the carriage by means of a slot in the rod, with which a pin y_9 attached to the carriage engages. This pin is lifted from the slot at the right time by a suitable mechanism. The object of the lever k_{10} is to furnish a ready method of changing the amount of easing up. The rod k_9 connecting with this lever may be inserted in any of the holes with which the lever is provided, so that any desired amount of motion may be imparted to the carriage. The amount of easing up necessary depends on the amount of twist that is put into the yarn, the most being necessary when the twist is greatest.

The motion is imparted to the carriage by the easing-up mechanism when the two halves of the easing-up clutch k_3, k_4 are in contact, in which case the pinion k_5 draws in the rack k_6 because of its rotation and, consequently, the carriage is also drawn in slightly.

BACKING-OFF MOTION

25. After the completion of the twisting motion, the actual spinning process is completed and it becomes necessary to wind the yarn on the bobbins or cops before another stretch can be spun. Before this can be done it is first necessary to reverse the direction of rotation of the spindles

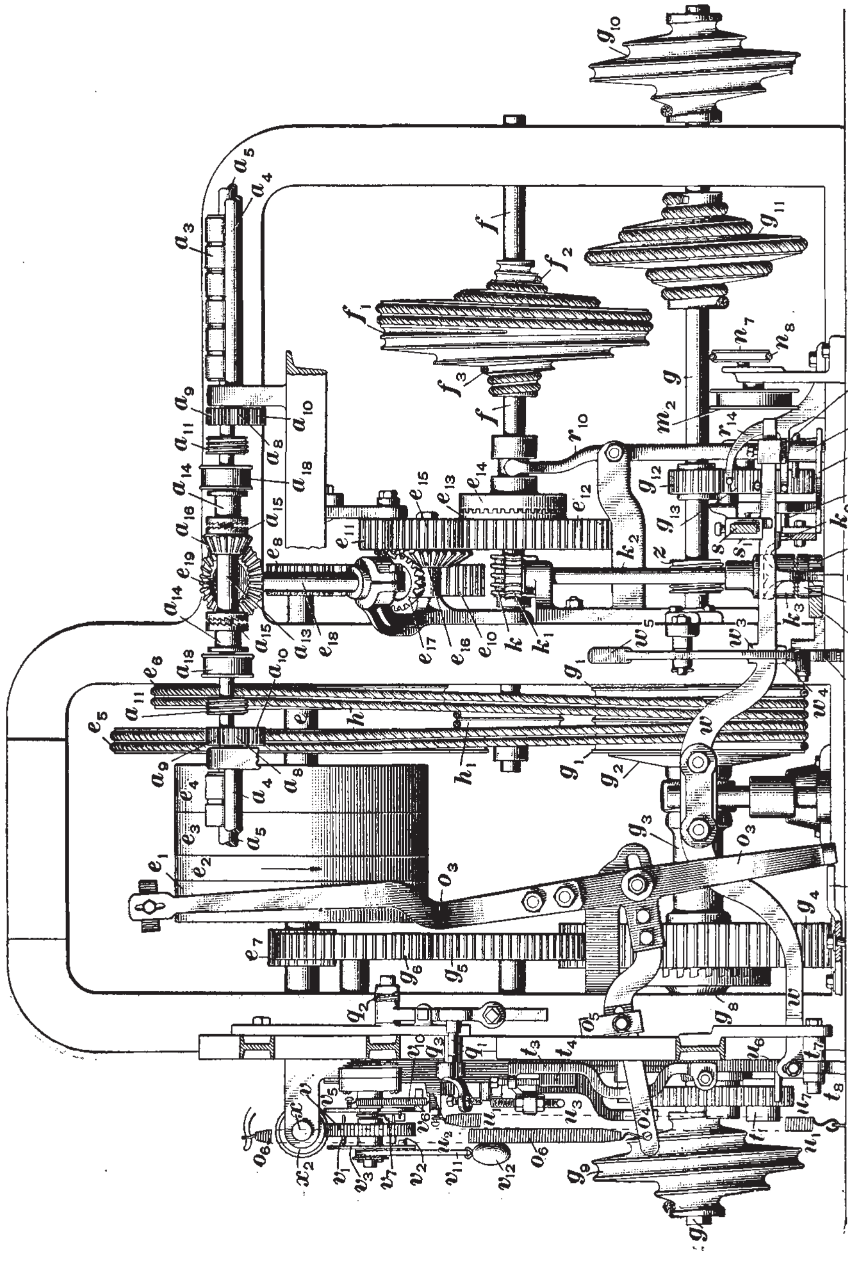


FIG. 17

for a sufficient number of rotations to unwind the coils from the top of the bobbin, but not enough to run over and unwind any of the yarn spun and wound on the bobbin at the previous draw of the carriage. The reason for this unwinding is that, when the spinning process has been completed, a number of irregular coils remain around the top of the bobbin that must be removed before the winding of the bobbin can begin.

In order to reverse the direction of the spindles, the direction of the rim band must be reversed. This is accomplished by driving the band from the grooved friction pulley g_1, Figs. 6, 14, and 17, loose on the drawing-in shaft g. The inside of this pulley is made conical and forms one-half of a friction clutch. The power for the back-off motion originates from the second driven pulley e_2, which is fast to a sleeve that is loose on the main shaft.

Fast to the same sleeve as the pulley e_2 is the gear e_7, which drives the gear g_4 through the intermediates g_6, g_5. The gear g_4 is fast to a sleeve g_3 that is loose on the drawing-in shaft. On the other end of the sleeve is a friction cone g_2 that fits into the grooved friction pulley g_1. In Fig. 6, the back-off friction cone g_2 is not shown in contact, but when the sleeve g_3 is operated on by the back-off lever w, Fig. 17 (which fits into the groove in the sleeve), the friction cone is thrust into the friction pulley, thus transmitting the power from the second pulley e_2 on the main shaft to the grooved pulley g_1 and driving the rim band in the opposite direction. From this it will be seen that the rim band is driven by three agencies during the time in which it is turning the spindles; namely, the grooved pulleys e_6, e_5, g_1, which are driven respectively by the pulleys e_3, e_4, e_2.

At the same time that the backing off is taking place, the winding faller descends, in order to guide the yarn on the bobbin during the next operation—that of winding on. When the winding faller descends, the counter faller simultaneously ascends, in order to keep the tension on the yarn and prevent its kinking up into snarls. The mechanism of the fallers will be considered later, as will also the builder rail, which governs the motion of the faller while guiding the yarn on the bobbin during the winding. It will be sufficient to say here that the winding faller descends quickly in order to make a hard bobbin and one that will unwind easily; it then ascends slowly until the carriage is drawn in.

DRAWING-IN MOTION

26. Leaving out all consideration of the fallers, it will be well to consider how the carriage is drawn in after the backing off and change of the fallers have taken place. The power for drawing in the carriage is derived from the second pulley e_2, Fig. 6, which imparts motion as explained in connection with the backing-off motion to the gear g_4 on the sleeve g_3. However, while the carriage is being drawn in, the backing-off friction cone is not in contact, but the sleeve g_3 is thrust in the other direction and one-half g_7 of the drawing-in clutch on the gear g_4 is in contact with the other portion g_8, which is fast to the drawing-in shaft g, thus imparting motion to the shaft when the belt is on the second pulley and the drawing-in clutch is in contact.

Referring to Fig. 17, which is a view of the headstock, showing the principal parts as seen from the front, or carriage side, of the mule, it will be seen that there are two scrolls g_9 and g_{10} fastened to the drawing-in shaft g. The drawing-in bands are attached to these scrolls and also to the carriage; thus, when motion is imparted to the gear g_4 and the drawing-in clutch is in contact, the scrolls will wind up the drawing-in bands and draw in the carriage.

The drawing-in scrolls have a different action from that of the draft scroll. With the draft scroll, it will be remembered that the band commences on the large diameter and, when imparting motion for the drawing-out of the carriage, is wound down on the small diameter. With the drawing-in scrolls the action is the reverse; the band is wound first on the small portion of the scroll, then on to the greatest diameter, when the carriage receives its greatest speed, and then on to a smaller diameter on the other side of the scroll.

The small diameter with which the scroll commences enables the heavy carriage to be started easily and afterwards moved more quickly, while the band running down again on to a small diameter enables the momentum of the carriage to be easily checked. Abruptness of action and the consequent strain on the bands and carriage are thus avoided and still the carriage is drawn in as rapidly as possible, the start and finish being slow. At the same time that the carriage is being drawn in, the spindles are being turned by a special device and are winding the yarn on the bobbins.

27. Check-Band.—It will be seen that there is an extra scroll g_{11}, Figs. 6 and 17, attached to the drawing-in shaft. The band is wound on this scroll in the opposite direction to the bands on the drawing-in scrolls and is known as the **check-band.** The check-band is unwound from its scroll while the drawing-in bands are being wound up, and vice versa. The check-band passes over a binder pulley that is fixed in a slotted casting attached to the floor and is then attached to the mule carriage. The binder pulley may be moved in the slotted casting by means of a screw for adjusting its tension.

The object of the check-band is to exercise a drag and avoid overrunning the carriage, which may readily occur, owing to its high and variable speed, while it is being drawn in by the drawing-in scrolls and bands; that is, the drawing-in scrolls might, were it not for the check-band, give the carriage such a high velocity that the momentum would cause it to overrun itself and go in faster than the scrolls could wind up the drawing-in bands.

The check-band also prevents the carriage from *banging in*, as it is technically called, when the carriage stops with a shock at the end of the draw. To prevent this, the check-band requires delicate adjustment, in order that the carriage may work smoothly while being drawn in, and come gently against the back stops without any shock. The more tension placed on the check-band by screwing back the binder pulley around which it passes, the more gently the

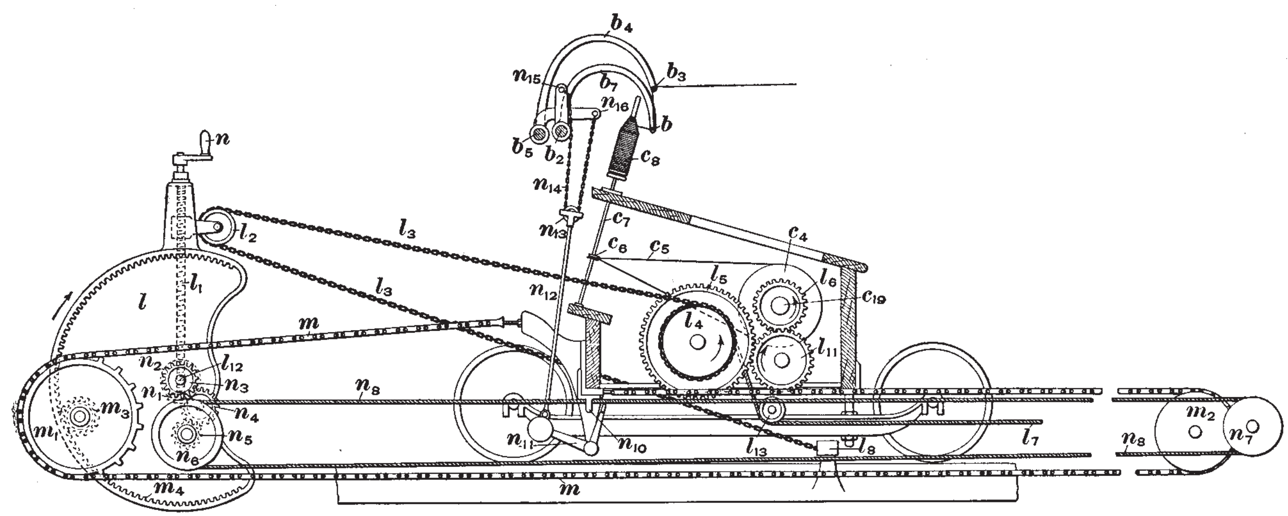

b4
n15
b7
b3
n16
b
b5
b2
c8
n
n14
l3
n13
c7
l2
c6
c5
c4
l1
l3
l5
l6
l
n12
c19
m
l4
n2
l12
l11
n1
n3
n8
m3
n4
m1
n5
n11
n10
l13
l8
l7
m2
n8
n7
n6
m4
m

Fig. 18

carriage will come to a stop at the finish of the drawing-in; and, vice versa, the looser the band, the harder the carriage will bang in.

QUADRANT

28. At the same time that the carriage is being drawn in, the spindles are being turned so as to wind the stretch of yarn between the delivery roll and the spindle on to the bobbin as it is released by the inward run of the carriage. It will be readily seen that in order to wind a stretch of yarn that is of a constant length for each draw of the carriage the spindles must make more revolutions at the start, when the bobbins are empty, than when sufficient yarn has been wound on the bobbin to give it its full size. This is owing to the varying diameter, which is only that of the barrel of the bobbin at the start and larger when the base of the bobbin has attained its maximum diameter; that is, when the *cone*, shown by the dotted lines in Fig. 23 (*a*), has been built. Between these two points the number of revolutions of the spindle required to wind the stretch of yarn is constantly decreasing. This variable speed of the spindles renders it necessary that some device other than the rim band be used for turning the spindles during the drawing in of the carriage. This is accomplished by means of the **quadrant** and accompanying mechanism, shown in Fig. 18. The turning of the spindles for the winding on of the yarn during the drawing in is in reality performed by the motion of the carriage itself, which, pulling against the quadrant l, unwinds the quadrant chain l_3 from the drum l_4, thus of course producing a rotation of the drum l_4 on its shaft. Attached to l_4 is a gear l_5 that meshes

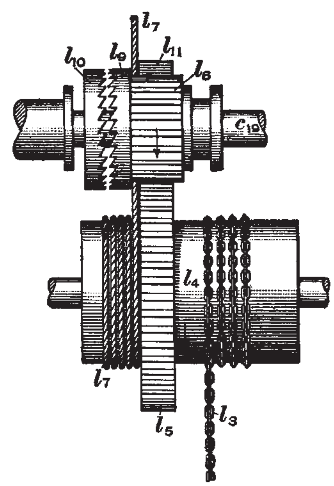


FIG. 19

with an intermediate gear l_{11}; this, in turn, meshes with the gear l_6 loose on the cylinder shaft c_{19}.

Referring to Fig. 19, which is a plan view of the drum l_4, the gear l_6 is fast to one-half l_9 of a clutch; both l_6 and l_9 are loose on the shaft c_{19}. The portion of the clutch marked l_9 is moved in contact with that portion marked l_{10}, which is fastened to c_{19}, immediately after the spindles have backed off and the carriage has started in. Thus, when the drum l_4, on which the quadrant chain l_3 is wound, is rotated, the motion is imparted to the drum c_4, Fig. 18, around which the spindle bands pass, thus imparting motion to the spindles.

The quadrant, as shown in Fig. 18, is driven by means of a chain m that is attached to the carriage. This chain passes around a pulley m_2 and then around the sprocket gear m_1, from which it is conveyed back to the carriage. Attached to the sprocket m_1 is a pinion gear m_3 that meshes into teeth m_4 cut on the inside of the circumference of the quadrant. By this mechanism the quadrant is revolved on its axis around the shaft l_{12}. Thus, when the carriage is drawn in, the quadrant turns toward the carriage. As the carriage comes out again, the quadrant recovers itself, because the chain m pulling over the pulley m_2 turns the sprocket m_1 in the opposite direction.

The quadrant chain l_3 is fastened to a casting l_8 attached to the floor and passes over a pulley l_2 attached to the quadrant before being wound on the chain drum l_4. The pulley l_2 is attached to a differential screw l_1 by means of a block, and by this means may be raised from a point nearly at the axis of the quadrant to a point outside its circumference. The entire quadrant is operated at each inward run of the carriage independently of the position of the pulley l_2.

Suppose that the pulley l_2 is at the bottom of the screw l_1, or *wound down;* then as the quadrant revolves, owing to the movement of the carriage, the position of l_2 will remain nearly the same, owing to its being practically at the axis of the quadrant. Under these conditions the spindles will receive the maximum number of turns, and the amount of the chain l_3 unwound from the drum l_4 will nearly equal the traverse of the carriage on its forward run.

Suppose, however, that the pulley l_2 is raised by means of the screw l_1 until it assumes the position shown in Fig. 18. In this case, the pulley will be carried forwards as the quadrant is turned by the carriage, owing to its being out of center in regard to its position on the quadrant, and less chain will be unwound from the drum l_4; consequently, there will be fewer revolutions of the spindles.

After a full set of bobbins has been doffed from the mule, the pulley l_2 is wound down as far as possible on the screw l_1 by means of the crank-handle n so as to give the maximum number of turns to the spindle. As the winding of the yarn on the bobbin in building the base proceeds, the pulley l_2 is wound up on the screw l_1 in proportion to the increasing diameter of the bobbin.

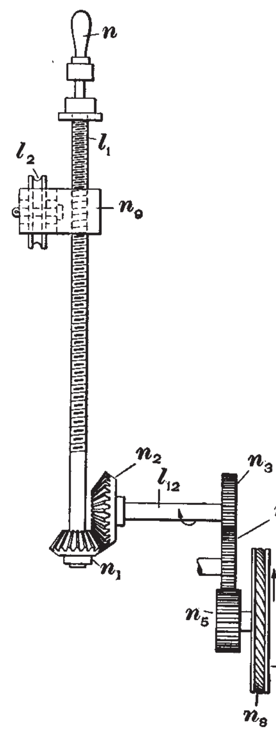


FIG. 20

29. Quadrant Regulator.—The differential quadrant screw is turned by an automatic device that is regulated by the tension of the yarn. If the yarn becomes too tight, as it will if the spindles make too many revolutions, the quadrant screw is turned so that the pulley l_2 will be raised, thus reducing the turns of the spindles and consequently allowing the yarn to be slackened. The pulley l_2 turns in bearings in the block n_9, Fig. 20. Owing to the fact that the screw l_1 is differential, that is, has a constantly changing pitch, it would be impossible to have a thread cut in the block n_9 that would fit the screw at all places; the block therefore has a smooth hole through which the screw passes, having only a pin projecting into the thread of the screw. Attached to the bottom of the quadrant screw is a bevel gear n_1 that meshes with a bevel gear n_2 fast to the shaft l_{12} on which the quadrant is centered. Attached to the same shaft is a gear n_3 that meshes with a gear n_4, this gear, in turn, meshing with a gear n_5. Fast to the same stud as this gear is a grooved pulley n_6.

The parts referred to are also shown in Fig. 18, where it will be seen that there is an endless feed-band n_8 passing around the pulley n_6 and also around a pulley n_7. This band passes directly beneath a casting n_{10} on the carriage, and an elbow lever n_{11}, known as a **grab lever,** is so arranged that under certain conditions it will pinch, or hold, the band against the casting n_{10}. The bite will only hold the band when the carriage is being drawn in. This mechanism does not move the quadrant pulley l_2 at each draw unless the tension of the yarn is such as to make it necessary. The band n_8 is not attached to the carriage; and if the grab lever n_{11} does not hold it against the carriage, there is no motion of the quadrant screw and pulley l_2.

The grab lever is controlled by the position of the fallers. Attached to the outer end of n_{11} is a rod n_{12}, at the top of which is a pulley n_{13}. Around this pulley a chain n_{14} passes and is attached to arms n_{15}, n_{16} fastened, respectively, to the faller shafts b_2, b_5. If the spindles revolve too fast, the yarn will become too tight during the winding as the carriage runs in; this will cause the counter faller b_3 to be lowered, and will allow the lever n_{11} to drop, which it will readily do, owing to its weighted end. The grab lever then assumes such a position that the band n_8, instead of passing freely between n_{11} and n_{10}, is gripped. The motion of the carriage on its inward run then pulls the band n_8 and imparts motion to the quadrant screw l_1 through the train of gears previously mentioned. The direction of this motion is such that its effect is to raise the roll l_2 around which the quadrant chain l_3 passes, thereby allowing less chain to be unwound and thus less turns of the spindles to be made, which will relieve the tension of the yarn by winding less yarn on the bobbin.

The device just explained only works until the base, or cone, of the bobbin is built, after which it takes the same number of revolutions of the spindles for each draw in order to wind on the stretch of yarn. After the cone is built, the spinner usually turns over the end link of the chain n_{14} on the lever n_{15}, thus raising the lever n_{11} from all possible contact with the rope n_8, as if the pulley l_2 is wound up to the top of the screw l_1, the band n_8 is liable to be broken if caught by the lever n_{11}.

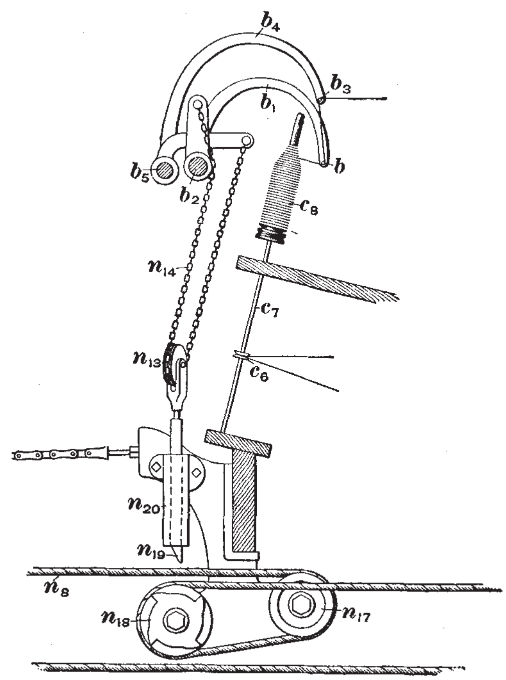


Fig. 21

The reason for having the quadrant pulley moved by a differential screw is that the motion is thus made proportional to the increasing amount of yarn wrapped around the bobbin as its diameter increases; that is, the thickness of a single layer of yarn around an empty bobbin will increase its diameter more, proportionally, than the same thickness when the cone of the bobbin is nearly built. The motion just described for controlling the position of the quadrant-chain pulley is called the **quadrant regulator** and sometimes the **quadrant governor.**

The quadrant-regulating device shown in Fig. 18 is somewhat unreliable, since after the mule has been in operation for some time, the band n_8 will wear grooves in the grab lever n_{11} and projection n_{10}, so that its operation becomes uncertain, as the band n_8 cannot then be as securely gripped. Another defect of this arrangement is that a frayed place or splice in the band will sometimes cause the band to be held and the pulley l_2 raised when in reality there is no necessity for so doing.

A better device for accomplishing the same purpose as the grab lever is placed on the latest-model mules. As shown in Fig. 21, when this device is used the band n_8 is led around a binder pulley n_{17} and then around another pulley that has attached to it a 4-tooth ratchet n_{18}. The chain n_{14} that connects with the fallers governs the motion of a rod n_{19} that is free to rise and fall through a slotted casting n_{20}. During the ordinary running of the mule, the ratchet n_{18} is rotated as the carriage is drawn in, but should the tension of the yarn in winding become so tight as to cause the counter faller to be lowered so as to slacken the chain n_{14} and lower the rod n_{19}, the latter will engage one of the teeth of the ratchet n_{18}, checking its motion and causing the band n_8 to be moved with the carriage and wind up the quadrant pulley l_2, Fig. 18.

Many spinners do not rely on the quadrant regulator, but raise the quadrant pulley l_2 by hand while the bottom of the bobbin is being built, giving the crank n a turn now and then as the height of the counter faller and the tension of the yarn dictate.

30. Action of Quadrant After Cone is Built.—While the cone, or first part of the bobbin, is being built, the quadrant pulley is constantly rising, but when the bottom of the bobbin has attained its final diameter, the quadrant pulley has reached the limit of its upward movement. The quadrant, however, has another function in winding the yarn, without reference to the building of the cone. The top of the bobbin is, of course, always cone-shaped, and the winding-faller wire, when the carriage is drawn in, first descends rapidly, and then rises slowly, being operated by the builder rail, which will be described later. Thus the yarn in being constantly shifted on the cone-shaped top of the bobbin is also being constantly wound on different diameters.

In order to accomplish this successfully, it is evident that the spindles must have a constantly increasing speed as the faller guides the yarn from the large diameter of the bobbin upwards to the nose, where the diameter diminishes to that of the shaft of the wooden bobbin or, if the yarn is being spun into cops, to the diameter of the spindle. This is accomplished by the throw of the quadrant as it moves forwards at each draw of the carriage, which in itself produces a variable speed of the spindles even when the position of the chain pulley on the quadrant is fixed.

When the quadrant pulley has been raised to the top of the quadrant screw and is stationary, there is a definite amount of chain unwound at each draw of the carriage and consequently a definite number of turns of the spindles. But, at the same time, the spindles have an accelerated speed in order to give them a greater number of turns at the finish of the draw when the faller is guiding the yarn on to the bobbin at its nose, where the diameter is smallest. The action of the quadrant itself is responsible for this, without the action of the quadrant screw.

The pulley on the quadrant, around which the quadrant chain passes, moves, in consequence of the motion of the quadrant, in the arc of a circle. This circular motion is composed of a lateral and a vertical motion; thus, as the quadrant pulley is moved while in the top part of its throw, the lateral motion, which is carrying it toward the carriage, allows a smaller amount of chain to be unwound from the chain drum than would be unwound if the quadrant were stationary, and, consequently, the spindles make a smaller number of turns.

As the quadrant continues to turn, the path of the quadrant pulley becomes more and more nearly at right angles to the motion of the carriage during drawing in; thus, a greater amount of chain will be unwound and there will be more turns of the spindles. The speed of the spindles will therefore constantly change in accordance with the positions the faller may occupy relative to the cone of the bobbin.

After the chain has been unwound from the drum, there must be some mechanism for rewinding it before the next inward run of the carriage. This is performed by means of the rope l_7, shown in Figs. 18 and 19, which is wound on the drum l_4 in the opposite direction to that in which the chain l_3 is wound, so that it winds up as the chain is unwound. From the drum l_4 it passes over a guide pulley l_{13}, Fig. 18, and thence to the rear of the machine, where it is fastened and the weight l_{14}, Fig. 5, hung on it. After the carriage is drawn in, the clutch l_9, l_{10}, Fig. 19, is released, so that the drum l_4 is free to revolve independently. As the carriage is drawn out, the rope l_7 is unwound, turning the drum l_4 in the opposite direction to that in which it revolves during the inward run of the carriage, and winding up the chain l_3, as it is slackened by the outward movement, ready for the next inward run of the carriage.

The quadrant chain is thus kept wound on its drum at all times when the clutch l_9, l_{10} is out of contact.

BUILDER MOTION

31. The object of the **builder motion** is to build on the bobbin the yarn spun at each successive outward movement of the carriage. As the carriage is drawn in, the quadrant mechanism imparts the necessary movement of the spindles, and the builder motion guides the yarn on to the bobbin in such a manner as to produce a bobbin of the required shape and size. The guiding of the yarn on to the bobbin is performed entirely by the winding faller, the counter faller simply keeping the yarn at the required tension and preventing slack yarn, which would form kinks.

32. Builder Rail.—The position and motion of the winding faller, therefore, regulate the shape and size of

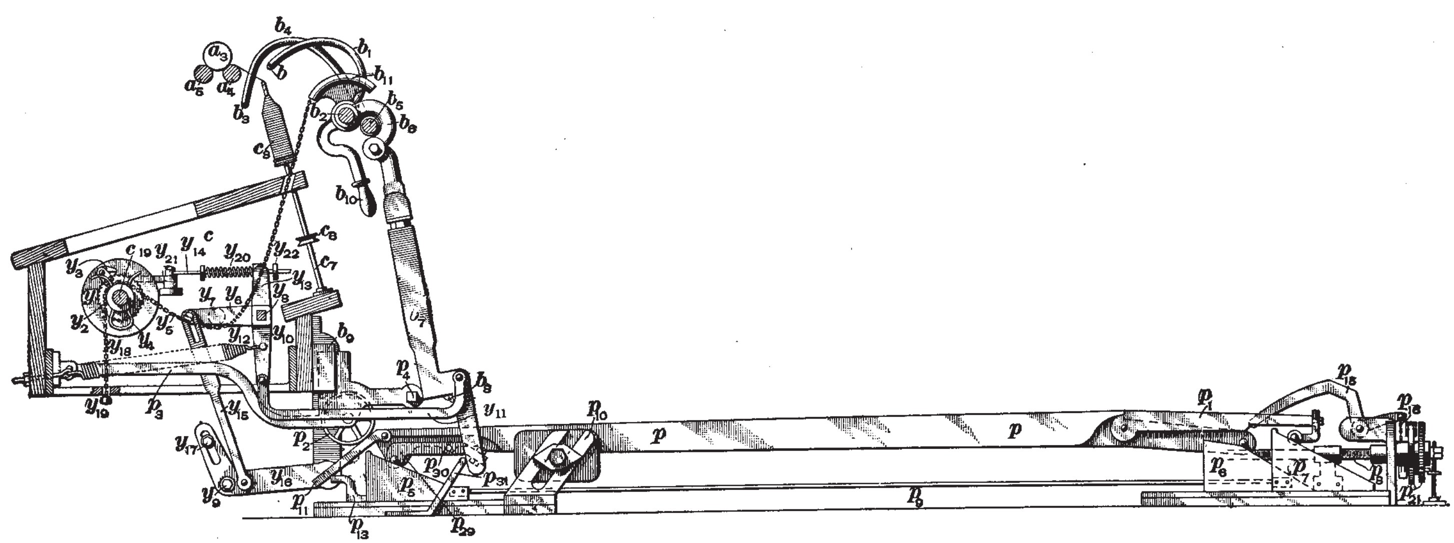


FIG. 22

the bobbin, and in performing its function of guiding the yarn on to the bobbin it is controlled by the position and shape of a rail known as the **builder rail.** The mechanism of the builder motion is shown in Fig. 22, in which the carriage is represented as being drawn completely in to the delivery rolls and the fallers as having just resumed their positions clear of the yarn, as when the drawing-out mechanism is in operation. A short arm b_6 attached to the shaft b_2 of the winding faller b is connected with a bar, or lever, b_7, known as the *faller leg.* A small wheel p_2 known as the *builder-rail traveler* is carried in bearings in the end of a lever p_3 and runs on the surface of the builder rail p when motion is imparted to the carriage. In order that the builder-rail traveler shall not have any lateral movement that would tend to cause it to slip off the builder rail, a projection of the lever p_3 fits into a slot b_9. By means of this arrangement the builder-rail traveler is free to move in a vertical plane but in no other direction, except as it is carried forwards and backwards by the movement of the carriage.

A stud p_4 is fixed in the lever p_3, and during that period of time in which the carriage is being drawn in and the yarn guided on to the bobbin, this stud fits into the angle b_8 of the faller leg, thus supporting it and allowing any vertical motion of the builder-rail traveler to be imparted to it and, through the arm b_6, shaft b_2, and sickle b_1 to the winding-faller wire b. The faller leg is held firmly in contact with the stud p_4 not only by its own weight and the tension of the yarn, which tends to throw the winding faller upwards, but also by means of the springs b_{12}, not shown in Fig. 22 but shown in Figs. 4 and 31, that tend to turn the shaft b_2 in such a direction as to keep the faller leg constantly pressing downwards. From this description it will be seen that the shape of the builder rail p, Fig. 22, and its altitude govern the vertical movement of the builder-rail traveler p_2 as it rolls along the surface of the builder rail while the carriage is being drawn in, and that the position and movement of the winding-faller wire b are governed by the same agency. The movement of the winding faller, however, is in opposition to that of the builder-rail traveler; that is, if the latter rises, the faller wire is depressed, while if the traveler is lowered the faller wire is raised.

The front part p_1 of the builder rail is inclined upwards for a short distance, while the main part p slopes backwards to the end of the inward run of the carriage, so that the traveler in moving over its surface first rises rapidly and then descends slowly, thus producing just the opposite effect on the faller wire; that is, the faller wire first descends rapidly and then rises slowly. Consequently, the yarn is first wound down on the bobbin in a series of coarsely pitched spirals and then wound up again in a series of finely pitched spirals. This method of winding each length of yarn formed at a single draw of the carriage gives the bobbin sufficient firmness to enable it to withstand all ordinary handling without unraveling or slubbing off at the nose.

The builder rail is composed of two parts p, p_1, the latter being in the form of a loose rail hinged to the rail proper. As the yarn is spun and wound on the bobbin it must constantly be wound higher and higher as the bobbin forms, and as this necessitates a corresponding movement of the winding faller, it is evident that as the formation of the bobbin proceeds the builder rail, since its movement is contrary to the movement of the faller wire, must be constantly lowered. This movement of the rail is obtained by means of the *shoes* p_5, p_6, p_7 on which it rests, the main part of the rail p being supported by the shoes p_5, p_6, and the loose rail p_1 by the shoe p_7. These shoes are all rigidly fastened together and when they are operated by the builder gears, which will be described later, they all move backwards in unison, thus lowering all parts of the builder rail. The motion of the shoes is intermittent, one movement taking place at each draw of the carriage; therefore, each stretch of yarn is wound on the bobbin in a slightly higher position than the previous stretch, thus accomplishing the building of the bobbin. When a new set of bobbins is started, the builder rail rests on the highest part of the shoes, but as the formation of the bobbin proceeds, the shoes are moved backwards and the rail lowered until, when the bobbin is finished, it is resting on the lowest part of the shoes. On some mules the builder rail is made in one solid piece, that is, without the loose rail p_1, and since in this case only two shoes, one at each end of the rail, are necessary, it is known as a *two-shoe builder rail*, whereas the one shown in Fig. 22 is called a *three-shoe builder rail*. The object of the three-shoe builder rail is to furnish a convenient method of readily adjusting the rail to form differently shaped bobbins and to relieve the yarn of any undue strain during the winding.

33. The immediate object accomplished by the loose rail p_1 is the lengthening of the *chase* as the cone, or bottom part, of the bobbin is building. The term chase refers to the length of the vertical movement of the winding faller during the time that it is operated by the builder rail; that is, the **chase** is the distance on the bobbin occupied by a single layer of yarn. If the layer of yarn is wound on $1\frac{1}{4}$ inches of the length of the bobbin, the length of the chase is $1\frac{1}{4}$ inches, etc. The lengthening of the chase is due to the difference in the shape of the shoes p_6, p_7, and only takes place while the cone of the bobbin is being built. It will be noticed that for a short distance at the top, the shoe p_6 is inclined at a lesser angle than the shoe p_7; thus, as both shoes are moved backwards at the same speed, the end of the loose rail p_1 will be lowered faster than the main part of the rail p during the first part of the movement. The effect of this is to increase the inclination of the loose rail and therefore the length of the vertical movement of the builder-rail traveler, of the winding

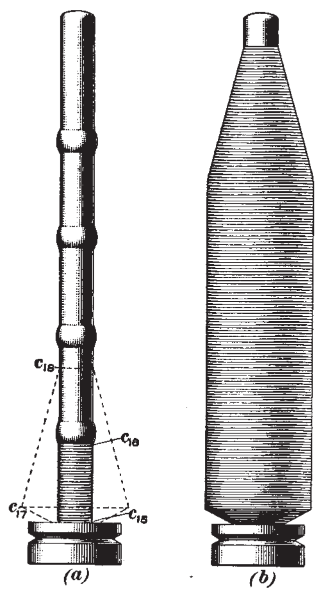


Fig. 23

faller, and the length of the chase. Thus, as shown in Fig. 23 (*a*), the first stretch of yarn will be wound on the bobbin between the points c_{15}, c_{16}, and as the builder rail is lowered, each succeeding layer will be wound on the bobbin slightly higher and the length of the chase also increased, until a layer c_{17}, c_{18} is formed. When this point is reached the shoes will have been moved backwards so that the builder rail is just commencing to move down the steeper part of the shoe p_6, Fig. 22, and the cone of the bobbin, shown by the dotted lines in Fig. 23 (*a*), will have been formed. From this point the slant of each shoe is the same; therefore, all parts of the builder rail will be lowered an equal distance at each draw of the carriage and the length of the vertical movement of the builder-rail traveler, of the winding faller, and the length of the chase will remain constant. Each successive stretch of yarn, however, because of the constant lowering of the builder rail, continues to be wound on the bobbin slightly higher than the previous stretch, until a full bobbin, as shown in Fig. 23 (*b*), is obtained.

As the builder rail is lowered it is guided by a slotted steadying bracket p_{10} with which a stud on the rail engages. The slot in this bracket slants in the opposite direction to the inclination of the shoes, so that as the rail is lowered it is thrown against the shoes, thus giving it greater stability and steadiness. The inclination of the slot also has the effect of moving the builder rail backwards in a horizontal direction as it is lowered, which will result in the rail being lowered somewhat more slowly than if a vertical slot were used; this backward motion of the rail will also increase the length of the short incline of the rail and shorten the long incline, because it will move the highest point of the rail nearer to the center of the movement of the carriage. This will result in the winding faller performing its downward motion at a slower rate of speed and its upward motion correspondingly quicker. This is beneficial, because as the bobbin is built higher there is less slack yarn caused by the backing-off motion unwinding the coils of yarn between the yarn already spun and the top of the spindle, on account of the diminished distance for such coils to form, and consequently there is greater strain on the yarn during the initial, or downward, movement of the winding faller. Therefore, by causing this downward movement of the winding faller to become slower as the bobbin increases in size, this strain on the yarn during the initial movement of the winding faller is mitigated.

At the back end of the builder rail a casting p_{11} known as the *flip* is hinged, the loose end resting on a casting p_{13}. As the rail is lowered the flip becomes raised relative to the rail, since the end attached to the rail is lowered with it, while the other end, resting on the casting p_{13} remains stationary. As a result, the angle, or corner, of the flip becomes raised above the surface of the builder rail and as the carriage comes against the back stops, the builder-rail traveler strikes the projection thus formed, and imparts a sharp snap, or *flip*, to the winding faller. The effect of this is to wind a few turns of yarn down over the nose of the bobbin, thus making a firmer nose and preventing the yarn slubbing up the bobbin. As the bobbin increases in size the amount of this movement of the winding faller will be increased, because the greater the distance that the builder rail is lowered, the farther the flip projects above its surface. The pin supporting the back end of the builder rail on the shoe p_6, instead of being fixed in the rail, is attached to a casting p_{29} that is fulcrumed at p_{30} and is adjustable by means of a setscrew. By this means it is possible to adjust the back end of the rail so that it will be higher or lower as may be desired. Raising the back end of the builder rail has the effect of shortening the length of the upward movement of the winding faller, and lowering it lengthens this movement, thus shortening or lengthening the taper of the bobbin.

34. Builder Gears.—The movement of the shoes that control the builder rail is imparted by means of the builder gears, of which Fig. 24 (*a*) is a front and Fig. 24 (*b*) a side view. A roll c_{12} is attached to a bracket fastened to the front of the carriage in such a position as to engage

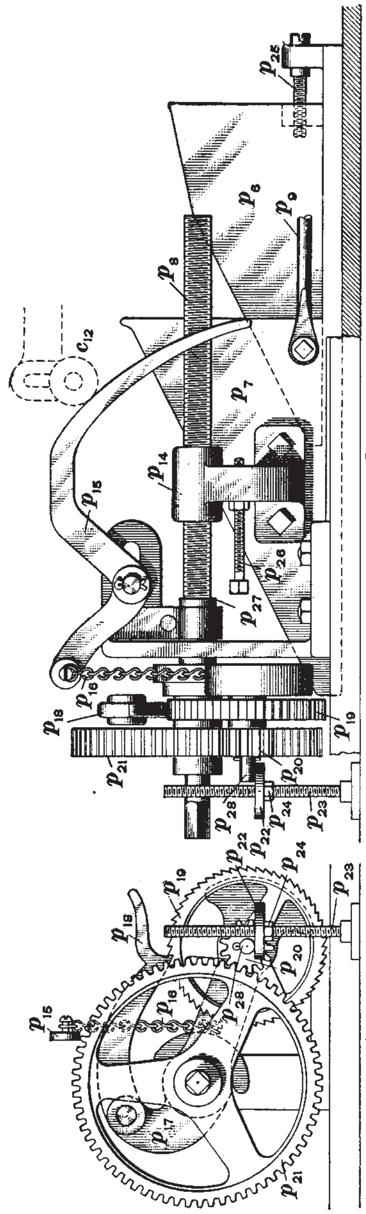


FIG. 24

a lever p_{15} at each draw of the carriage. As the lever p_{15} is engaged by the roll c_{12} the chain p_{16} will raise an arm p_{17} that is loosely supported on the shaft of the screw p_8. In one end of the arm p_{17} is a stud p_{28} that carries a ratchet p_{19} compounded with a gear p_{20} that meshes with a gear p_{21} that is fastened to the shaft of the screw p_8. At the other end of the arm p_{17} is fastened a pawl p_{18} that engages with the ratchet p_{19}. As the arm p_{17} is raised (together with the ratchet p_{19} and gear p_{20}), in consequence of the roll c_{12} engaging the lever p_{15}, the gear p_{21} will be turned, because the teeth on the ratchet p_{19} are inclined in such a direction that the pawl p_{18} will prevent it and, consequently, the gear p_{20} from rotating. Since the gear p_{21} is fastened to the shaft of the screw p_8, this will impart a slight rotary motion to the screw, and as the latter is threaded in a casting p_{14} attached to the shoe p_7, the shoe will be moved backwards, allowing the builder rail to be lowered slightly.

The shoe p_7 has an extended base, to which the shoe p_6 is attached by means of an adjusting screw p_{25}; the shoe p_5, Fig. 22, is attached to the shoe p_7 by means of the rod p_9. Thus the motion of the screw p_8 is transmitted to each of the shoes, and the builder rail thereby lowered.

As the carriage is drawn in, the roll c_{12} is drawn away from the lever p_{15}, and in consequence the tension on the chain p_{16} is relieved and the arm p_{17} falls, because of the weight of the ratchet p_{19} and gear p_{20} at its extremity. As this takes place the gear p_{20} is turned and the pawl p_{18} takes up on the ratchet p_{19}, assuming a new position for moving the gear p_{21} at the next draw of the carriage. In order to prevent any movement of the shoes and builder rail other than that imparted by the correct working of the builder gears, the screw p_8 turns in a friction plug, or bushing, p_{27}, which causes the screw to turn with sufficient difficulty to prevent any movement from vibration or the shock of the builder-rail traveler on the rail when the faller leg is locked.

The distance that the builder gears fall when released by the inward run of the carriage is regulated by means of a table p_{22}, which is threaded on a fixed screw p_{23} and supports the weight of the arm p_{17} by means of an extension of the stud p_{28} on which the ratchet p_{19} and gear p_{20} are centered. The lower this table is adjusted on its screw support, the greater the number of teeth that the pawl p_{18} will take up in the ratchet p_{19} at each fall of the builder gears, and consequently the faster the builder rail will be lowered. The faster the builder rail is lowered, the greater the speed at which the winding faller will rise, and the faster the winding faller rises, the smaller in diameter will be the bobbin; hence, the table p_{22} furnishes a ready means of regulating the size of the bobbin. The higher this table is adjusted on the screw, the larger will be the diameter of the bobbin, since in this case the builder rail will be lowered at a slower speed and the corresponding speed of the winding faller in rising will allow more yarn to be placed on the bobbin. A check-nut p_{24} locks the table p_{22} in any desired position and prevents accidental changes in the size of the bobbins.

The diameter of the bobbin may also be changed by setting the roll c_{12} on the carriage in a higher or lower position. In the former case a larger bobbin will be made, since less motion will be imparted to the builder gears and rail, while in the latter case a smaller bobbin will be made, because the builder gears will be lifted higher and will consequently lower the builder rail to a greater extent.

35. It is not out of place in connection with the size of the bobbin to mention the factors governing its hardness or firmness of structure, since this element governs the diameter of the bobbin to a certain extent, in that a soft bobbin is of larger diameter than a hard one, in consequence of the individual layers of yarn not lying so closely together. The hardness of the bobbin may be regulated by means of the weights b_{19}, Figs. 4 and 31, which by their connection with the counter-faller shaft b_5 govern the force that the counter-faller wire b_3 exerts on the yarn, and consequently its tension during winding. If more weight is applied to the counter faller, a greater tension is produced on the yarn during winding; hence, a harder bobbin will be formed. These weights are made similar to the weights of a pair of scales, and as many may be used as will be necessary to produce a bobbin of the required hardness, provided that the strength of the yarn is sufficient to withstand the amount of tension necessary to produce a bobbin as firm as desired. As the number of weights used and the consequent tension of the yarn depends largely on the strength of the yarn, coarse yarn requires more tension than finer yarn. Sometimes when running out lots there will remain only two or three jack-spools to be spun, in which case the weight on the counter faller should be correspondingly decreased.

OPERATION OF THE MULE AS A WHOLE

36. So far only those mechanisms that deal with the essential operations of the mule have been considered, and nothing has been said of other mechanisms that enable the parts performing the different functions of the mule to be put in operation at certain periods, nor of those mechanisms by means of which one motion is discontinued in order that another may begin. The action of the mule will now be considered during a complete cycle of the movements of a single draw, commencing with the carriage drawn in with the spindles in close proximity to the delivery rolls and ending with the reengagement of the parts previous to the next draw of the carriage.

37. Shipper Lever.—The movement of the mule as a whole is controlled primarily by means of the shipper lever o, Fig. 25, which is fulcrumed on a stand bolted to the floor at the front of the machine. A sliding incline o_2 attached to the shipper lever by means of a rod o_1 controls the movement of the belt lever o_3 and, consequently, of the driving belt, the end of the belt lever being pressed against the incline by means of a spring o_6 that is attached to an arm o_4 of the belt lever, also shown in Fig. 17. By pushing in the upper end of the shipper lever o toward the carriage the incline o_2 will be drawn forwards, as shown in the illustration, throwing the belt on to the loose pulley e_1 and stopping the mule in whatever position the carriage is, without regard to what motion is in operation at that time. Drawing the upper end of the shipper in the opposite direction will have the opposite effect and, with one exception that will be noted later, will start the mule in operation without regard to the position of the carriage or other parts, so that the motion of the mule will commence at exactly that period of its complete action in which it was previously stopped.

STARTING OF MULE

38. As the mule is started, therefore, the shipper lever is pulled away from the carriage and the incline o_2 moved backwards, which will allow the spring o_6 to pull the belt

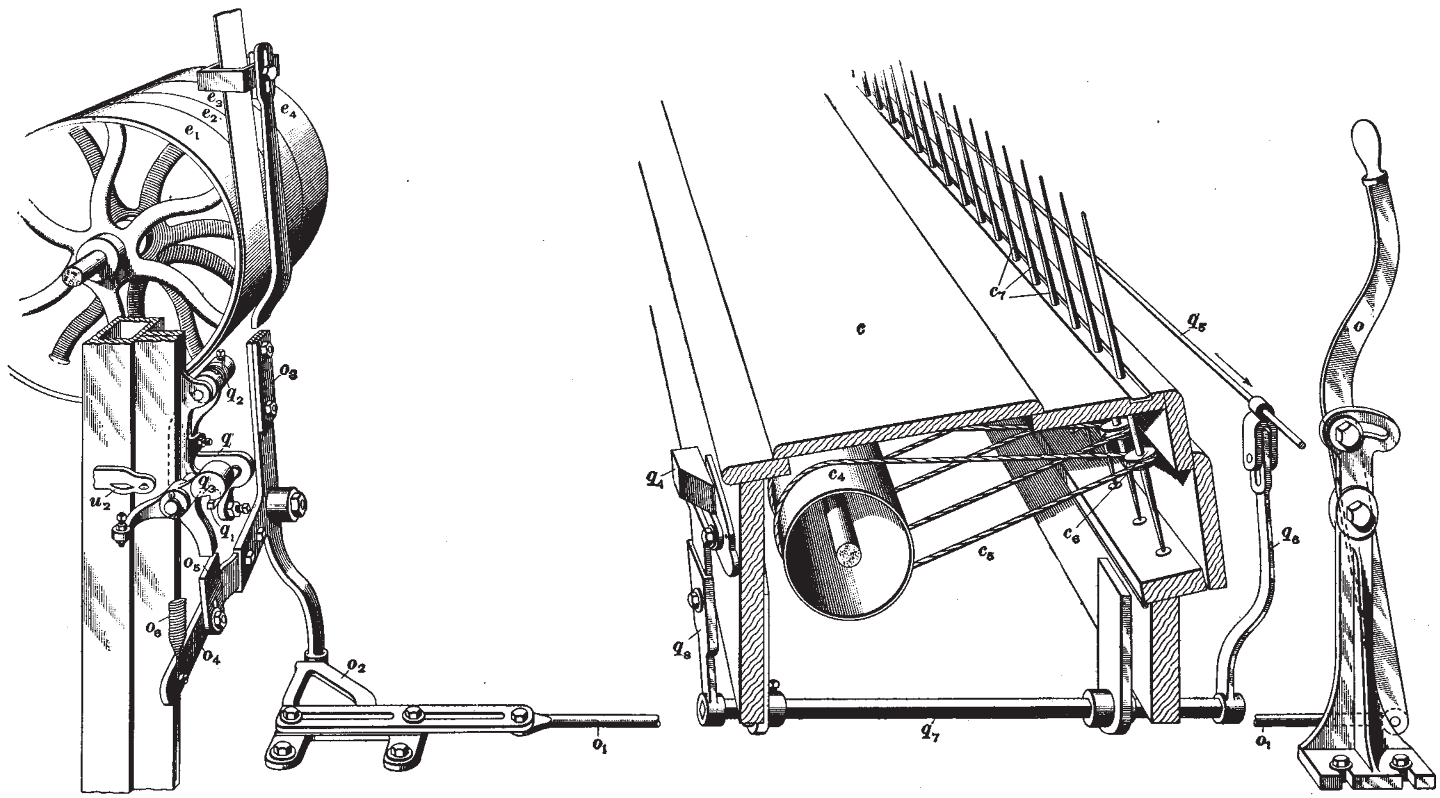

e3
e2
e1
e4
o3
q2
q
u2
q3
q1
o5
o6
o4
o2
o1
c7
c
q5
o
q4
c4
c6
c5
q6
q8
q7
o1

Fig. 25

lever o_3 over and thus throw the driving belt on to the driving pulleys. This movement of the belt lever is checked when the driving belt reaches the third pulley e_3 by an adjustable stop t_4, Fig. 27 (*a*) and (*b*), attached to the end of the lever t_3. The belt is moved over the pulley e_2, Fig. 25, but does not remain in contact with it for more than a fraction of a second; moreover, the pulley e_2 is virtually loose at this time, since neither the backing-off friction cone nor the drawing-in clutch are in contact, as the backing-off lever is in its neutral position. The motion of the driving belt, therefore, is at the start communicated to the third pulley e_3, which transmits the power to the draft scroll f_1, Figs. 6 and 17, the delivery rolls, and the smaller grooved rim-band pulley e_6. Thus three operations are commenced at the start—the carriage begins to recede from the delivery rolls, first slowly, by virtue of the dwell motion; the roving is delivered by the delivery rolls; and motion is imparted to the spindles.

39. Detent Mechanism.—The one instance in which the mule will not be started if the shipper handle is pulled away from the carriage is when the **detent mechanism,** shown in Figs. 25 and 27 (*a*) and (*b*), is unlocked. A lever q in which is fixed a stud q_1 tends to be forced forwards by a coil spring q_2, but may be locked back by means of a detent catch q_3 that engages with the stud q_1 whenever the lever is forced backwards far enough to allow this catch to drop over the stud. When, however, the detent catch q_3 is unlocked and the lever q is in its forward position, as shown in Fig. 25, its lower end is directly above a casting o_5 bolted to the arm o_4 of the belt lever, making it impossible for the mule to be started, because the casting o_5 will come in contact with the lower end of the lever q and prevent the arm o_4 from rising high enough to allow the belt to be shipped to the third pulley e_3. When, however, the lever q is moved backwards and the stud q_1 locked by the detent catch q_3, the lower end of the lever will be back far enough so that the casting o_5 will escape it and the belt lever be free to move the belt to the third pulley e_3 and also the fourth pulley e_4, if desired.

The lever q is locked by means of a movable wedge q_4, Fig. 25, on the carriage that is operated by a sliding rod q_5 on the front of the carriage, through the lever q_6, the shaft q_7, and the lever q_8. The wedge q_4 comes in contact with an adjustable setscrew in the lever q and if the rod q_5 is moved in the direction of the arrow, will assume such a position as to force back the lever q and allow it to becme locked. It will be seen, therefore, that when the carriage is drawn in, if it is desired to start the mule, not only must the shipper lever o be drawn forwards, but the rod q_5 must also be moved in the direction of the arrow, or to the left of the spinner.

The object of this detent mechanism is to allow the spinner to stop the mule at the end of any draw—that is, when the carriage is drawn in—from any position in which he may be. For instance, if he was at one end of a long mule and desired to stop the carriage in order to piece up several broken ends, or to place a new spool of roving in the mule, it would be very inconvenient to accomplish this with the shipper lever, as this would be 25 or 30 feet away. It should be particularly noted that the rod q_5 if moved to the right of the spinner, or in a direction opposite to the arrow, will stop the mule only when the carriage has been drawn completely in; that is, the mule will continue in operation and complete the draw, but will stop at the end of its inward motion. While the mule is running, therefore, the rod q_5 must be kept to the limit of its movement in the direction of the arrow, so that the wedge q_4 will be in position to lock the lever q each time that the carriage comes in, as otherwise the mule will stop. The lever q is unlocked at every draw of the carriage by means of a projection u_2 attached to the twist slide—a mechanism that will be described presently—which, when the twist slide drops, strikes an adjustable setscrew in the detent catch q_3, thus freeing the stud q_1 and lever q. Thus, if the wedge q_4 is not in position to lock the lever q again, the carriage must stop.

40. Roving Stop-Motion.—With the belt on the third pulley e_3, the roving motion, drawing-out motion, and rim band continue in operation without change until the requisite length of roving is delivered, whereupon the delivery rolls are stopped by the roving stop-motion, while the motions of the carriage and rim band still continue.

DISCONNECTION OF DRAWING-OUT MOTION

41. Disengagement of Drawing-Out Clutch.—The next change that takes place is the checking of the outward movement of the carriage. When the carriage is drawn out until the spindles are 72 inches, or about that distance, from the delivery rolls, a bunter on the carriage comes in contact with a lever r, Fig. 26 (a), forcing its upper end forwards and moving the rod r_1 attached to its lower end backwards. At the other end of the rod r_1 is a wedge r_2 that slides in a slot in the draft slide r_3, as shown in detail in Fig 26 (b). As the wedge r_2 is forced backwards it raises from a notch r_4, Fig. 26 (a), in the draft slide a stud s_4 that is attached by a lever s_3 to a rod s known as the *latch rod*. As this takes place the draft slide is drawn forcibly backwards by a spring r_7 attached to it and to the stand r_{14}, its motion being checked when it has moved the proper distance by a casting r_9 against which it strikes. The draft slide is cast with a recess r_5 in one end [see Fig. 26 (b)], which, together with the wedge-shaped end r_6, serves as a guide for the lower end of the lever r_{10}. The upper end of this lever r_{10} is fitted with a yoke to operate the movable half e_{14} of the toothed drawing-out clutch, also shown in Fig. 17. As the draft slide is drawn backwards, therefore, the lower end of the lever r_{10} is forced into the recess r_5 in the slide, and its upper end disengages the drawing-out clutch e_{14}, thus checking the outward movement of the carriage. A spring r_{12} keeps the drawing-out clutch in contact when the lever r_{10} does not hold e_{14} away from e_{13}.

42. Easing-Up Motion.—At the same time that the drawing-out motion is disengaged, that is, when the draft slide is released, the easing-up motion is put in operation. This is accomplished by means of a raised place r_{13} on the edge of the draft slide, on which rests the stud k_8 that holds

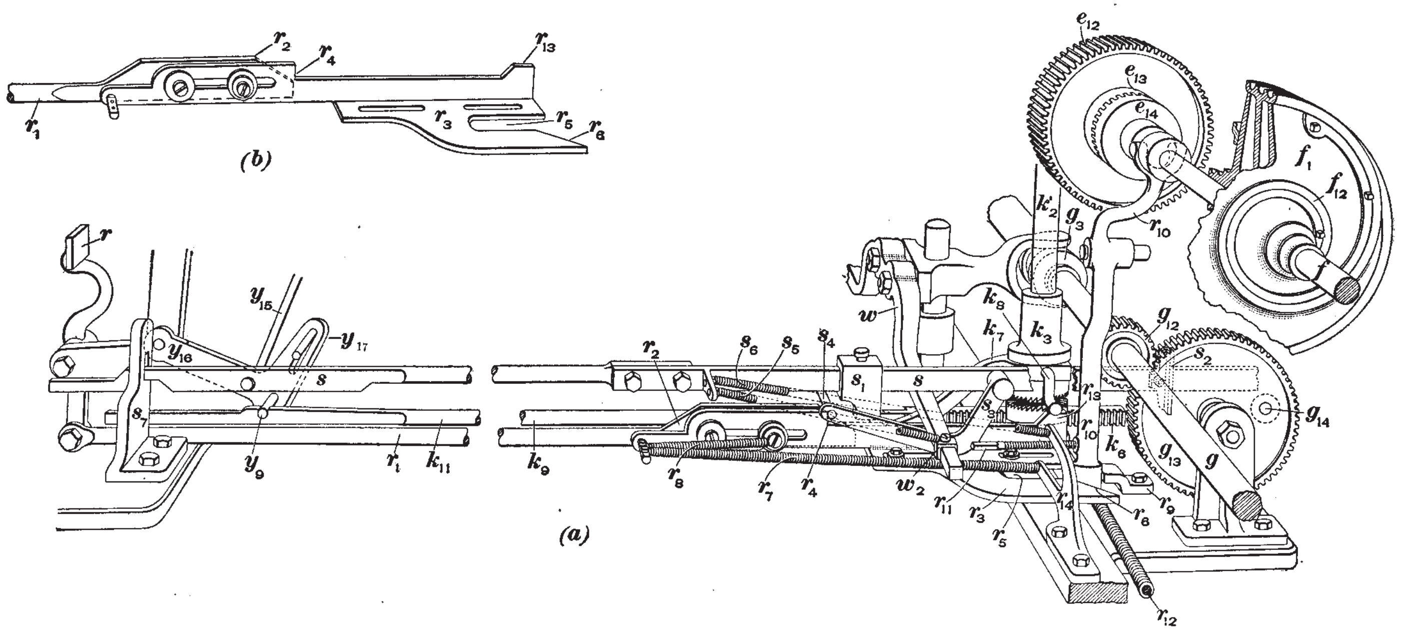


FIG. 26

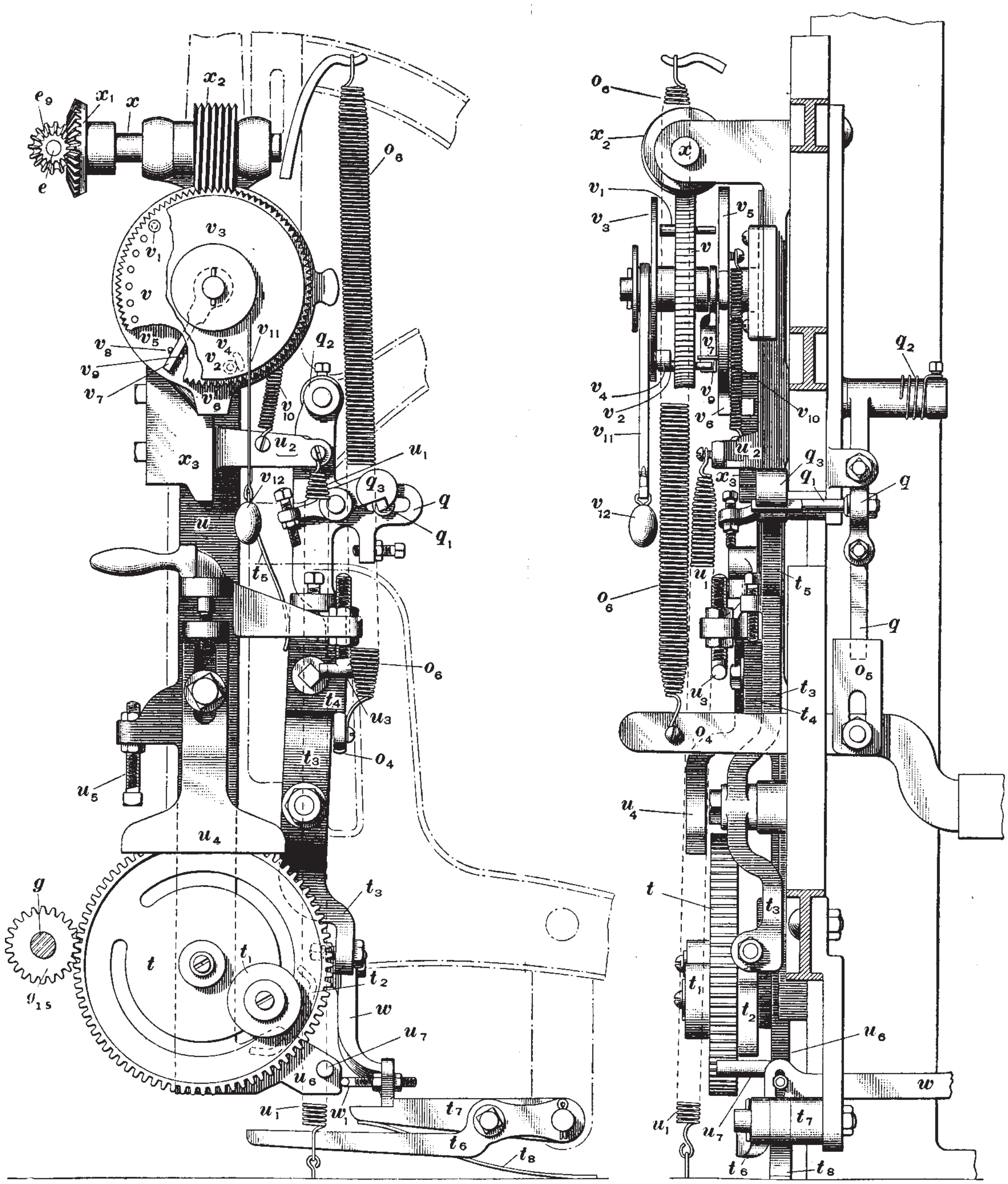
the easing-up clutch k_3 out of contact when the easing-up motion is not in operation. As the draft slide is released, this raised edge r_{13} moves out from under the stud k_8, thus allowing the part k_3 of the easing-up clutch to drop in contact with k_4, Figs. 16 and 17, and the carriage to be eased up.

It will be noted that as the carriage is drawn out, the stud y_9 drops into the notch in the rod k_{11} and thus replaces the rods and consequently the rack k_6 in their initial positions.

43. Accelerated Speed.—At the same time that the easing-up motion is in operation the spindles are being driven at the accelerated speed, which necessitates that the belt be shifted to the fourth driven pulley e_4, Fig. 6, in order that the large grooved pulley e_5 may drive the rim band. This is accomplished at about the time that the carriage reaches the end of its outward movement, in the following manner: When the belt is on the third pulley, the arm o_4, Fig. 27, of the belt lever rests against the stop t_4 on the lever t_3. As the carriage is being drawn out, motion is imparted to the drawing-in shaft g by reason of the drawing-in bands being unwound from their scrolls; in consequence, motion is imparted to the gear g_{15}, which is fast to the drawing-in shaft, and transmitted to the gear t, which meshes with g_{15}. On the back of the gear t is a projection t_2 that as the gear rotates comes in contact with an adjustable setscrew in the end of the lever t_3, thus forcing the lower end of the lever t_3 outwards, against the pressure of a flat spring t_5, and releasing the arm o_4 of the belt lever. When this release takes place, the spring o_6 will pull the arm o_4 upwards until it is stopped by an adjustable **T** piece u_3, thus shipping the driving belt to the fourth pulley e_4.

DROPPING OF THE TWIST SLIDE

44. The Twist Slide.—The accelerated speed continues to put twist into the yarn until it is checked by the dropping of the twist, which is accomplished by means of the mechanism shown in Fig. 27 (*a*) and (*b*). The gear e_9, which is attached to the main shaft e of the headstock, drives a gear x_1



(a) (b)

FIG. 27

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fastened to a short cross-shaft x, to which is fixed a worm x_2 that imparts motion to the twist-pin gear v; this gear is loose on a stud fixed in the twist slide u, which is simply a casting free to fall in a vertical direction through a limited distance unless locked. The stud that supports the twist-pin gear v also carries a lock-plate v_5 and a cover-plate v_3, both of which are loose on the stud. The lock-plate has a projection v_6 that rests on a casting x_3 bolted to the framework of the mule, and in this manner holds the twist slide u in a raised position so that the pin gear v will mesh with the worm x_2. In addition, the stud on which the lock-plate is supported carries a knock-off v_7 that is supported between two pins v_8, v_9 on the lock-plate in such a position as to be engaged by the pin v_1, which may be placed in any one of the holes with which the twist gear v is provided. As motion is imparted to the twist-pin gear, the lock-plate remains stationary until the pin v_1 comes in contact with v_7, whereupon the lock-plate will be moved, against the tension of a spring v_{10}, sufficiently to allow the projection v_6 to slip off the casting x_3 and a strong spring u_1 to pull the twist slide u and all parts connected with it to a lower position, thus among other results allowing the twist gear to become clear of the worm x_2.

During the time that the gear v has been turning it has been imparting motion to the cover-plate by means of a pin v_2 that engages a projection v_4 cast on the inside of the plate; this motion of the cover-plate winds up a weight v_{12} that is attached to it by means of a leather strap v_{11}. When the twist gear is removed from contact with its driving worm, the weight v_{12} turns the plate v_3 and, consequently, the gear v in the opposite direction until the pin v_2 comes in contact with v_7, thus resetting the twist-pin gear in its initial position. The lock-plate is returned to its initial position by the spring v_{10}, the projection on the lock-plate engaging with the casting x_3 immediately that it is raised above it.

45. With the dropping of the twist several changes are made in the action of the mule, the immediate result being the stopping of the accelerated speed and the commencement of the backing off of the spindles. As the twist slide u is drawn down by the spring u_1, the **T** piece u_3 that is threaded in an extended arm of the slide casting forces down the arm o_4 of the belt lever until the driving belt is carried from the fourth to the second driven pulley. In order that the arm o_4 shall be carried down just far enough to bring the belt to this pulley, an adjustable setscrew u_5 is threaded into another extended arm of the slide casting u and by striking against a stop on the framework of the mule governs the extent of the fall of the twist slide and, consequently, the length of movement of the **T** piece u_3.

As the arm o_4 is carried below the stop t_4 on the lever t_3, the spring t_5 swings the lever t_3 to the right to its original position at the beginning of the drawing-out motion ready to receive the arm o_4 again when the belt is shipped to the third pulley at the next draw of the carriage.

46. As the pin v_1 in the twist gear controls the dropping of the twist slide, it also controls the checking of the accelerated speed and, consequently, the amount of twist placed in the yarn. By moving v_1 away from v_7 more twist will be placed in the yarn, while setting the pin forwards will have the opposite effect. It might be thought that instead of the knock-off v_7 that is carried loosely on the stud and secured to the lock-plate v_5 by the pins v_8, v_9, a simple projection on the lock-plate would serve to unlock the twist slide. This arrangement, however, has a special purpose in that it allows the pin gear v to make more than a single revolution if it is desired to place a greater amount of twist in the yarn than can be obtained in the ordinary way. This extra amount of twist is obtained by removing one of the pins v_8, v_9 that support the knock-off v_7; suppose, for instance, that the pin v_9 is taken out. When the twist gear v is reset by the weight v_{12}, it will be rotated until the pin v_2 strikes the knock-off v_7 and forces it against the right-hand side of the pin v_8. Ordinarily the twist gear v revolves while the twist is being placed in the yarn until the pin v_1 strikes the knock-off v_7 so as to turn the lock-plate v_5 and disengage the projection v_6 from the casting x_3, which allows the twist slide u to drop; but in this case since the pin v_9 is removed, no support is given v_7 to accomplish this result until v_1 has pushed it around one complete revolution and forced it against the left-hand side of the pin v_8. The twist gear therefore makes one complete revolution before the twist slide drops, in addition to the number of holes that the pin v_1 is set. This, consequently, gives an adjustment whereby the amount of twist in the yarn can be greatly increased or even doubled if so desired. For instance, suppose that 70 holes of twist are wanted and the twist gear contains only 50 holes; then all that is necessary is to set the pin v_1 for 20 holes and remove the pin v_9, which will give 20 holes plus one revolution of the twist gear (50 holes) or 70 holes of twist. The number of holes of twist required by yarns of different sizes varies, and it may be generally stated that coarse yarn requires fewer holes of twist than finer yarn. Much also depends on the stock, as yarn made from poor and weak stock naturally requires a greater amount of twist to give it sufficient strength to withstand the weaving operation. Warp yarn also is generally harder twisted than filling yarn.

47. Engagement of Backing-Off Motion.—When the belt has been shipped to the second driven pulley e_2, Fig. 6, by the dropping of the twist slide, the power is transmitted through gears e_7, g_6, g_5, g_4, and sleeve g_3, Figs. 6 and 17, to the backing-off friction cone g_2. As the twist slide falls, another extended portion u_6, Fig. 27 (*a*), of the slide casting, which has previously held the back-off lever w in its neutral position, is lowered so as to pass from contact with an adjustable **T** piece w_1 threaded in the end of the back-off lever. The back-off lever, being now free to move, is drawn forcibly over by a spring s_5, Figs. 26 and 32, putting the back-off friction cone g_2, Figs. 6 and 17, in contact with the grooved friction pulley g_1. The rim band is then driven slowly in the opposite direction by the pulley g_1, so that the spindles, also being turned in the opposite direction, will unwind the coils of yarn between the top of the bobbin and the yarn already wound on it, thus preparing for winding the stretch of yarn on the bobbin.

48. Unlocking of Detent Catch.—Another function performed by the falling of the twist slide is the unlocking of the detent catch q_3, Figs. 25 and 27, which makes it impossible for the arm o_4 to rise sufficiently to ship the belt to the third pulley and thus draw the carriage out again, unless the wedge q_4, Fig. 25, is in a position to lock the detent catch when the carriage comes in. This is accomplished by the projection u_2 that comes in contact with the adjustable setscrew in the end of the detent catch q_3, thus raising it from the stud q_1 in the detent lever q.

It will be understood that all of the various functions performed by the dropping of the twist occur simultaneously with the fall of the twist slide and not in consecutive order as it is necessary to describe them.

BACKING OFF

49. Changing of Fallers.—As the backing-off motion is put in operation and the center shaft of the carriage thereby reversed, the fallers are changed so as to assume a position for winding the yarn on to the bobbin. A ratchet y_2, shown in Figs. 22, 29, and 30, and in detail in Fig. 28, is fast to the center shaft c_{19} of the carriage and is provided with an extended hub, around which a leather-lined steel clipper spring y_4 is placed. One end of this spring is extended between two pins in a pawl y_3 attached to a flange y loose on the shaft c_{19}. While the shaft c_{19} is being driven in the

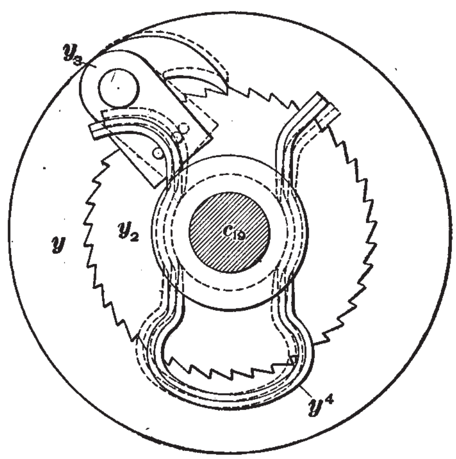


FIG. 28

ordinary direction, shown by the arrow in Fig. 29, the pressure of the spring y_4 on the pawl y_3 is such as to keep the pawl out of contact with the ratchet y_2, but immediately that the backing-off motion starts in operation and the direction of rotation of the shaft c_{19} is thereby reversed, the pressure of the spring y_4 will be in the opposite direction, and the pawl y_3 will be thrown in contact with the teeth of the ratchet gear, which will therefore impart motion to the flange y, since the pawl is attached to the flange. This flange forms part of a drum y_1, which is loose on the shaft and has attached to it a chain y_5 known as the *back-off chain*, the other end of which is attached to a segment b_{11} fastened to the winding-faller shaft b_2. As motion is imparted to the drum y_1 the chain y_5 is tightened and the shaft b_2 of the winding faller turned until the faller leg b_7, Fig. 22, rises so that it will slip over the stud p_4; this is accomplished by means of a strong spring y_{12} attached to a lever y_{10}, to which the faller leg is connected by means of a connecting-rod y_{11}. The winding faller b is therefore lowered so that it will assume the correct position for winding the stretch of yarn, which of course is governed by the position of the builder rail, through the traveler p_2 and faller leg b_7.

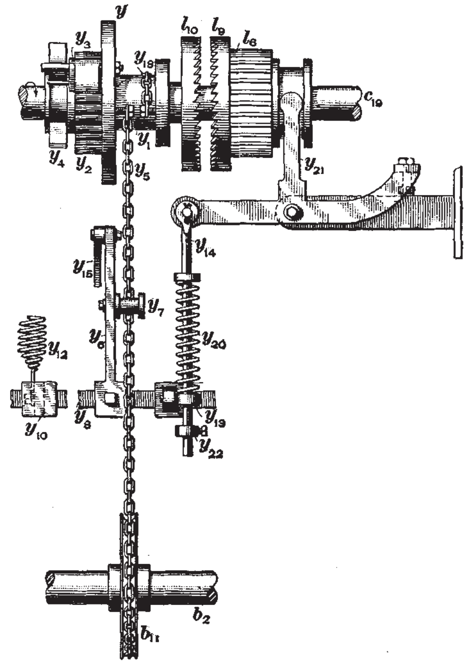


FIG. 29

At the same time that the winding faller descends, the counter faller must ascend, in order to keep the proper tension on the yarn and prevent the formation of kinks. The mechanism allowing this to be accomplished is shown in Fig. 31 (*a*) and (*b*). While the carriage is being drawn out and until the backing-off motion changes the fallers, they are locked as shown in Fig. 31 (*b*), so that neither faller wire is in contact with the yarn, leaving the spindles free to perform their function of drafting and twisting the roving into yarn. The winding faller b is held above the stretch of yarn by means of a spring b_{12} that is attached to the shaft b_2 of the faller by a leather strap in such a manner

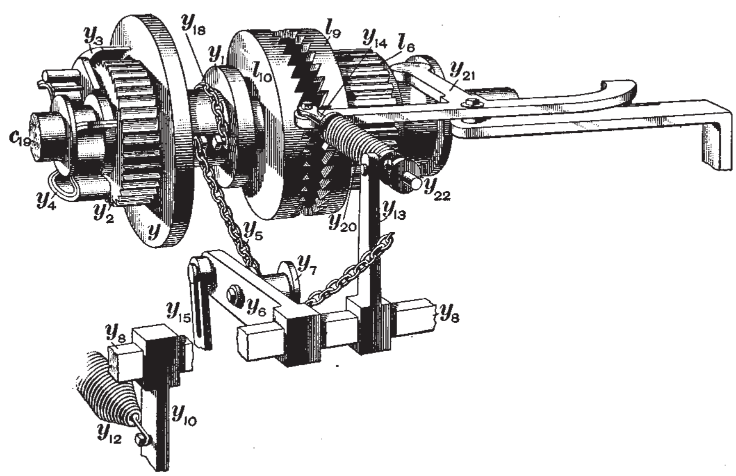
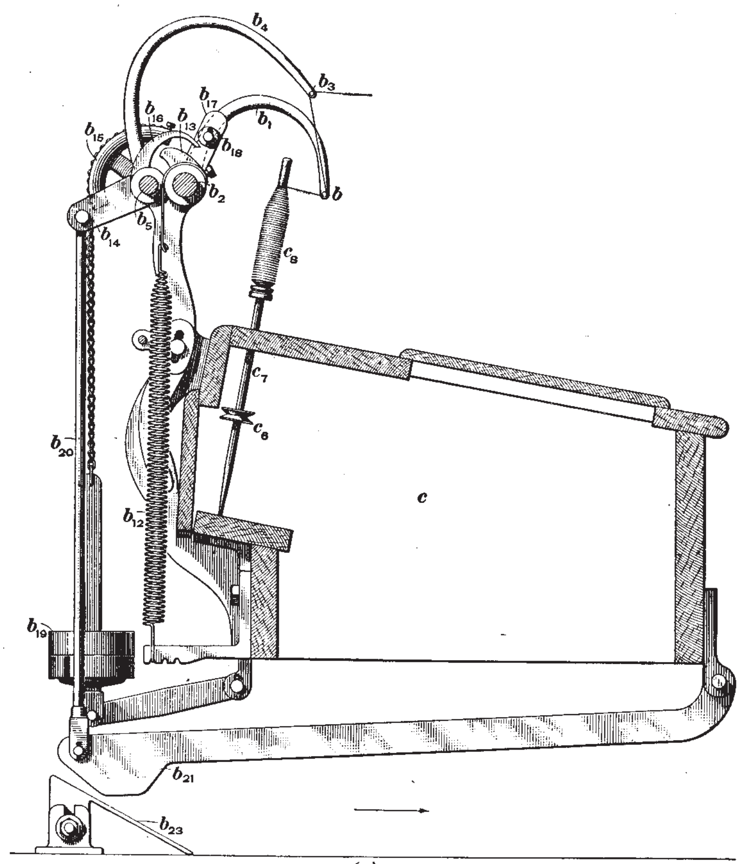


Fig. 30

as to give the faller wire a constant tendency to move upwards. The height to which the winding faller rises is limited by a stop b_{13} that is setscrewed to its shaft b_2 and rests on the top of the counter-faller shaft b_5 when the winding faller b is in its highest position. The counter faller b_3 also has a tendency to be raised, because of the pull exerted by the weights b_{19} on the segment b_{15} which is attached to the counter-faller shaft b_5. Previous to the change of fallers by the backing-off mechanism, however, the counter faller is locked just below the top of the spindles by a locking finger b_{16}, which is fastened to the counter-faller shaft b_5 and is prevented from rising by a roll b_{18} supported by a casting b_{17} fastened to the shaft b_2 of the winding faller.

When the winding-faller shaft is operated by the tightening of the back-off chain, the fallers assume the position shown



(a)

FIG. 31

in Fig. 31 (*a*). As the winding-faller shaft is turned to lower the winding faller and lock the faller leg, the roll b_{18} is moved from the locking finger b_{16}, thus unlocking the counter faller and allowing the weights b_{19} to raise it into a position that is governed only by the tension of the yarn.

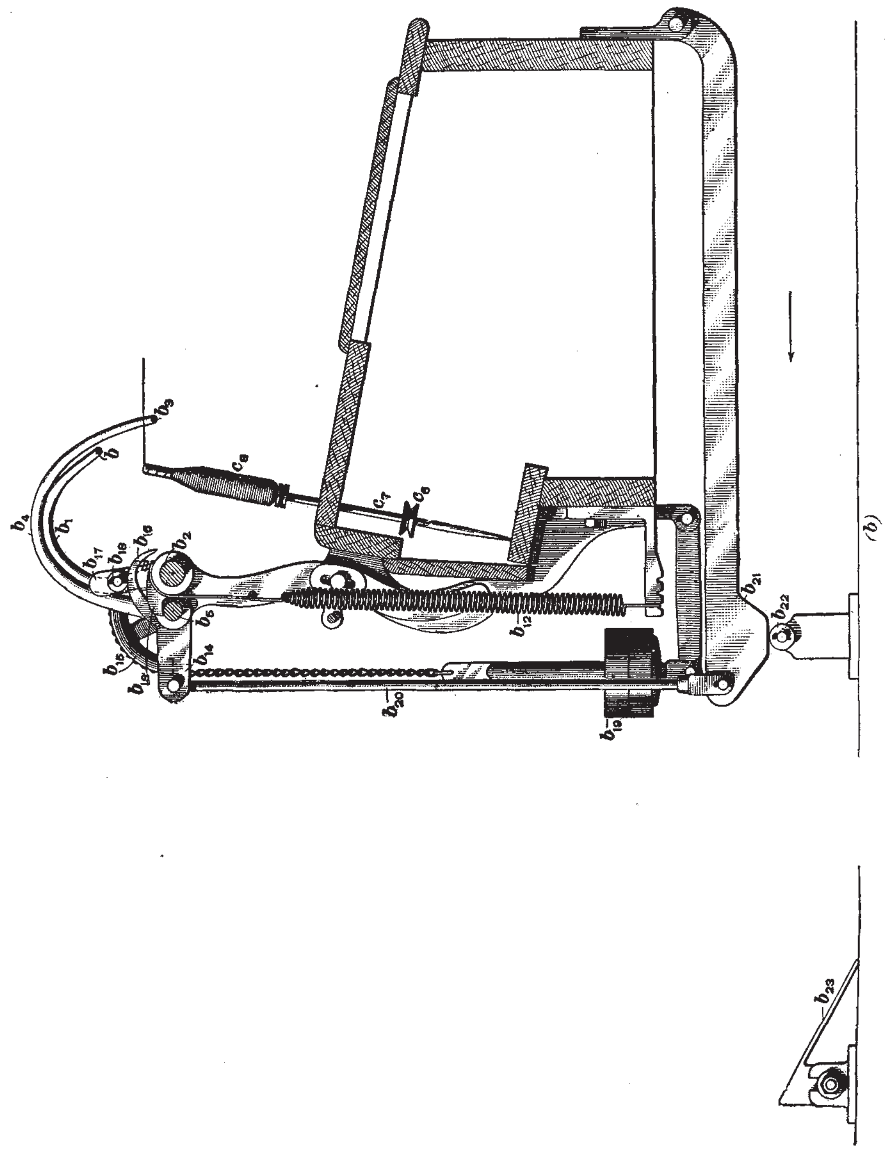

b_4
b_1
b
b_3
c_8
c_7
c_6
b_2
b_{16}
b_{18}
b_{17}
b_5
b_{15}
b_{14}
b_{12}
b_{20}
b_{19}
b_{21}
b_{22}
b_{23}
(b)

FIG. 31

There is a tendency for the counter faller when unlocked to rise too abruptly and with considerable force, and since this is liable to strain the yarn and break the ends, its initial upward movement is checked by an incline b_{23} bolted to the floor in such a position that when the fallers change, it will be directly under a lever b_{21} connected to the counter faller by a rod b_{20} and casting b_{14}, which is setscrewed to the counter-faller shaft. As the fallers change and the counter faller rises, the lever b_{21} will fall on the incline, which will thus support the weights b_{19} and prevent any further upward movement of the faller wire. As the carriage is drawn in the lever b_{21} will slide down the incline b_{23} until the tension of the yarn on the counter faller becomes sufficient to support the weights b_{19}.

50. Disconnection of Easing-Up Motion.—In addition to its other functions, the movement of the square shaft y_6, Figs. 22, 29, and 30, known as the *rocker-shaft*, also disconnects the easing-up motion. As the mule backs off and the rocker-shaft is turned by the action of the spring y_{12} it will raise the connecting-rod y_{15}, which will also raise a lever y_{16} fulcrumed on a casting bolted to and extending below the bottom of the carriage. The stud y_9 [see also Figs. 16 and 26 (*a*)], which is fastened in the lever y_{16}, by engaging with the notch in the easing-up rod k_{11}, communicates the easing-up motion to the carriage. As the lever y_{16} is raised, however, this stud is withdrawn from the notch in the easing-up rod k_{11}, and the easing up of the carriage thereby discontinued.

51. Engagement of Winding Clutch.—Still another function performed by the backing off is the putting-in gear of the winding clutch, by means of which the quadrant mechanism imparts motion to the spindle-band cylinder. Referring to Fig. 22, it will be seen that as the back-off chain y_5 raises the faller leg b_7 so that it will slip over the stud p_4, motion will be imparted to the rocker-shaft by the spring y_{12} as it pulls the lever y_{10} toward the back of the carriage. The result of this is that the lever y_{13}, which is also attached to the rocker-shaft, will be moved toward the front of the carriage. As this takes place, a rod y_{14} that is passed through a hole in a casting attached to the upper end of the lever y_{13} and held in position by a spring y_{20} and collar y_{22} will also be drawn toward the front of the carriage, thus operating the lever y_{21}, Figs. 29 and 30, to which it is attached, and throwing the part l_9 of the winding clutch in contact with l_{10}. With the clutch in contact, motion will be imparted to the spindles as the carriage runs in, by the quadrant chain. A chain y_{18} attached to the drum y extends through a hole in a girt and has a weight y_{19}, Fig. 22, attached to its extremity. The object of this is to keep the drum in position and the slack out of the chain y_5 when the pawl y_3 is disengaged from the ratchet y_2.

It will be understood that all of the movements depending on the backing-off motion take place simultaneously with the tightening of the back-off chain as the spindles are reversed, and occupy but a comparatively short period of time.

DRAWING IN

52. As the carriage is now ready to be drawn in, the backing-off motion is discontinued and the drawing-in motion put into operation, as follows: The movement of the stud y_9, Fig. 26 (*a*), in being lifted from the notch in the easing-up rod k_{11} is great enough to allow the stud to strike and raise the latch rod s, thus unlatching it from the casting s_7, which has previously held it in a forward position. As the latch rod is released, a strong spring s_6 pulls it forcibly backwards, and a casting s_1 setscrewed to it comes in contact with the back-off lever w; this moves the back-off friction cone g_2, Figs. 6, 17, and 32, from contact with the pulley g_1, thus stopping the backing off of the spindles, and also throws the half g_7 of the drawing-in clutch in contact with g_8, putting the drawing-in motion in operation. The back-off lever is prevented from moving in this direction until after the twist slide has fallen and pushed down the catch t_7, which until this occurs is held in the position shown in Fig. 27 (*a*) by the flat spring t_8. When the twist slide falls, however, a stud u_7 fastened to it strikes a lever t_6 and thus releases the catch t_7 which is fastened to this lever. This is a safety device that prevents the drawing-in motion from being accidentally put in operation at the same time that the drawing-out motion is working, which it will be understood would cause a serious smash.

When the latch rod has been drawn back and the casting s_1 has forced the backing-off lever over so that the drawing-in motion is in operation, the lever is locked in this position by means of a catch w_6, Fig. 32. This catch, which forms one

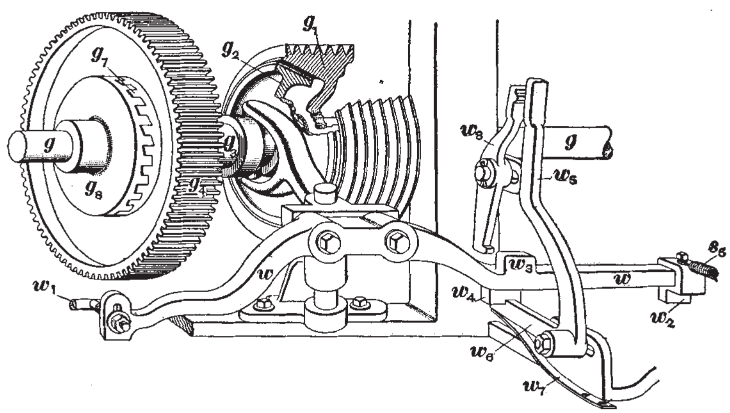


FIG. 32

arm of an elbow lever w_5, is held in a raised position by a spring w_7, so that it engages a projection w_4 of the back-off lever when the latter is forced backwards, which of course is against the tension of the spring s_5. This locks the back-off lever with the drawing-in motion in operation.

The adjustable stud y_{17}, Fig. 26 (a), in the lever y_{16} is simply a safety stud that rests just above the latch rod s and thus prevents its becoming unlatched until the mule backs off and the lever y_{16} is raised, since a smash would occur if the latch rod should accidentally be unlatched.

53. Locking of Twist Slide.—While the carriage is being drawn in several mechanisms are replaced in their initial positions preliminary to the next draw of the carriage. The twist slide is raised by means of the roll t_1, Fig. 27 (*a*), on the gear t. This gear is of course now turned, by the gear g_{15}, in the opposite direction to that in which it revolved while the drawing-in shaft was receiving motion from the unwinding of the drawing-in bands during the drawing out of the carriage. As the gear t is revolved the roll t_1 comes in contact with an adjustable casting u_4 on the twist slide u and thus raises the slide to its original position. Although the **T** piece u_3 is raised with the twist slide, the arm o_4 of the belt lever will be prevented from changing its position by the detent lever q (see also Fig. 25), which was unlocked at the dropping of the twist. As the twist slide is lifted it raises the twist-pin gear v, so that it will again mesh with the worm x_2, although no motion will be imparted to it until the gear e_9 is again revolved by the driving belt being shipped to the drawing-out pulley. The twist is locked in position by the projection v_6 of the lock-plate v_5, which is returned to its position on the casting x_3 by the spring v_{10}.

54. Replacing of Latch Rod and Draft Slide. When the carriage has been drawn about half way in, the latch rod and draft slide are moved forwards and locked in the following manner: As previously described, the draft slide r_3, Fig. 26, was drawn backwards by the spring r_7 when the stud s_4 was raised by the movement of the rod r_1 and wedge r_2 that results from the pressure of the carriage on the bunter r at the completion of the drawing-out motion. As soon as the easing-up motion is put in operation the pressure on r is removed. This allows a spring r_8 to pull the rod r_1 and wedge r_2 forwards so that the recess r_4 will be clear to receive the stud s_4. Then as the latch rod is unlatched by the upward movement of the stud y_9 and drawn back by the spring s_6, the stud s_4 is carried back into the recess r_4 in the draft slide. Any forward movement now imparted to the latch rod will also move the draft slide to its initial forward position. This movement of the latch rod is obtained from a roll g_{14} attached to a gear g_{13} that is driven from a gear g_{12} fastened to the drawing-in shaft. As the gear g_{13} rotates, the roll g_{14} engages with a casting s_2 setscrewed to the latch rod, which is thereby forced forwards, together with the draft slide, until it latches on the casting s_7, so as to be held forwards.

It might be thought that replacing the draft slide would allow the spring r_{12} to pull the lever r_{10} over and throw the drawing-out clutch e_{14} in contact; this is not so, however, since as the draft slide is replaced, the lever r_{10} is held by a long-headed screw r_{11} attached to it, that when the drawing-in motion is in operation extends behind a casting w_2, Figs. 26 and 32, setscrewed to the back-off lever w, which of course is then locked in such a position that the casting will be far enough backwards to accomplish this. This long-headed screw r_{11} is also a safety device, since it will not permit the drawing-out clutch to lock until the drawing-in clutch disengages. As the draft-slide is replaced the stud k_8 is lifted on the raised part r_{13} of the draft slide. This raises the upper part k_3 of the easing-up clutch from the lower part, in which position it remains until the draft slide is again released and drawn back by the spring r_7 at the end of the next outward run of the carriage.

REENGAGEMENT

55. Disengagement of Drawing-In Motion.—As the carriage reaches the end of its inward run the several parts are reengaged for the next draw, but first of all the drawing-in motion must be disconnected. This is accomplished by means of the lever w_5, Fig. 32, which is struck and forced back by a bunter on the carriage. As this happens the arm w_6 is lowered and the back-off lever released, whereupon the spring s_5 draws it over and throws the drawing-in clutch out of contact, moving the back-off lever until the **T** piece w_1, Fig. 27 (*a*), strikes u_6. As this movement takes place the catch t_7 is raised by the spring t_8 and thus locks the back-off lever so that the drawing-in motion cannot go into operation until the twist slide drops again; as it is also prevented by u_6 from moving in the opposite direction so that the backing-off friction cone will engage, it occupies what is termed the *neutral* position.

In order to make the disengagement of the drawing-in motion positive, so that there will be no liability of a smash should the spring s_5 fail to operate the back-off lever, a lever w_8, Fig. 32, is placed in such a position that it is struck at one end by the lever w_5 as the latter is forced back by the bunter on the carriage. The other end of the lever w_8 engages with a projection w_3 on the back-off lever, so that the drawing-in motion is disconnected in any case when the carriage strikes the lever w_5.

56. Engagement of Drawing-Out Motion.—When the drawing-in is discontinued, the drawing-out motion is put in operation, so as to move out the carriage for the next draw, as follows: When the spring s_6, Fig. 26 (*a*), moves the end of the back-off lever w forwards, the casting w_2 slips off the screw r_{11} and allows the spring r_{12} to operate the lever r_{10} and put the part e_{14} of the drawing-out clutch in contact with e_{13} and the drawing-out motion in operation. At the same time that this is accomplished the driving belt is shipped from the second to the third driving pulley and another draw commenced, provided of course that the wedge q_4, Fig. 25, was in such a position when the carriage came in as to lock the detent lever q so that the arm o_4 of the belt lever may rise until stopped by t_4 in the position shown in Fig. 27 (*a*). If the detent lever is not locked the belt will remain on the pulley e_2, but as the drawing-in clutch and back-off friction are out of connection, no motion will be imparted to any part of the mule except the loose train of gears e_7, g_6, g_5, g_4, Fig. 6.

As the carriage reaches the end of its inward motion several other important reengagements take place. The roving motion is thrown into gear again by the roll c_9, Fig. 9, on the carriage striking the lever i. The dwell motion is also operated by the segment gear j_1, Fig. 13, coming in contact with the rack j. The fallers are also caused to resume their position clear of the yarn preliminary to the next outward run of the carriage, in the following manner: As the carriage reaches the end of its inward run the faller leg b_7, Fig. 22, strikes a casting p_{31} bolted to the floor and is thus unlocked from the stud p_4. This allows the spring b_{12}, Fig. 31 (b), attached to the winding-faller shaft b_2 to raise the winding faller until clear of the yarn; that is, until its motion is checked by the stop b_{13}. The counter faller is lowered at the same time by means of a roll b_{22} attached to a casting that is bolted to the floor. This roll engages the inclined part of the lever b_{21}, raising it and also the rod b_{20} and lever b_{14} and thereby lowering the counter faller. As the counter faller is lowered the locking piece b_{16} attached to the counter-faller shaft engages with the roll b_{18} and locks the faller in position. When the faller leg b_7, Fig. 22, is struck by the casting p_{31} and unlocked, the rocker-shaft y_8 is operated and the half l_9, Fig. 30, of the winding clutch disengaged from l_{10}, and as the carriage starts to be drawn out again the center shaft c_{19} will be driven by the rim band.

This completes the cycle of movements of the mule during one draw of the carriage. The mule is now ready to repeat its operations for the next draw.

SPECIAL POINTS

DOFFING

57. When a set of bobbins becomes filled with yarn they must be removed and empty bobbins substituted; this operation is known as **doffing.** When doffing a full set of bobbins from the mule, the builder rail is first wound up while the carriage is coming out. This is accomplished by lifting the pawl p_{18}, Fig. 24 (a) and (b), and winding back the builder gear p_{21}, screw p_8, and consequently drawing the shoes p_5, p_6, p_7, Fig. 22, forwards by means of the crank-handle n, Fig. 18, which is removed from the quadrant screw for this purpose and placed on the screw shaft of the large builder gear, the end of which is square in section to allow this. As the shoes are moved forwards the rail is raised, which causes the winding faller to go to the base of the bobbin when the fallers are changed by the backing-off motion. The mule is allowed to continue in operation until the fallers change, when it is stopped immediately by means of the shipper lever *o*, Fig. 25. The shipper lever is then given several sharp jerks, so that sufficient motion will be imparted to the mule to allow the spindles to make four or five revolutions. As the winding faller is down, this winds, or ties, the yarn around the base of the bobbins, thus preventing their unraveling during subsequent handling. The winding faller is next locked down by pressing it below the bobbin and fastening it by means of a small catch on the carriage provided for this purpose. Then by leaning over the carriage and pulling the rim band toward the carriage, motion is imparted to the spindles; this will wind the yarn around them and thus tie it so that the ends will not be broken down when the full bobbins are removed. It is well to tie the yarn firmly around the spindles, and as the turning of the spindles by means of the rim band gives slack quadrant chain, because the spindle drum is turned without drawing in the carriage, the carriage may now be *jerked* in by power until the quadrant chain is tight. This gives slack yarn because this movement of the carriage is accomplished without turning the spindles, the quadrant chain being slack. The counter faller is now locked down with the winding faller by means of the catch mentioned and the full bobbins removed from the spindles and placed in a basket. Empty bobbins may now be placed on the spindles and, by means of a short length of board, pressed down until their tops are flush with the tops of the spindles. Care should be taken in pressing down the bobbins in this manner to avoid bending the spindles or splitting the bobbins.

After all the bobbins are placed on the spindles, the quadrant pulley l_2, Fig. 18, is wound down to the bottom of its screw l_1 by means of the crank-handle n and the link in the quadrant-governor chain n_{14} turned down. The fallers may now be unlocked. Then by leaning over the carriage and drawing the rim band toward the carriage a half turn of yarn may be wound around the new set of bobbins. After making sure that the quadrant chain is tight, the carriage is run in slowly, checking the power with the shipper lever; otherwise, the carriage will bang in hard against the back stops. If the quadrant chain is not tight, the faller leg b_7, Fig. 22, may be pulled out of contact with the stud p_4 by hand. This pulls over the rocker-shaft y_8, releases the winding clutch from contact, and allows the weight l_{14}, Fig. 5, to drop, turning the drum l_4, Fig. 18, by means of the rope l_7 and taking the slack out of the quadrant chain l_3. After the quadrant chain is tightened, the faller leg may be locked again by depressing the winding faller with the handle b_{10}, Fig. 22. Immediately that the carriage is drawn in against the back stops, the shipper lever may be pulled forwards and the mule started in operation.

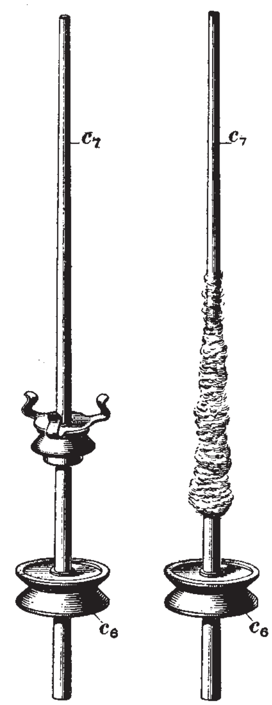


FIG. 33

BOBBIN CLIPS

58. In order to spin the yarn well, the bobbin must be level, or flush, with the top of the spindle; the usual method of accomplishing this is to wind packing yarn around the spindle so as to make the bobbin fit tight and be held at the right height. A better way to accomplish this result, however, is to use a **bobbin clip,** or holder, of which there are several kinds on the market. Fig. 33 shows a spindle packed with yarn in the old way and also one equipped with an ordinary type of bobbin holder.

Among the advantages of the bobbin clip may be mentioned the following: (1) It saves the packing under the bobbins and the time in putting it on. (2) It causes the bobbin to run true by being held firmly and at a common center; that is, not allowing the bobbin to wabble in consequence of uneven yarn packing. (3) The bobbins are always flush with the top of the spindles and are not split or broken by being thrust over the packing. It also saves the use of a stick for pounding the bobbins down to their proper level. (4) It saves time in cutting off the excess of waste and packing from around the spindles.

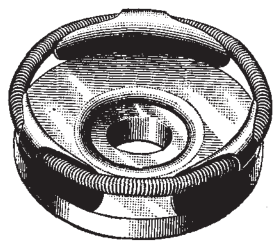


FIG. 34

59. An improved device for holding the bobbin on the spindle is shown in Fig. 34. This consists of a clip that is placed on the spindle and holds the base of the bobbin by means of three steel lips that are pressed on the bobbin by a spring.

SPINDLE BANDS

60. In regard to the **spindle bands,** great care should be taken to replace loose bands, as they make soft bobbins, which greatly increase the amount of waste. The best band to use is an endless fulled-wool band. These may be purchased or may be made at the mill if the mill owns a spindle-band machine. Knotted bands are undesirable.

WASTE

61. The amount of **waste** made in a spinning room is governed to a large extent by the degree of care with which the draft is set to accommodate different batches and kinds of stock. If the draft is not adjusted properly, the ends will be constantly breaking, thus increasing the waste and also the labor of the spinner in piecing up ends.

Generally speaking, the longer and coarser the stock, the quicker the carriage should be drawn out. If the ends break close to the delivery rolls, it is an indication that the drafting is too slow. This is especially apt to be so in the case of long stock, as the long fibers take the twist more rapidly and thus become hard to draw out to the required size of yarn. On finer stock, if the roving breaks about half way between the delivery rolls and the spindles when drawing, it is an indication that the carriage is being drawn out too fast. Short stock, or stock in which there is a liberal supply of waste, must be drawn much more slowly than the longer grades of wool.

Large alterations in the draft may be made by means of the draft gear e_8 or the intermediate draft gear e_{11}, Fig. 7. A larger gear in either case increases the speed of the draft scroll and consequently of the carriage, and a smaller gear has the opposite effect. The finer adjustments of the draft are made by changing the position of the drawing-out, or draft, scroll by means of the handle f_{10}, Fig. 13, or by changing the wings of the draft scroll.

With the draft set to conform to the grade of the roving, a mule should make very little waste. Waste in the spinning room is expensive, and as most of it is partly twisted and the rest has been mixed with hard ends on the floor, it is swept up and put with the hard waste at night. The spinners should be required to keep the waste off the floor and to keep the hard and soft waste separate.

It is a good plan to have two boxes or baskets attached to each mule, one for hard and one for soft waste. In this manner the spinner can keep the hard and soft waste separate and the latter can be mixed with good wool and run through the cards again.

CLOCK

62. A **clock** for registering the amount of yarn spun is generally applied to all modern mules, although it is of great value in cases where the spinners are paid according to the amount of yarn that they spin; but is often disconnected when spinners are paid by the day or week. As shown in Fig. 35, the clock motion is driven from the drawing-in shaft g, on which is fastened a worm z (see also Fig. 17) that imparts motion to a segment gear z_1 cast in the form of a bell-crank lever. To one arm of this lever is attached a rod z_2 that has

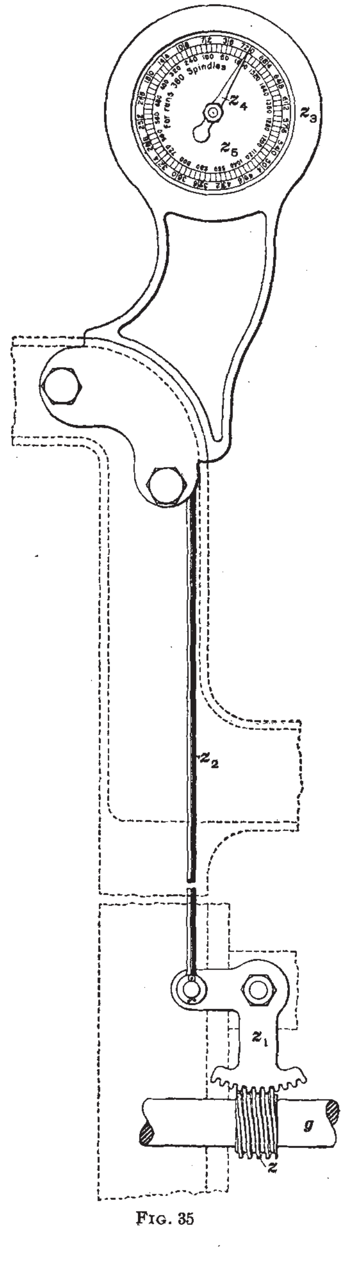


FIG. 35

on its upper end a pawl engaging with a 10-tooth ratchet gear contained in the clock case z_3. Compounded with this ratchet is a single-threaded worm meshing with a 160-tooth worm-gear, to the shaft of which the pointer z_4 is attached. As the carriage is drawn out, the rod z_2 is raised, but as it is drawn in, the motion of the shaft g is reversed and the rod lowered, the pawl on its end moving the ratchet 1 tooth. Ten draws of the carriage will therefore impart one revolution to the ratchet gear, as the latter contains 10 teeth, and since the 160-tooth worm-gear is driven by a single worm, 10 times 160, or 1,600, draws of the carriage will be required to move the indicator z_4 one complete revolution. The dial z_5 contains two rows of figures; the inside row is numbered from 0 to 1,600 and simply indicates the number of draws the carriage makes. The outside row of figures varies according to the number of spindles that the mule contains, and indicates the number of pounds of 1-run yarn spun. If the mule is a 360-spindle machine, the outside row of figures is numbered from 0 to 720, whereas if the mule contains only 280 spindles, the highest number of the outside row would be 560; that is, the outside row of figures will register a number equal to twice the number of spindles, because the length of yarn spun at one draw by each spindle is 2 yards; or in other words, in 1,600 draws, or one revolution of z_4, a number of pounds of 1-run yarn equal to twice the number of spindles will be spun. If a mule is spinning yarn of any other size than 1-run, in order to find the number of pounds produced it is simply necessary to divide the reading of the clock by the size of the yarn. For instance, if a mule is spinning 3-run yarn and the clock registers 288 pounds, only $288 \div 3 = 96$ pounds of yarn has been spun; or if 4-run, 72 pounds, etc.

SIZE, GAUGE, SPEED, AND HORSEPOWER

63. The size of woolen mules is designated by the number of spindles, and mules are constructed with any number of spindles that may be required, the usual custom being for a mill to order mules of a size suited to its requirements. Such sizes as 120-, 160-, 200-, 220-, 260-, 300-, 320-, 360-, and 400-spindle mules are common sizes.

The gauge of a mule is the distance between the centers of two consecutive spindles. Ordinary woolen mules are generally constructed with a $1\frac{3}{4}$- or 2-inch gauge, although any gauge may be made, according to the requirements of any particular case. Heavy mules for spinning carpet yarns are usually made with a wider gauge than ordinary mules. Any increase in the gauge increases the length of the machine relative to the number of spindles.

The driving pulleys of the mule are 14 inches in diameter, and for ordinary woolen spinning should make from 320 to 360 revolutions per minute. Mules with a smaller number of spindles may be speeded faster than larger mules, which are generally speeded slower on account of the increased weight of the carriage in the latter case. Wide-gauged and heavy carpet mules should be speeded slower.

The horsepower consumed by a mule is a variable quantity, since while certain motions are in operation a very much larger amount of power is necessary than while certain other motions are in operation. Thus, when the carriage starts away from the delivery rolls the power consumed is very great, whereas while the mule is backing off the power amounts to practically nothing. It may be stated that on an average a 300-spindle mule will require from 3 to 4 horsepowers.

WOOLEN AND WORSTED WARP PREPARATION

(PART 1)

INTRODUCTION

1. Between the processes of spinning and weaving there are several intermediate operations necessary before the yarn that is to constitute the warp of a fabric can be placed in suitable form for the weaving process. The object of these operations is to place the warp yarn on the loom beam so that it may be readily unwound as the cloth is woven and in a manner best suited for making a perfect fabric in the loom. In order that this object may be accomplished, it is evident that a definite number of threads or warp ends must be wound on the loom beam, according to the specifications of the cloth to be woven, and that each of these threads must be of the same length; that is, the required length of the warp.

To obtain the best results in weaving it is also imperative that each end of the warp shall be laid on the loom beam under the same tension, so that the warp will leave the beam evenly and the threads have a uniform tension while being woven. This is important not only in order to avoid poor weaving or the production of faulty cloth from the loom, but also to produce a fabric so constructed that the subsequent operations will not injure it. For instance, suppose that a fabric is being woven in which all of the warp ends have the proper tension with the exception of a few threads that are wound loosely on the beam. It must necessarily follow that these threads will be woven into the cloth loosely throughout the whole piece, and if the fabric is piece-dyed a light shade, they will dye *darker* than the body of the fabric. The reason for this is that in a thread that is loose in the fabric the fibers do not lie so closely together and so will absorb the dyestuff more readily, thus taking up more of the dye and becoming darker in shade. Even in cases where the goods are not dyed in the piece, there is a strong tendency for a loose thread to show more prominently on the face of the cloth, since it is not drawn down level with the other threads by the tension of the warp. In some fabrics, also, loose threads are liable to cockle, thus producing a serious defect and causing the cloth to be classed as seconds.

2. Not only is it necessary when making a warp to have the right number of ends on the beam for the cloth to be woven, but it is also necessary in the preparation of some warps to use differently colored threads and to arrange the pattern of the warp correctly in order that certain effects of coloring may be obtained in the fabric. By examining any piece of cloth that contains threads of different colors in the warp it will be seen that these colors are arranged in a definite order, or **pattern,** which is repeated a certain number of times in the width of the cloth. In order to weave such a cloth, it is evident that the colors in the warp must be arranged in the same order on the beam as they are arranged in the cloth.

3. Another operation that is sometimes performed during the preparation of the warp is the application of a suitable dressing compound, or **size,** to the yarn, the object being to glue down the projecting fibers and make the thread smooth, so that the chafing of the reed and harnesses will not wear or rough up the yarn during the operation of weaving.

4. When the warp has been wound on the beam in suitable form so as to be readily unwound while being woven, it is next necessary to draw the separate ends of the warp through the harnesses according to the designer's draft and also to draw the correct number of ends through each dent of the reed. After drawing in and reeding, the preparation of the warp is complete and it is then placed in the loom by the loom fixer and the cloth woven by the weaver.

5. As a summary of the foregoing it may be stated that the yarn that is to compose the warp of a fabric must be wound on the loom beam with an even and uniform tension; the pattern of the warp and the number of ends in the warp must be regulated; the warp may or may not have a suitable sizing compound applied in order to enable it to withstand the weaving process to better advantage; and the yarn must be drawn in through the harnesses and reeded.

6. Processes Employed in Warp Preparation.—In order to accomplish these results there are four processes generally employed, the object of which is to ultimately make a warp from the yarn as it comes from the spinning room on bobbins. These processes are: (1) *spooling*, (2) *dressing*, (3) *beaming*, (4) *drawing in* and *reeding*. Although these operations are in reality separate and are so spoken of when considered separately, it is customary to speak of the operations of warp preparation in general as *dressing*, all of them being conducted in a department known as the *dressing department*, usually under the charge of the boss weaver, or sometimes in large mills, a boss dresser.

SPOOLING

THE SPOOLER

7. The first operation necessary in the preparation of a warp is that of **spooling**, the object being to take the yarn from the bobbins on which it is spun, or twisted, and wind it on dresser spools, or jack-spools. These spools are constructed with a long wooden barrel having a head on each end, and are made to hold a certain number of threads, depending on the capacity of the spooler. The machine for spooling the yarn is commonly known as a **spooler**, and is shown in Fig. 1.

8. Bobbin Stand.—A bobbin stand similar to that shown in connection with the spooler is always necessary when the yarn is received on bobbins, as is generally the case with woolen yarn. It is for the purpose of holding the bobbin securely, in order to allow the thread to be unwound.

Spoolers and bobbin stands are usually made for 40 ends, but occasionally for 48 ends; the number of ends is regulated by the number of holes in the guide bars of the spooler. Guide bars with a smaller number of holes can be substituted and used if necessary.

9. Operation.—The operation of the spooler is as follows, the references being to Fig. 2. The bobbins *a* are placed on fixed pins, or spindles, on the bobbin stand and the yarn is passed behind one of two rods a_1 that serve as guides, and thence over hooks in the top of the stand. From these hooks the yarn passes to another row of hooks in the top of the spooler. The yarn next passes through a perforated guide bar *b* that has a traverse motion and then around two tension rolls *c*, *d* that are covered with leather having a roughened surface.

From the tension rolls the yarn passes through another traversing guide *e* and is ultimately wound on the spool *f*, the bar *e* being for the purpose of building the yarn on the spool smoothly. The spool is driven by friction with the

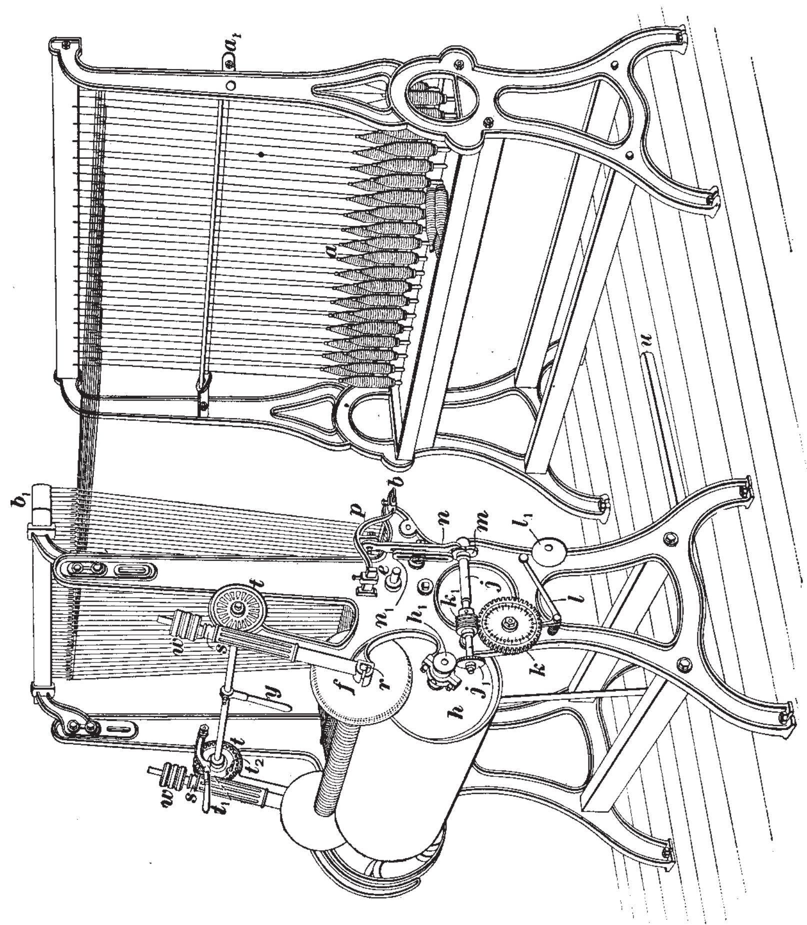


Fig. 1.

drum *h*, on which it is held firmly by means of a device that will be explained later. The drum is exactly 1 yard in circumference, so that at each revolution that it makes, 1 yard of yarn is wound on the spool. The beam b_1, in which the

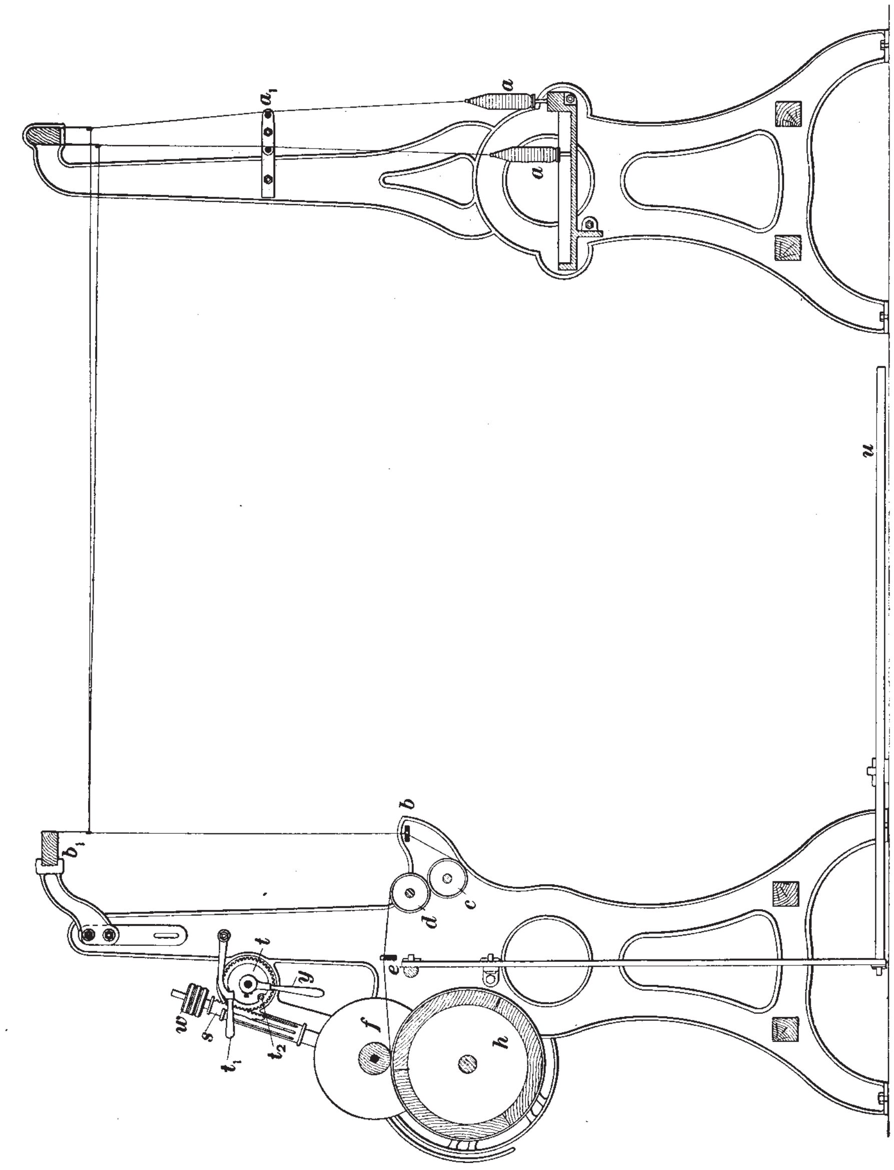


FIG. 2

row of wire hooks is placed, is adjustable by means of slots in its supporting uprights (as shown in Fig. 1), so that if the operative is of small stature it may be lowered in order to facilitate the work when tying in broken ends.

10. Tension Rolls.—The tension rolls *c*, *d* are driven only by means of the yarn passed around them; they thus regulate the tension with which the yarn is wound on the spool and also prevent kinks from passing forwards to the spool. The tension may be regulated by the position of the tension roll *d*, which may be moved farther back into another set of slots for increasing the tension or farther forwards to decrease the tension. The tension is also regulated in some cases by means of the frictional resistance of a cord fastened at one end to the framework of the machine; the other end is led around a grooved iron pulley at the end of the tension roll and has a weight attached. In this case more or less tension may be obtained by increasing or decreasing the amount of weight or the length of cord in contact with the pulley.

Although rolls covered with leather are best, many spoolers are equipped only with smooth, polished tension rolls. The guide *b* has a traversing motion, in order that the yarn shall not run in one place and thus wear grooves in the tension rolls, and also to correspond with the movement of the guide *e* and thus reduce the strain on the yarn as it traverses.

11. Measuring Motion.—There is a measuring, or clock, motion attached to the spooler, which is shown in Fig. 3, as well as in Fig. 1. On the shaft of the drum *h* is a worm h_1 that meshes with a 30-tooth worm-gear j_1 attached to a side shaft *j*. Attached to this shaft is a worm k_1 that meshes with a dial gear *k*. This gear is marked off so that the number of yards spooled can be readily ascertained. The drum *h* is 1 yard in circumference; the worm h_1 is a single-threaded worm; the worm-gear j_1 has 30 teeth; and the worm k_1 is single-threaded. Therefore, it will be readily seen that each tooth on the dial gear equals 30 yards of yarn on the spool, and that in order to find the number of yards spooled it is simply necessary to multiply the number of teeth that the dial gear *k* moves by 30. This may also be reckoned by means of the scale marked on the dial gear.

There is an *alarm* connected with this mechanism whereby a bell is made to ring when a given number of yards has been spooled. In the dial gear *k* there is a row of holes, in any one of which a peg l_2, Fig. 4, may be placed. This peg

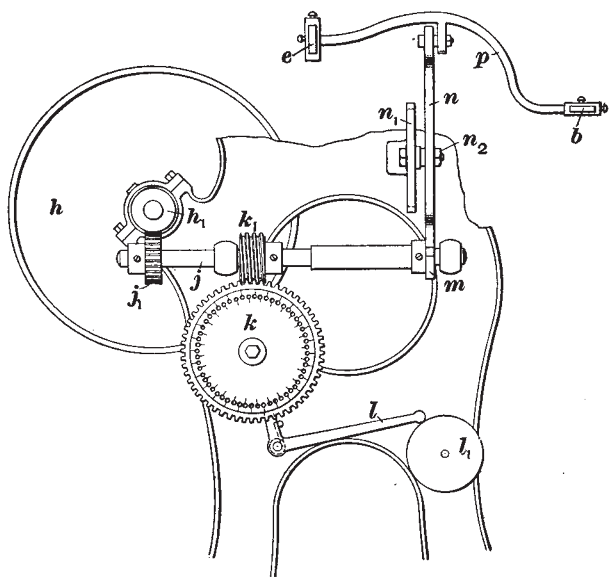


FIG. 3

when brought around by the rotation of the dial gear raises a hammer *l*, which is pressed against the bell l_1 by a coil spring upon the stud on which the hammer is centered. When the peg slips past the hammer, it will fall against the bell, thus notifying the operator that the desired number of yards have been spooled. It will be readily seen that the bell may be made to ring when any multiple of 30 yards of yarn has been spooled by simply placing the peg in the correct hole in the dial gear.

12. Traverse Motion.—One of the most important parts of a spooler is the traverse motion. Referring to Figs. 1 and 3, it will be seen that the guide bars *b*, *e* are connected outside of the frame of the machine by a curved bar *p*. By this means the guide bars are made to move in unison, thus not only keeping the tension rolls free from grooves and building a level spool but also at the same time avoiding unnecessary strain on the yarn. The reciprocating motion of the guide bars is obtained by means of a double heart cam *m*, Figs. 3 and 4, attached to the shaft *j*, which has a constant rotary motion imparted to it by its connection with the drum *h*. The cam *m* imparts motion to a lever *n* that is pivoted on a stud n_2, on which it swings, and connected to the curved bar *p*. The stud n_2 may be moved vertically in a slotted stand n_1, and if moved upwards the length of traverse that the lever *n* imparts to the guide bar *e* is reduced, or if moved downwards the length of traverse of the guide bar is increased. This adjustment of the stud n_2 allows the length of the traverse to be regulated so that each thread will wind close up to the adjacent threads without leaving hollows in the surface of the yarn on the spool, and also without overlapping or being wound over the adjacent threads. Sometimes when making a pattern on the dresser a full spool is not wanted, in which case it may be desirable to alter the length of traverse. Suppose that it were necessary to have only 20 ends on a spool; then a thread could be drawn through every other hole in the guide bars and the traverse

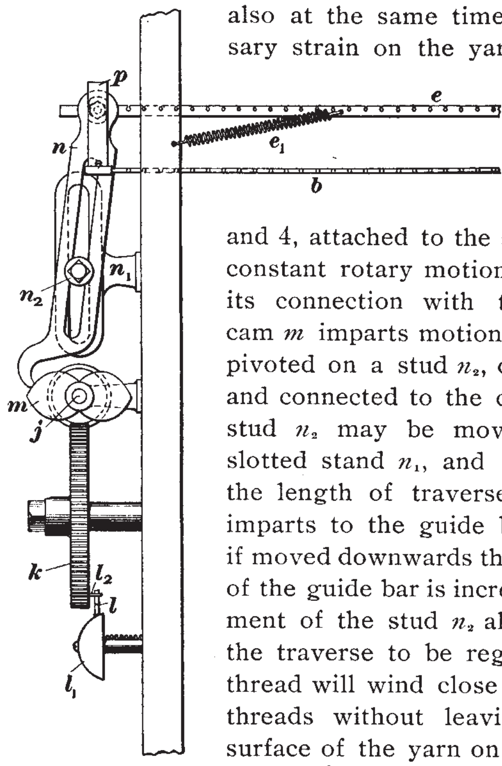


FIG. 4

increased to twice the original throw. This is not often done, however, and many operators would simply draw the 20 ends either in the middle or at one end of the spool, running perhaps an odd waste end of a different color at the side of the desired ends to keep them from slipping down. A spring e_1 tends to pull the guide bar *e* toward the side of the machine, and as the guide bar is connected to the lever *n*, the lower curved end of the lever *n* is constantly pressed against the face of the cam *m*.

As the cam revolves it will alternately allow the point of the lever *n* to move closer to or be forced farther from the shaft *j*, which will give a corresponding traversing movement to the guide bars *b*, *e*. As the cam *m* is a double one, it will cause two complete traverses of the guide bars to be made for each revolution of the shaft *j*.

13. Spool-Holding Device.—In order that a rotary motion may be imparted to the spool so that the yarn will be wound on the same, it is necessary that the spool shall be held in contact with the rotating drum with sufficient pressure to drive the spool by the frictional contact between it and the drum. It was formerly the custom to obtain this pressure by hanging weights with iron hooks upon the gudgeons, or journals, of the spool. The objection to this method is that it is apt to wear out the spools rapidly by loosening and otherwise damaging the journals, and is also inconvenient in the operation of the machine. A better method of holding the spool firmly in contact with the drum is that employed on the spooler shown in Fig. 1. In this case the journals of the spool are carried on bearings *r* formed in the ends of racks *s*. Weights *w* fastened to extensions of these racks exert a pressure on the journals of the spool and keep the latter in contact with the drum *h* with sufficient pressure to prevent slipping.

In order that the spool may be raised from the drum when replacing a full spool with an empty one, two gears *t* are fastened to a shaft passing across the machine. These gears mesh with the rack, and when the handle *y* is raised, the racks and the spool also will be raised from contact with the drum. A pin t_2 on the gear t engages with the dog t_1, so that when the spool has been raised it is prevented from dropping again until the dog t_1 is disengaged from the pin.

Occasionally it will be found that there is some tendency for the spool to slip on the drum of the spooler, especially if the drum has become very smooth through wear. The clock of the measuring motion is therefore liable to register a greater length of yarn than is actually wound on the spool. A good way to prevent the spool from slipping is to wind a strip of rough leather around the drum until its surface is completely covered. Fillet card clothing with the teeth removed is a good material to use for this purpose. Covering the drum with leather not only prevents slipping, but also increases the diameter of the drum slightly, so that there is no danger of the amount of yarn on the spool being less than registered by the clock.

14. Belt Shipper.—Beneath the spooler, as shown at Fig. 1, there is a lever u pivoted on a pin projecting from the floor and connected with the belt guide, by means of which the belt may be shifted upon the tight-and-loose pulleys by the foot of the operator, thus allowing the machine to be stopped very readily for the purpose of tying in broken threads.

15. Speed.—The main driven pulleys of a spooler are usually from 12 to 14 inches in diameter, and for good results should run from 100 to 120 revolutions per minute.

16. Stop-Motion.—Nearly all modern spoolers are equipped with a stop-motion, which is a device for stopping the machine immediately when one of the bobbins becomes exhausted or a slug or tangle in the yarn causes an end to break. This motion therefore prevents imperfect spools from being made, since it will be seen that if the machine is not immediately stopped when an end breaks or runs out, many yards of thread will be missing on the spool because of the high velocity at which the drum of the spooler is driven. When this happens, the operator finds the broken end and repairs it, of course without unwinding the yarn that has been spooled on other parts of the spool in the interval of time between the breaking of the thread and the stopping of the machine, with the result that the spool has one end that is several yards shorter than the others. If the broken end is much shorter than those on either side, it leads to another defect; for in this case a hollow of considerable depth is formed in the spool and the ends on each side have a tendency to fall into this and wind over the short end after it has been pieced up. When such a spool is placed in the creel behind the dresser, there will be difficulty in making it unwind properly without some of the ends becoming broken and imperfect work resulting.

Fig. 5 (*a*) and (*b*) shows a stop-motion applied to the ordinary type of woolen and worsted spooler. On the main shaft of the machine, which carries the drum h, an eccentric l is placed just inside the frame and on the pulley side of the machine. This eccentric imparts motion to an arm l_1, to which a casting l_2, having an inverted **V**-shaped slot in one end, is bolted. An oscillating rod j_1 extending across the entire width of the machine is supported from a shaft j_2 by arms, one of which j extends below the shaft j_2 and has a pin j_3 fastened at its lower end. The pin j_3 passes through the slot in the casting l_2, and as the rod l_1, l_2 has no support except from the eccentric l and the pin j_3, the upper part of the slot in l_2 rests loosely on the pin j_3 during the ordinary working of the machine. As the eccentric revolves, motion will be given to the pin j_3 and the lever j will be moved forwards and backwards about its fulcrum at j_2, and the rod j_1 will consequently have an oscillating motion. Each end a that is being spooled is threaded through a guide k_2 in a drop finger k, which is supported loosely by a rod k_1 extending from one side of the spooler to the other. Each drop finger is independent of the others, and can swing on the rod k_1. Besides having a guide for the thread to pass through, each finger is made with a projection k_3 extending downwards, and constantly tending to pull the finger down by its weight. The tension of the thread is sufficient to hold

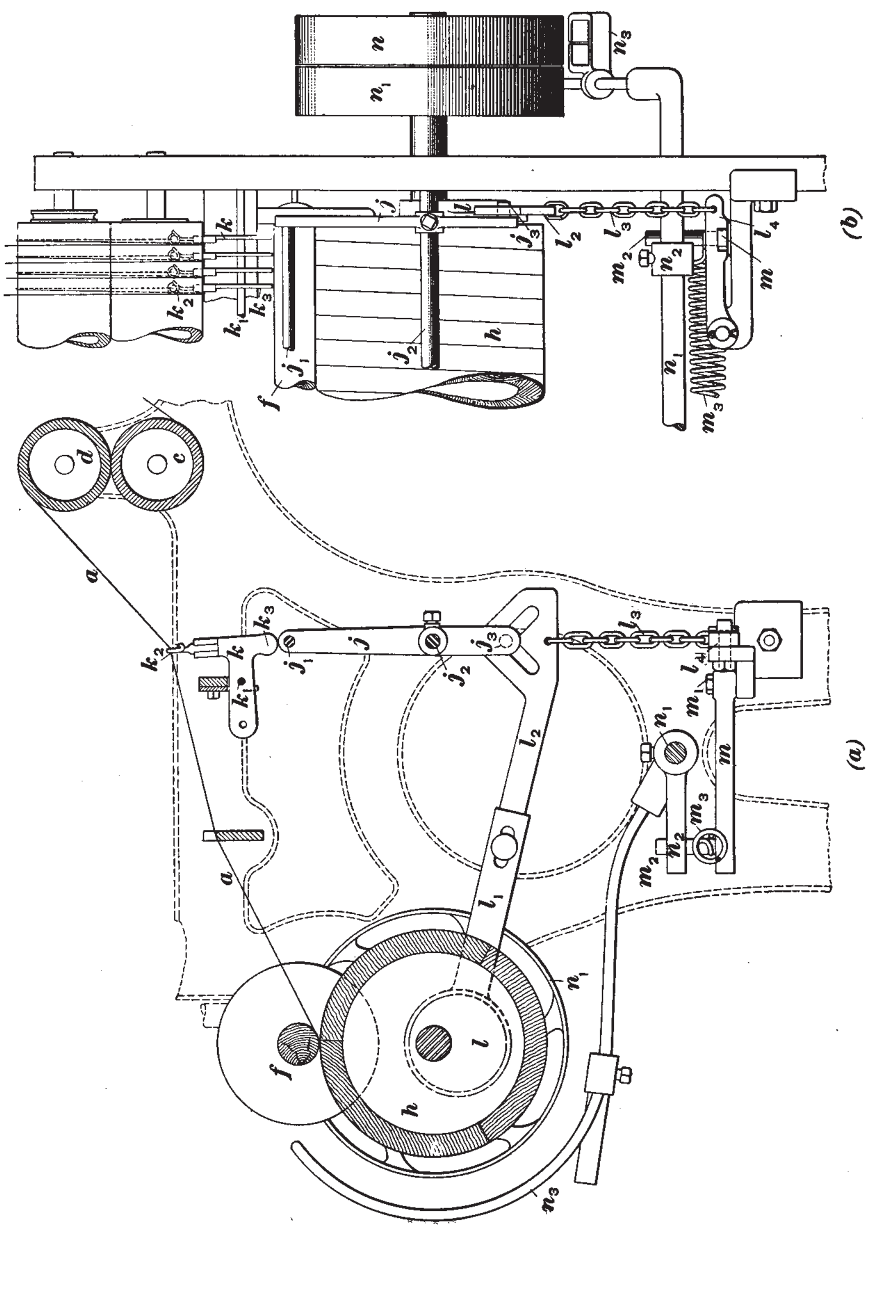


Fig. 5

the drop finger in a raised position during the ordinary working of the machine, in which position it is impossible for it to come in contact with the oscillating rod j_1 situated just beneath it; but, if for any reason the thread should become broken or missing, the drop finger will fall, since it is so weighted as to be supported only by the thread. Whenever this happens, the extension k_3 on the drop finger will come in contact with the oscillating rod j_1 and check its motion; the lever j will therefore also be held firmly, and, since the eccentric l is not stopped and the pin j_3 is held fast, the casting l_2 rises because of the upper edge of the slot being forced past the pin j_3. As the slot provides an inclined surface on either side of the pin j_3, it is immaterial on which side of the extension k_3 on the drop finger the rod is engaged. When the casting l_2 rises it will tighten a chain l_3, which in turn will raise a lock lever l_4 and thus release a lever m fulcrumed at m_1. At the end of the lever m is a stud m_2 to which a spring m_3 fastened at the opposite side to the framework of the machine is attached. When the lock lever l_4 is raised and the lever m released, the spring draws the lever over, and the stud m_2 coming in contact with a finger n_2 setscrewed to the shipper rod n_1 forces the belt from the tight pulley n to the loose pulley n_1 by means of the guide n_3 through which the belt passes. The finger n_2 does not interfere with the regular shipping of the belt, and when the broken end has been replaced the shipper rod is forced back again, in so doing shipping the belt to the tight pulley and forcing the lever m back so that it will again be locked by the lock lever l_4.

If it is desired to make a spool with fewer ends than there are drop fingers, the unused drop fingers must be raised so that they will not stop the machine. This may be accomplished by passing a wire through the holes in the rear of the fingers, the weight of the wire holding the fingers in a raised position; or the fingers may be tied up.

WORSTED CREEL

17. When worsted yarn is being spooled, it is usually necessary to substitute a creel for the bobbin stand shown in Fig. 1, since worsted yarn is usually received in the dressing room on small spools. Fig. 6 shows a common type

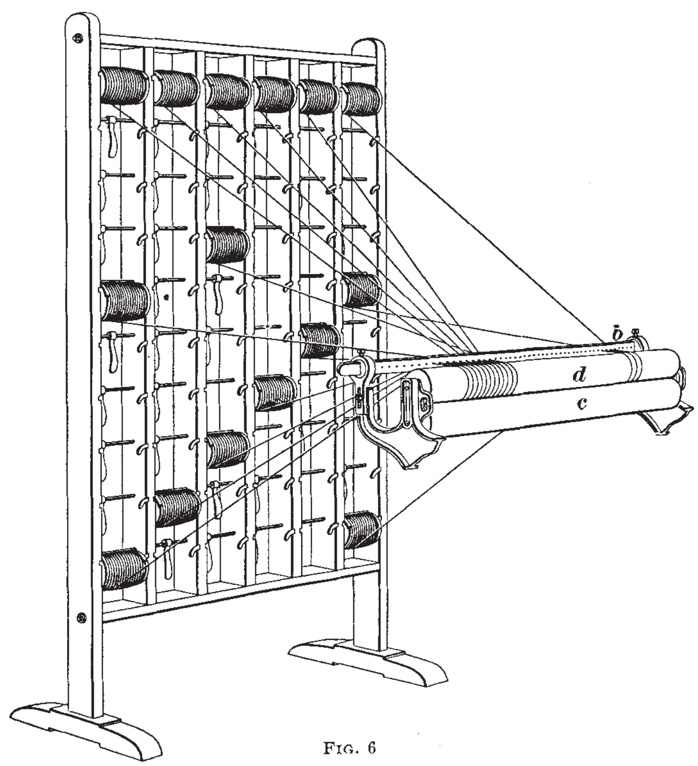


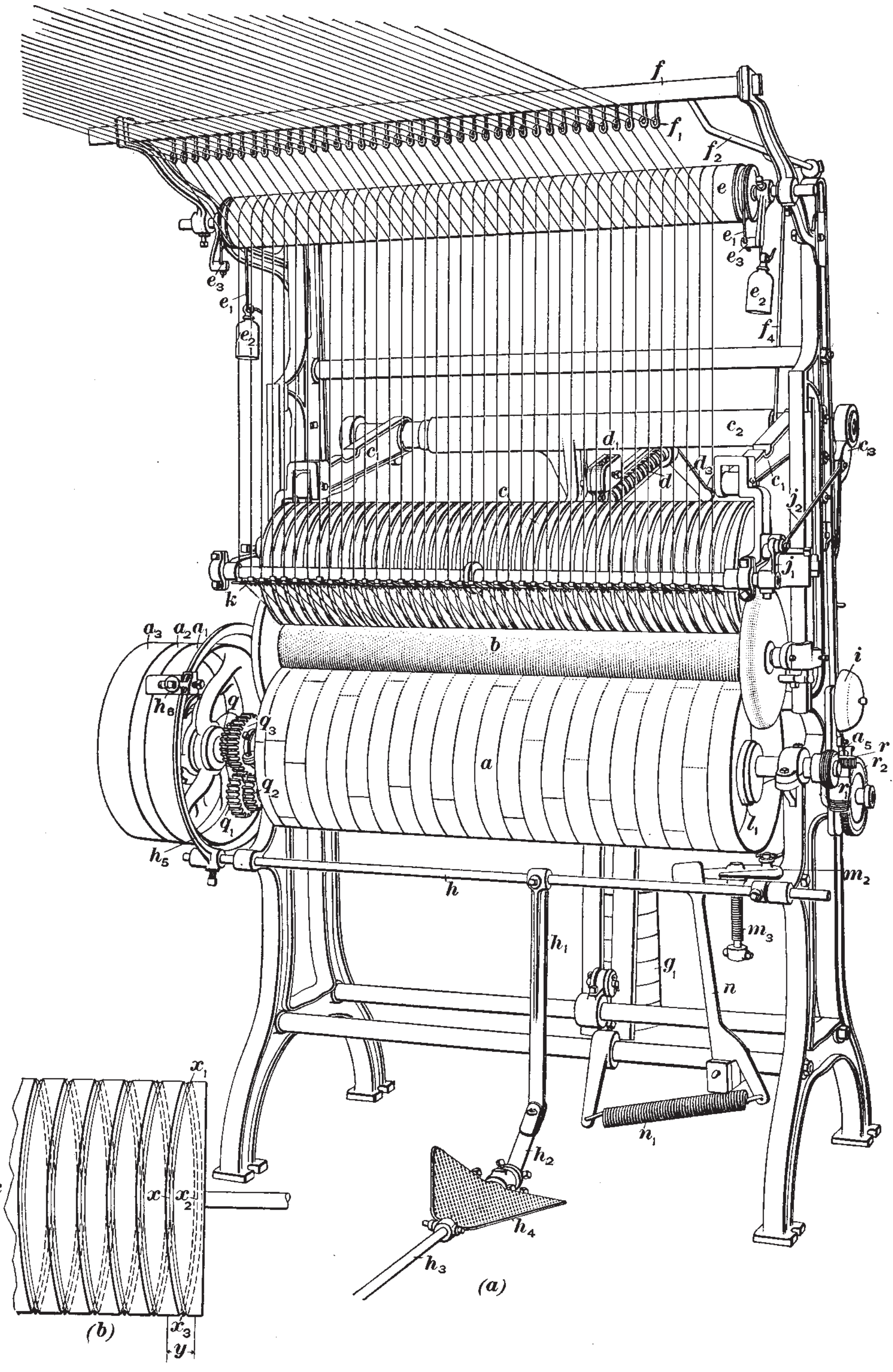
FIG. 6

of creel used for this purpose. It consists simply of a wooden framework arranged so that the spools containing the yarn may be placed on wooden skewers, which are supported in slots cut in the framework of the creel. In order to secure enough friction on the spool to prevent the spool from overrunning when the spooler is stopped, small castings are hung loosely upon rods extending across the creel. These castings are grooved on the under side so that they will fit over the head of the spool and by virtue of their weight prevent the same from turning too freely. Sometimes instead of iron castings, small wooden paddles are used for placing the friction on the spools. These are usually arranged to rest on the surface of the yarn and not on the head of the spool.

THE COMPRESSING SPOOLER

18. In the ordinary type of spooler the hardness of the spool is regulated to a great extent by the amount of tension that is placed on the yarn during the spooling. If any attempt is made to increase the firmness by increasing the weight on the journals, or gudgeons, of the spool, it will result in greater pressure being exerted on the ends than in the center of the spool, as the spool tends to spring at the center. This will make a spool with a greater diameter in the center than at the ends and will result in unsatisfactory warps, since the fact that some ends are wound loose and others tight causes uneven tension. If an increase of the firmness of the spool is obtained by placing a greater tension on the yarn, the results are even more unsatisfactory, since in this case not only will the elasticity of the yarn be injured, but frequent stoppages with consequent loss of production will be necessary on account of the tension frequently breaking the yarn.

It is the object of the **compressing spooler** to overcome these difficulties and to wind the yarn on the spool in such a manner that not only will each thread have the same length, but the spool also will be made much firmer and will contain from 30 to 50 per cent. more yarn than a spool made in the ordinary way. This latter point is of great advantage in itself, since the spools will run longer in the dresser, and consequently the time consumed in tying in new spools and the number of knots in the warp will be reduced to a minimum. Since increased firmness of the spool is obtained by this system without undue tension on the yarn in spooling, the elasticity of the yarn is not impaired in the least, but is



f
f_1
f_2
f_4
e
e_1
e_2
e_3
c
c_1
c_2
c_3
d
d_1
d_3
j_1
j_2
k
a_3
a_2
a_1
b
i
h_6
q
q_3
q_2
q_1
a
a_5
r
r_2
l_1
h_5
h
m_2
m_3
h_1
g_1
n
n_1
h_2
h_4
h_3
(a)
x_1
x
x_2
x_3
y
(b)

FIG. 7

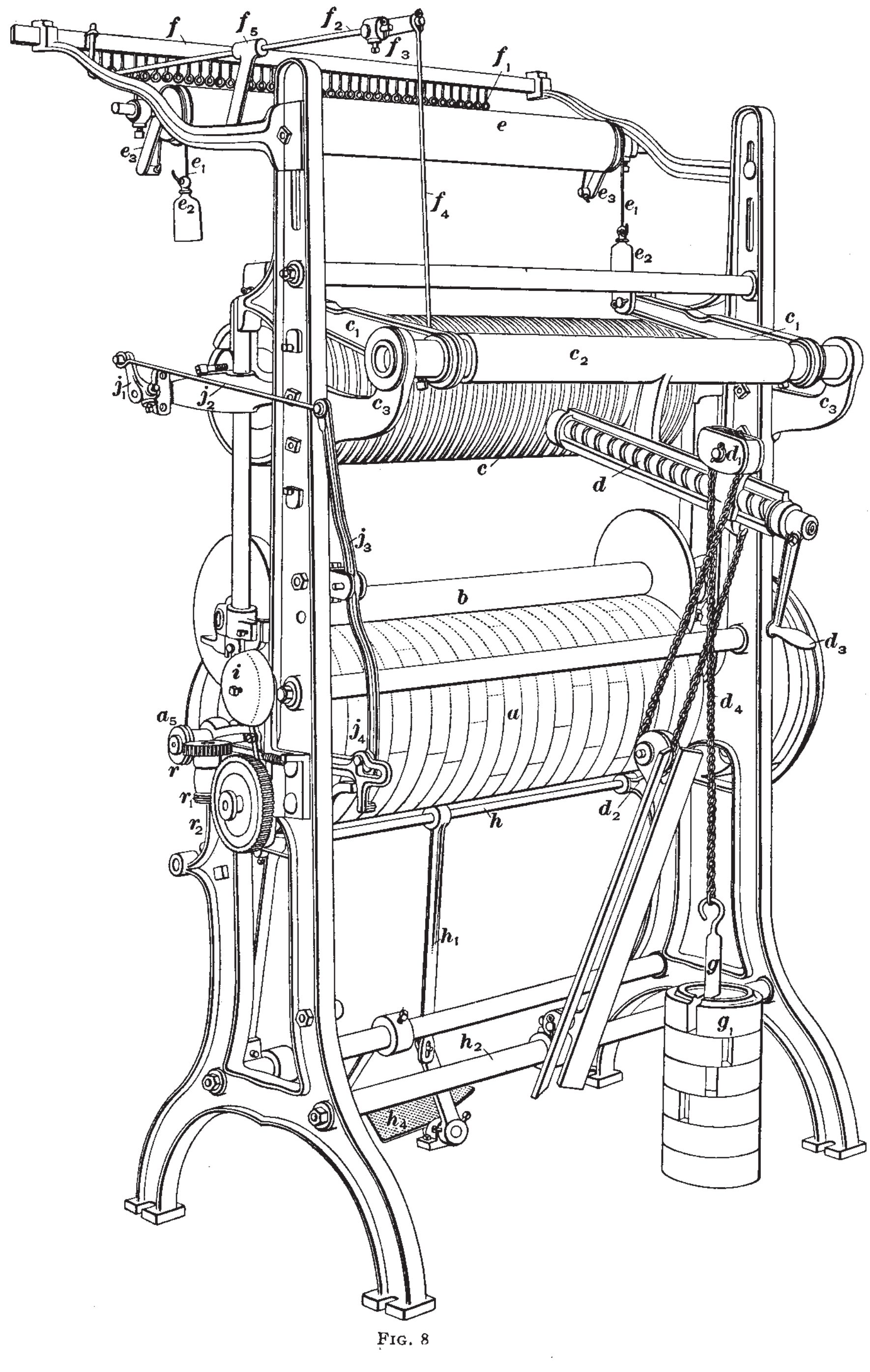

f
f5
f2
f3
f1
e
e3
e1
e2
f4
e3
e1
e2
c1
c2
c1
j1
j2
c3
c3
c
d1
d
j3
b
d3
i
a5
a
d4
j4
r
r1
r2
h
d2
h1
g
g1
h2
h4

Fig. 8

fully retained. A front view of the compressing spooler is shown in Fig. 7 (*a*), while Fig. 8 shows the appearance of the machine as seen from the rear. It is important to notice that Fig. 7 (*a*) shows the machine in operation, while Fig. 8 shows it stopped for the removal of a full spool.

19. The operation of this spooler is as follows: The spool b, on which the yarn is wound, is carried on the usual rotating drum a, which is covered with a filleting of rough leather. Resting on top of the yarn as it is wound on the spool is a heavy iron compressing roll c supported in bearings at the end of two arms c_1, c_1. These arms are attached to a shaft c_2 that is journaled in brackets c_3, c_3, which are bolted to the side frame of the machine.

The object of this roller c is to exert a heavy pressure on the spool, so that the yarn will be wound in such a manner as to form a firmly compressed spool. The pressure on the yarn is obtained by the weight of the compressing roll itself, and also by means of the weights g_1 at the rear of the machine. Carried in a casting that is part of the shaft c_2 is a screw d, which may be turned by a crank d_3; this screw carries a sliding block d_1, in which a pulley is mounted. Attached to the bottom of the block is a chain d_4, which is led through a pulley d_2 attached solidly to the framework of the machine, then back through the pulley in the sliding block and finally to a spindle g, upon which a number of weights g_1 may be placed, according to the desired pressure to be exerted by the compressing roll. The object of the screw arrangement is to provide for the raising of the compressing roll when it becomes necessary to remove a full spool from the machine and replace it with an empty one.

While the machine is in operation, the compressing roll rests on the surface of the yarn, and the block d_1, being screwed to the end of the screw nearest the compressing roll, passes the fulcrum of the shaft c_2 and exerts a downward pressure on the compressing roll, thus holding it firmly on the yarn. When, however, it is desired to raise the compressing roll for replacing the full spool with an empty one, the block d_1 is screwed back to some such position as is shown in Fig. 8. When this is done, the weight g_1 will operate outside of the fulcrum, and the weight of the compressing roll will be counterbalanced so that it may be raised.

20. Traverse Motion.—The compressing roll is cut with a number of grooves corresponding to the number of ends that it is possible to place on a full spool. These grooves take the place of the traversing thread guide in the ordinary type of spooler. They are somewhat **V** shaped and about $\frac{3}{16}$ inch in depth, and instead of being cut in a true circle around the compressing roll, are cut at an angle, so that as the compressing roll rotates, the grooves have an oscillating motion and the thread is guided back and forth the distance between two rings. By this means, the traverse motion is obtained without any chafing of the yarn as is the case with the traversing guide bar on the ordinary type of spooler.

Fig. 7 (*b*) shows the arrangement of the grooves on the compressing roll and illustrates the principle on which the traverse action of the roll is based. With the roll in the position shown, the thread is being wound on the jack-spool at a point x_3, exactly in the center of its traverse motion, but as the roll continues to revolve, the point x will come in contact with the spool and thus guide the thread to the left. The continued movement of the compressing roll will then bring the thread back as the point x_1 is exactly over the point x_3. Then, as the motion continues, the thread will be carried to the right as the point x_2 is brought in contact with the spool, and so on, until the point x_3 is again reached.

It will be seen that in making a half revolution between the points x and x_2 and through the points x_1 or x_3, the thread will be traversed the distance y, which is equal to the distance between two rings. It will also be noted that the thread is traversed to the right and then back again to the left in one revolution of the compressing roll, that is, it makes one traverse to each half revolution of the roll; and since the circumference of the compressing roll is 25 inches, one complete traverse is obtained with $12\frac{1}{2}$ inches of yarn, whereas in the ordinary spooler, 15 yards of yarn is necessary for each traverse. This renders the spool especially firm, and if only a few ends are to be spooled it is unnecessary to run extra ends on each side, since the traverse is so short that the yarn will build up squarely without any support at the sides. Another advantage of this traverse motion is that if, when tying in a broken end, the operator should place the end in the wrong groove of the compressing roll, in one revolution of the roll the thread would be carried back to its proper groove, in which it would drop and continue to run. The reason for this is that the tendency of the thread to stay in the groove is not sufficient to cause it to stay in a groove on either side of the proper one for the reason that the thread is pulled out of its true course and compelled to run in a direction that forms an angle with the direction in which it is inclined to run.

21. Tension Roll.—The yarn that is being spooled is taken from a bobbin stand of ordinary construction and passed overhead through wire hooks f_1, then round a tension roll e, then through a small porcelain pot eye k to the spool. The object of the tension roll e is not so much that of placing tension on the yarn as to regulate the yarn so that the same length of each thread will be delivered. The tension is obtained by means of cords e_1 fastened to a casting e_3 and passing over a groove in each end of the tension roll. On the other end a weight e_2 is hung, thus securing the requisite friction. This friction may be easily varied by means of the casting e_3, which is setscrewed to the stationary shaft of the tension roll e and may be readily turned in either direction, by loosening the setscrew so that more or less of the cord will be in contact with the tension roll. If more of the cord is in contact with the roll, the friction will be increased, and vice versa. With this type of spooler, very little friction should be placed on the tension roll, since the object of this machine is compression rather than tension. The tension roll is covered with leather in order that it may firmly grip the yarn, and the bar *f* in which the wire hooks are placed is given a slow lateral movement so that the yarn will not wear grooves in the roll. This movement is obtained by means of the rod f_4 attached at one end to the arm c_1 of the compressor and at the other to a casting f_3 setscrewed to the rod f_2, which is carried in a bearing f_5 bolted to the frame of the machine; the other end of the rod f_2 is bent at right angles to the main part of the rod and engages with the bar *f*. As the spool builds, the compressor roll and the arms *c* are raised, this motion imparting a slight lateral movement to the bar *f* so that it will gradually move to the left in Fig. 8. This traversing motion, of course, is very slow, since only one traverse is made while the spool is building.

22. Slow Motion.—A slow motion is attached to the compressing spooler so that the machine may be run at a slow speed while bobbins are being tied in or while the operator is watching for a bobbin to run out. At other times the machine may be run at its maximum speed. The position of this motion is shown in Fig. 7 (*a*), but Fig. 9 shows its construction in detail. The main shaft of the machine, on which the drum *a* is fastened, carries three pulleys a_1, a_2, a_3; the pulley a_3 is a tight pulley and is setscrewed to the shaft of the machine; the narrow pulley a_2 is the slow-motion pulley and is loose on the sleeve *p*; the pulley a_1 is a loose pulley and is loose on the same sleeve as the slow-motion pulley. On the inside of the loose pulley and fastened to the sleeve *p* is a gear *q* meshing with a gear q_1 loose on a stud fastened to the framework of the machine. Compounded with this gear is a gear q_2, which drives a gear q_3 fastened to the main shaft of the machine. On the other end of the sleeve *p* is a ratchet p_1, which is driven by means of a pawl p_2 fastened to the slow-motion pulley. When the belt is on the loose pulley a_1, no motion will be imparted to the machine, but when the belt is on the slow-motion pulley a_2, the pawl p_2

will engage the teeth of the ratchet p_1 and drive the drum a at half speed through the sleeve p and the gears q, q_1, q_2, q_3. When the belt is on the tight pulley a_3, the machine will be driven at its full speed.

The reason for driving the slow motion with a pawl and ratchet, as shown, is that as the belt takes hold of the tight pulley in being shifted from the slow-motion pulley, the slow-motion pulley, if fast to the sleeve, would begin to run at a speed in excess of that of the tight pulley, because

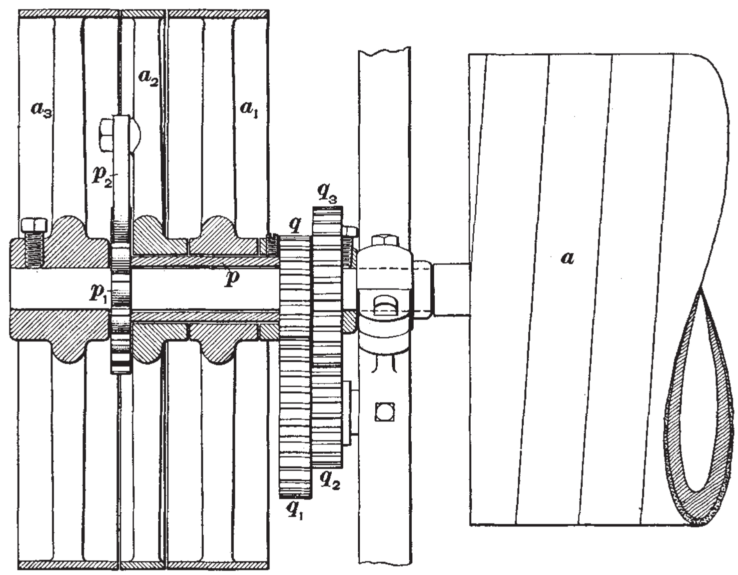


FIG. 9

motion would be imparted to the slow-motion pulley from the pulley a_3 by the gears q_3, q_2, q_1, q. This letting go of one pulley and taking hold of another would make a jump in the speed, since the slow-motion pulley would act as a brake until the belt was shifted entirely on to the fast pulley, if it were not for the pawl and ratchet. The pawl makes a release, so that as the belt begins to take hold of the tight pulley it releases the slow-motion pulley, which makes the latter act as a loose pulley.

The belt is shifted on the three pulleys by means of the shipper rod *h*, Fig. 7 (*a*), on one end of which an iron hoop h_5 is setscrewed. To this hoop an adjustable belt guide h_6 is fastened; this belt guide, together with the hoop, to which it may be fastened in any position, is so constructed that a belt may be guided on the pulleys when delivered at any angle. Attached to the shipper rod is a casting h_1 at the lower end of which is a slot engaging with the lever h_2, which is attached to a rod h_3 carried in bearings on the floor. A treadle h_4 attached to this rod enables the machine to be easily started or stopped.

23. Measuring Motion.—The compressing spooler is equipped with a measuring motion very similar to that previously described. On the main shaft of the machine is a single-threaded worm a_5, Fig. 10, engaging with a worm-gear *r* of 30 teeth. This worm-gear is fastened to a small upright shaft carried in a bearing bolted to the framework of the machine. Fastened to the lower end of the upright shaft is another single-threaded worm r_1 engaging with the dial, or clock, gear r_2, which contains 100 teeth. In this gear is a pin r_3, which is for the purpose of ringing a bell *i* whenever the desired number of yards has been spooled. This pin comes in contact with a hammer i_1, forcing it away from the bell *i* against the tension of the spring i_2. As the gear r_2 revolves, the hammer i_1 slips off the pin r_3 and the spring draws it forcibly back, thus ringing the bell. The drum *a* is exactly 1 yard in circumference; the worm a_5 is single-threaded; the worm-gear *r* has 30 teeth; and the worm r_1 is single-threaded. Therefore, 1 tooth of the dial gear equals 30 yards of yarn wound on the spool, and since the dial gear contains 100 teeth, one revolution of the latter will equal 3,000 yards of yarn spooled. When the pin r_3 is in such a position that the hammer i_1 has just slipped from it and rung the bell *i*, the 3,000-yard mark on the dial gear r_2 will be exactly opposite the pointer r_4, and since one complete revolution of the dial gear will be required before the bell will ring again, it follows that 3,000 yards of yarn, as indicated by the pointer, will be spooled before the bell rings again. If any other number of yards is desired to be spooled, the dial gear is loosened, removed from the worm r_1, and

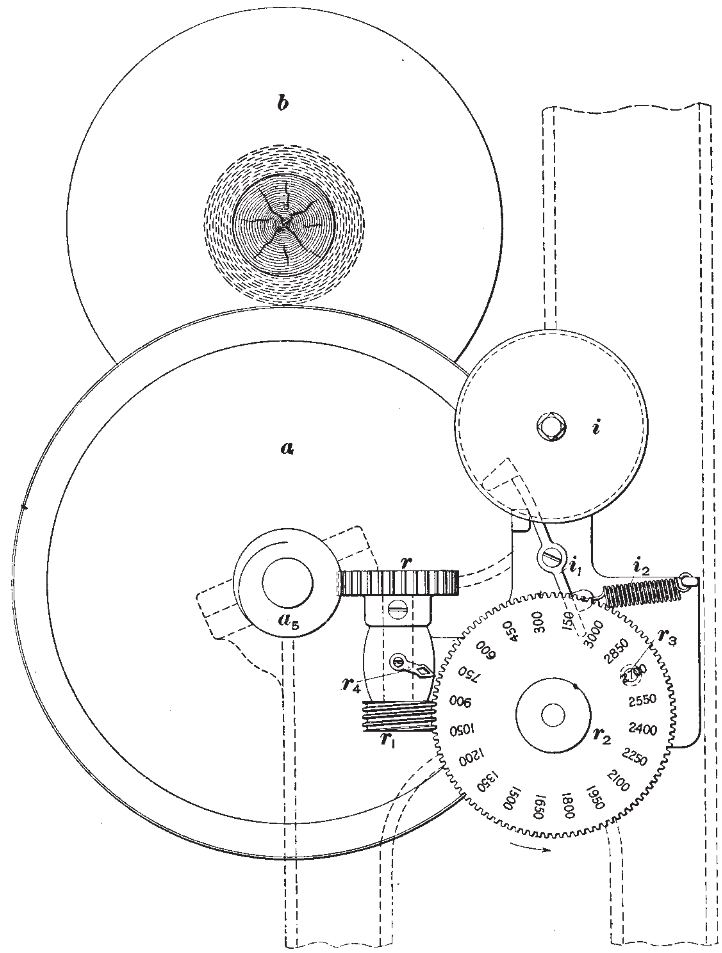


FIG. 10

replaced in such a position that the pointer r_4 will indicate the desired number of yards, which number will therefore be spooled before the bell will ring.

24. Stop-Motion. — The compressing spooler is equipped with a very simple and reliable stop-motion for stopping the machine when any thread becomes broken or runs out. This motion is shown in Fig. 11 (*a*) and (*b*), the former showing the device as seen from the side and the latter as seen from the front of the spooler. The yarn in passing to the spool is carried through small porcelain pot eyes in the end of drop fingers k, which are so arranged as to be supported by the tension of the thread. These drop fingers are fulcrumed at k_1 and have a small projection designed to engage with the grooved oscillating bar j, if for any reason the thread becomes broken and allows the finger to drop. Motion is imparted to the oscillating rod j by means of the eccentric l on the main shaft of the machine. This eccentric imparts motion to an arm l_1, at the end of which is bolted a casting l_2 having a long slot with a **V**-shaped notch at the top. A pin j_4 fastened in a lever j_3 supports the casting l_2 and the arm l_1 when the machine is in a normal condition, the pin resting in the **V**-shaped part of the slot. By this means the eccentric imparts an oscillating motion to the lever j_3, which through the connecting bar j_2 and the casting j_1 setscrewed to the end of the grooved bar j imparts an oscillating motion to the latter. Whenever a thread breaks and the drop finger engages the grooved bar, the oscillation of the latter is checked, which in turn stops the lever j_3. The movement of the eccentric then draws in the arm l_1 so that the pin j_4 will move out of the **V**-shaped slot, in so doing raising the casting l_2. At the end of the casting l_2 is a small projection l_3, which ordinarily clears the curved lever m; but, when the casting l_2 is raised, l_3 comes in contact with the end of this curved lever. When this happens, the action of the eccentric will impart motion to the lever m, and, through the connecting-rod m_1, to the lock lever m_2. The catch in the end of the lock lever ordinarily holds in position the lever n, which is forced against it by a strong spring n_1; but, when the rod m_1 is pushed back, the casting is turned on its shaft and releases the lever, which then

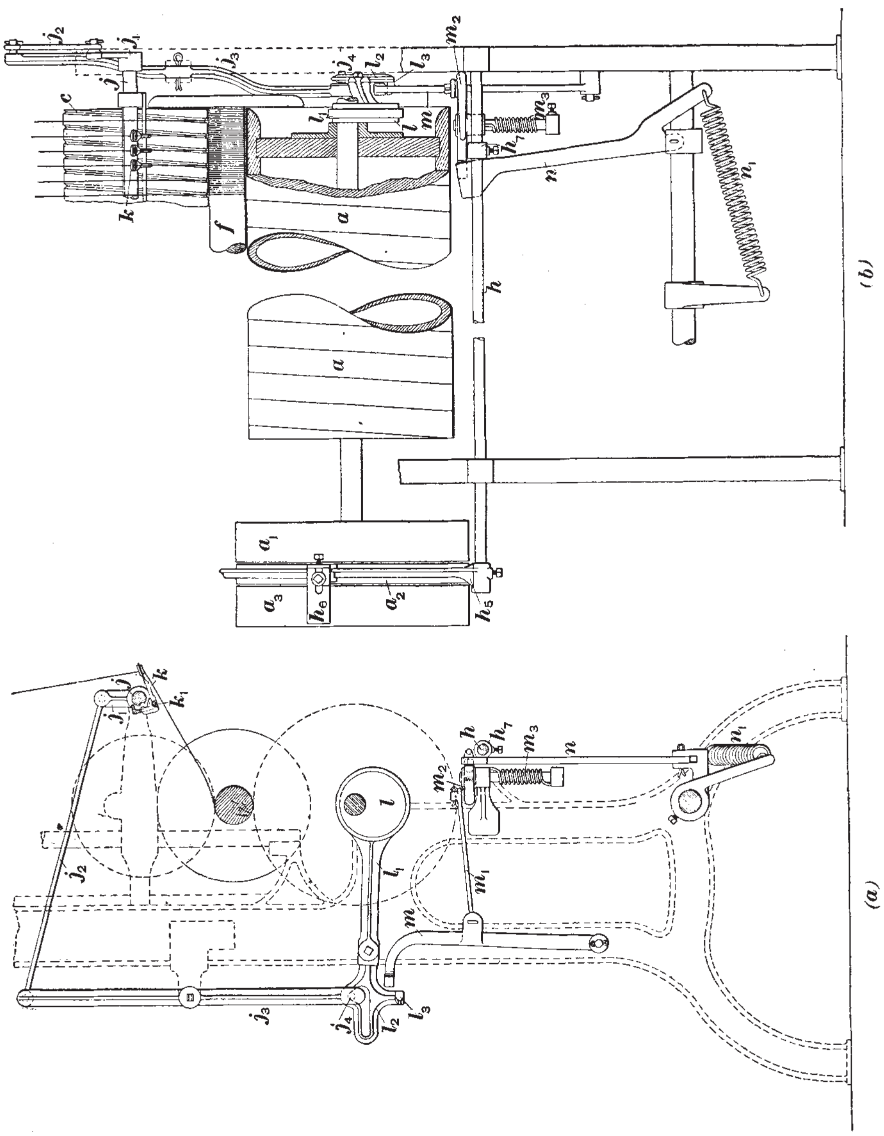


Fig. 11

comes in contact with the collar h_7 setscrewed to the shipper rod h, and by means of the spring n_1 forces over the shipper rod and shifts the belt from the tight to the loose pulley. A spring m_3 is so arranged as to hold the lock lever m_2 in contact with the lever n, so that the spooler will not be stopped by the vibration of the ordinary running of the machine. A recess in the lock lever receives the lever n when the machine is stopped by the stop-motion.

WOOLEN AND WORSTED WARP PREPARATION

(PART 2)

DRESSING

INTRODUCTION

1. Dressing is the process of unwinding the yarn from the spools and arranging it in the form of *sections*, in which each thread has its proper place and is arranged parallel to the other threads. These sections are then arranged side by side on a large reel until a sufficient number have been obtained to form the entire warp. Sometimes, during the dressing, a suitable sizing compound is added to the yarn so that its strength is increased and the breakage of the warp in the loom reduced to a minimum. The machine through which the warp yarn is passed for the purpose of applying this size and to arrange the spools of yarn into sections of the warp is known as a *dresser*.

As it would be impracticable to handle at one time in the dresser the total number of threads necessary to form even a narrow warp and at the same time to properly arrange the ends and apply the sizing compound, the necessity of forming the warp in sections is apparent. The number of ends that are to form one section of the warp are therefore spooled and the spools thus prepared placed in a creel at the rear of the dresser. The yarn from these spools is then passed through the dresser, where the size is applied and the yarn dried, after which it passes to the large reel. When one section of the warp has been wound on the reel, the yarn is cut and another section of the same length wound on the reel beside the first section. This operation is repeated until the total number of ends and the total width of the desired warp is obtained.

DRESSERS

COMBINATION DRESSER

2. There are several types of **dressers,** varying principally in the method of drying the yarn after the application of the size. In the **combination dresser,** which takes its name from the method of drying the yarn, this is accomplished by the combined action of a heated copper cylinder and several banks of steam coils. Fig. 1 is a view of the general construction of the machine, while Fig. 2 is a section showing the passage of the yarn from the dresser spools in the creel to the warp reel.

3. Application of the Size.—The yarn passes from the dresser spools *a* through the reed *b*, which is known as the **tying-in reed,** and serves to separate each end of the section so that the spools can be properly tied in, and then between two light-running rolls *c*.

The sheet of warp threads next passes between the size roll *d* and the squeeze roll *p*, which is usually covered with cloth. Nearly half of the circumference of the size roll is immersed in the size contained in the size pan *e*, which is a narrow trough extending across the entire width of the dresser. The size is kept at the right temperature either by means of steam coils immersed in the size, or by making the size pan with a false bottom, thus forming a tight compartment underneath, into which live steam can be admitted. This latter arrangement is known as a *steam-jacketed size pan* and is, on the whole, preferable to the other method. The bottom, or size, roll brings up the size and applies it to the yarn as it passes between the two rolls.

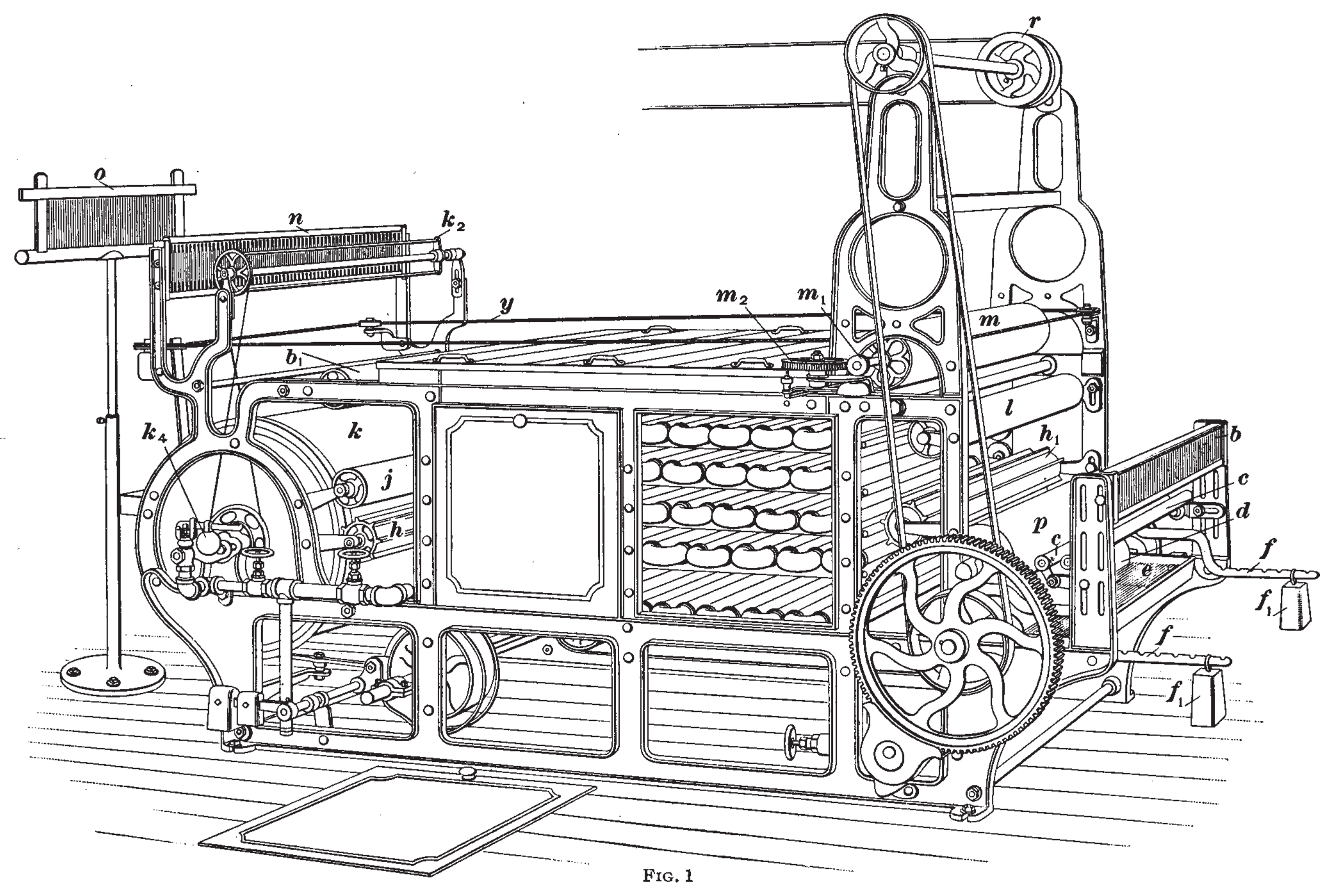


FIG. 1

The top roll acts simply as a squeeze, or press, roll to work the sizing compound into the yarn and at the same time to remove all the excess. The pressure on this roll is controlled by two levers *f*, one on each side of the machine; it may be regulated by means of the weights f_1, which if moved nearer the end of the lever will increase the pressure, and decrease it if set nearer the roll. Sufficient pressure should be applied to the yarn passing through the squeeze rolls to insure the removal of all the excessive size, which flows back into the pan over the surface of the roll *d*.

4. Drying.—After being sized, the yarn passes between coils of heated steam pipes to a skeleton roll *h* and then to another skeleton roll h_1, passing through the heated steam coils for the second time. Skeleton rolls are constructed with a number of projecting blades, on which the yarn rests. These extend the full width of the roll and prevent the yarn from touching any portion of the roll except the top of the blades. Their use is due to the fact that if the yarn while still moist and extremely adhesive by reason of the nature of the size applied to it were to come in contact with a smooth roll, there would be a tendency for it to stick and wind around the roll, thus causing a serious smash. This is very liable to happen if the machine is stopped for a time, since a stoppage allows the yarn to become securely attached to the rolls. As the yarn only touches at four or five points on a skeleton roll, there is no danger of this occurring, and, as it becomes somewhat drier in passing between the steam coils, the danger is entirely obviated and skeleton rolls are no longer necessary.

After passing around the skeleton roll h_1, the yarn passes back between the heated steam coils and then over a smooth tin roll *j* and around the steam-heated copper cylinder *k*. From the copper cylinder it passes through the steam coils again to a smooth tin roll *l*, and then back through the coils to another tin roll l_1. From this latter roll it finally passes over the steam coils and emerges from the dresser by passing around the measuring roll *m*; it then passes along the

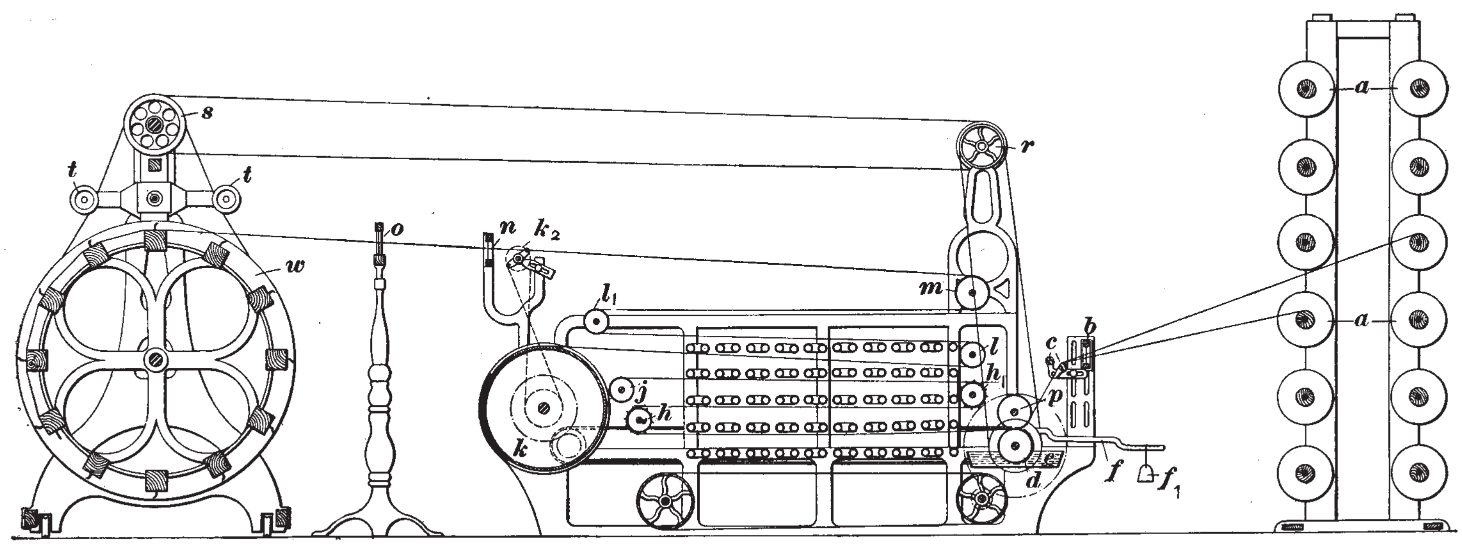


Fig. 2

top of the dresser, through the lease reed *n* and the condensing reed *o* to the warp reel, upon which the section of yarn is wound.

By this method the yarn is subjected to the heat of the steam coils six times after being sized, as well as being passed around the heated copper cylinder, so that the yarn is thoroughly dried before it is wound upon the reel. If it were placed on the reel while moist with size (which is largely composed of glue), the separate threads would become glued together and it would be practically impossible to weave or even beam the warp without an excessive number of broken ends, and even if it were woven, it would be a poorly running warp and would cause much trouble in the weave room. If a warp is not thoroughly dried, there is also great danger of mildew, which is a fungus growth caused by the damp condition of the yarn. When portions of a warp are mildewed, they cause spots in the woven cloth that it is impossible to remove.

5. The **combination dresser** is a very rapid dryer, as the heating capacity is large, consisting of five coils of steam pipe with eighteen pipes in a coil, as well as the large copper cylinder. It is sometimes built with eight coils of pipe and the length also may be increased indefinitely, allowing any number of pipes to be placed in a coil, so that the heating capacity is practically unlimited. Sometimes, when especially ordered, this dresser is built without the copper cylinder; in this case the yarn is dried simply by means of the steam pipes, and there is no doubt that this is to be preferred for dressing the very finest yarns.

The machine is arranged to be connected with a pipe from the boilers for the supply of steam, in which case a reducing valve should be used for reducing the pressure, or it may be connected directly to the steam-heating pipes. The pipes and copper cylinder of the dresser are tested with 40 pounds steam pressure before leaving the machine shop, but in practice a 15-pound steam pressure is sufficient for obtaining any results that may be desired, while dressers are ordinarily run with from 8 to 12 pounds pressure. It is provided with a safety valve k_4, which should always be kept in working order and set so as to blow off at the required steam pressure; otherwise, there is the liability of an explosion of the copper cylinder or the steam pipes.

The copper cylinder is also provided with an atmospheric valve, which admits air to the cylinder when the steam is turned off. This is necessary because as the cylinder is cooled a vacuum is formed inside by the condensation of the steam, and the pressure of the air on the outside tends to collapse the cylinder unless means are adopted for equalizing the internal and external pressures. The top and sides of the dresser are enclosed with wooden and sheet-iron coverings, which greatly aid in retaining the heat and consequently in the rapid drying of the yarn. It also increases the production of the machine, since, if dried rapidly, the yarn may be run through the machine faster. The comfort and efficiency of the operator are also promoted by enclosing the machine, since the covering furnishes protection from the intense heat. The side panels may be removed and the yarn exposed in order to piece up broken ends or for any other purpose. One of these panels is shown removed in Fig. 1.

6. Shaking Motion.—A **shaker,** or beater, is usually applied to dressers for the purpose of shaking the yarn just before it passes through the lease reed n, in order to loosen and free all threads that may be adhering to one another because of the adhesive nature of the sizing compound, so that they will pass freely through the reed without being broken. This device k_2 consists of two parallel rods fastened on opposite sides of a rotating shaft, and driven by means of a cord from a grooved pulley on the cylinder shaft. The sheet of yarn passing through the reed rests on the rods, which, in rotating, shake apart the ends that may be stuck together with size. This mechanism also prevents the yarn from wearing the lease reed in one place, thus greatly lengthening the life of the reed.

7. Measuring Motion.—The **measuring,** or **clock, motion** on the combination dresser is very similar to the one on the woolen spooler. On the shaft of the measuring roll m is a single-threaded worm m_1 that meshes with a dial, or clock, gear m_2 containing 120 teeth. The measuring roll is 18 inches, or $\frac{1}{2}$ yard, in circumference, so that one revolution of the clock gear will equal 60 yards of yarn passed over the measuring roll. There is a bell and hammer operated by a pin placed in the clock gear, as on the spooler.

8. Driving.—Beneath the dresser is a pair of cone pulleys by means of which different speeds may be given to the yarn as it passes through the machine; this regulates the time that the yarn is in contact with the heated air for drying, so that there is no need of keeping it in the machine longer than necessary nor of allowing it to be reeled in a moist condition.

The dresser has tight-and-loose pulleys 10 inches in diameter, which should be driven from 120 to 140 revolutions per minute. By means of a shipping device operated by an endless rope y running entirely around the top of the machine, as shown in Fig. 1, it is possible for the operator to stop the machine from either side.

TWO-CYLINDER DRESSER

9. In the **two-cylinder dresser** shown in Fig. 3, the principal feature of difference from the machine previously described is in the method of drying the yarn, which in this machine is accomplished by means of two copper cylinders k, k_1. It is claimed as a disadvantage of this machine that the yarn is injured by contact with the heated copper cylinders without having first been partially dried by steam pipes. A dresser of the two-cylinder type is, however, very convenient to operate, because of the greater facility afforded for piecing ends that break in the machine.

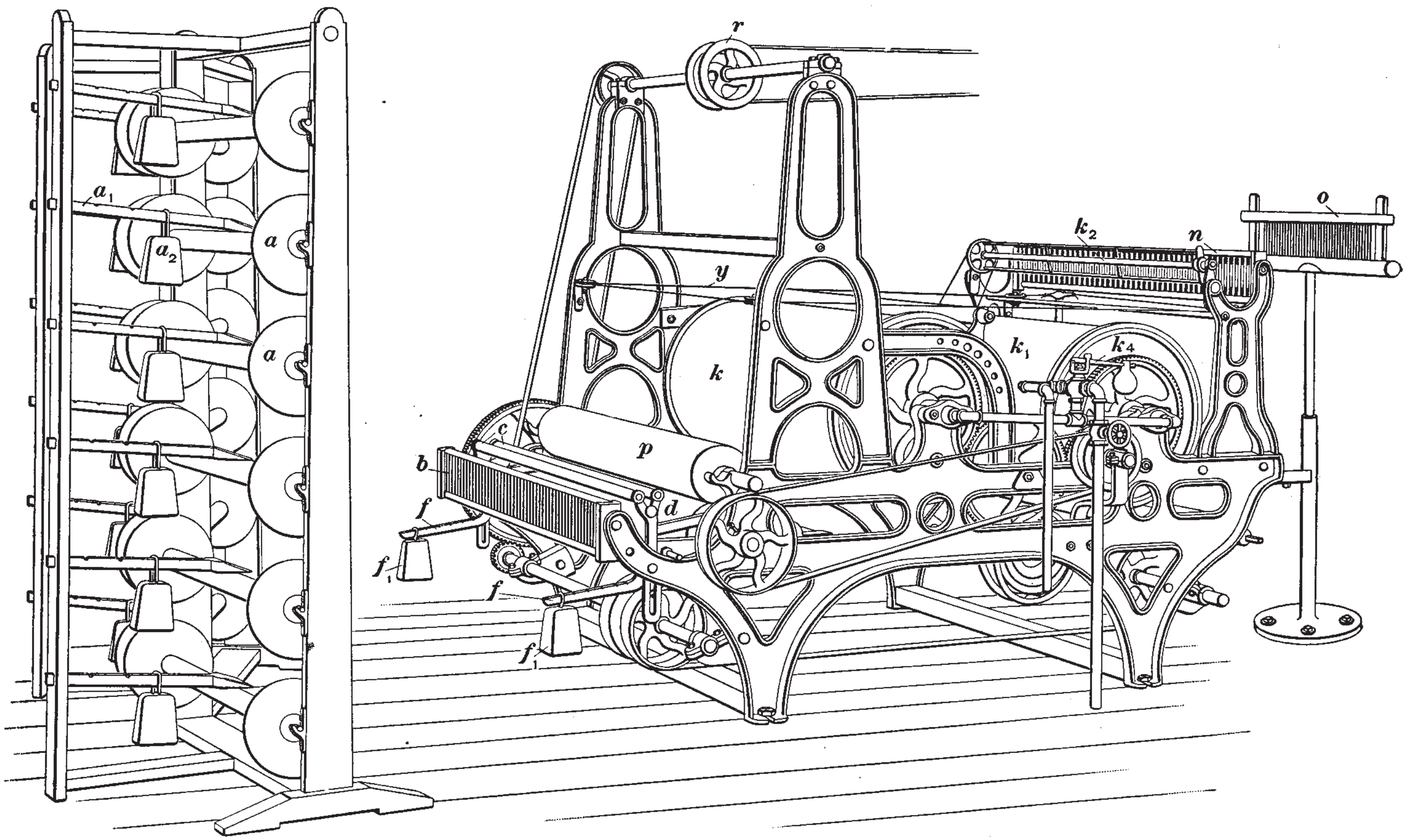


Fig. 3

FOUR-CYLINDER DRESSER

10. The **four-cylinder dresser** shown in Fig. 4 is similar to the two-cylinder machine with the exception that four copper cylinders k, k_1, x, x_1 are used for drying the yarn instead of two. The object of increasing the number of drying cylinders is to increase the capacity of the machine;

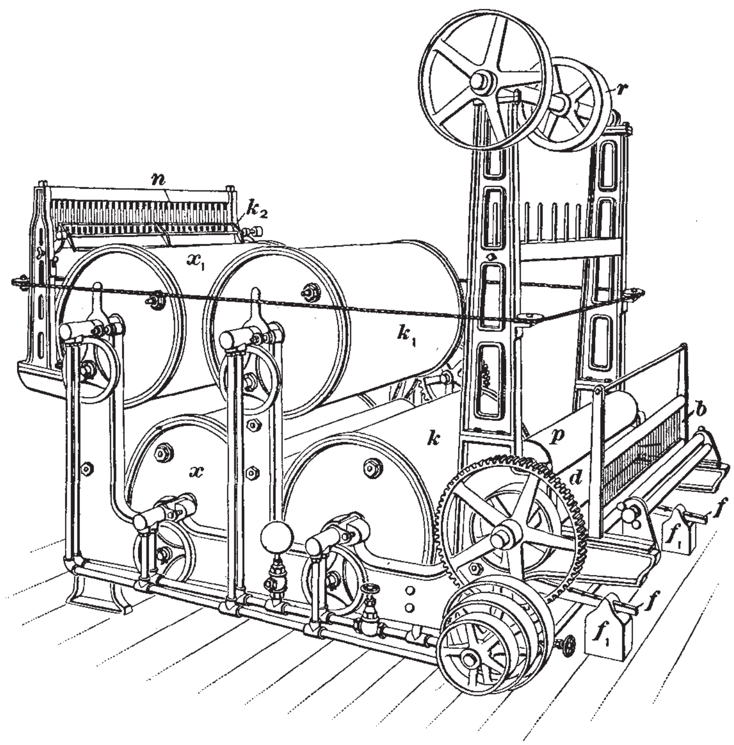


FIG. 4

the greater the heating surface, the faster may the yarn be dried and the more rapidly may it be run through the machine. There is no danger of mildew if the yarn is thoroughly dried before it leaves the dresser; but, on the other hand, it is detrimental to apply too much heat to the yarn, besides being an inconvenience to the operator. This latter point is more noticeable with cylinder dressers, which are open, than with the enclosed combination dresser.

SIZE

11. **Size** is not always applied to woolen yarn, and some mills rarely make use of any sizing compound whatever, claiming that it injures the brilliancy of the colors and is also disadvantageous because of the necessity of scouring it from the cloth in the finishing; the practice of sizing is becoming less common each year. On some yarn, however, there can be no doubt that the application of size is beneficial and actually necessary in order to give the yarn the strength required for weaving.

It will be understood that the constant chafing of the yarn in passing through the heddles on the harnesses tends to wear and weaken the yarn and break it; while the reed, in working forwards and backwards in beating up the filling, chafes the yarn even more than the harnesses. Very often on fibrous yarns the reed will scrape the loose fibers from each thread and collect them in *buttons* just behind the reed and in front of the harnesses. When these buttons grow large through the constant accumulation of loose fibers and the warp is drawn forwards by the take-up, the yarn will not be able to pass through the reed and so will be broken out.

It is the object of sizing to apply a mixture to the yarn that will fasten these loose fibers to the body of the yarn, thus not only increasing the power of the yarn to resist chafing but also actually increasing the strength of the yarn.

The substance generally employed as the base of sizing compounds for woolen yarn is glue. In the majority of mills pure glue and water are commonly used, the strength of the size being regulated by the character of the yarn to be treated. For instance, it would not only be unnecessary to apply a strong sizing compound to a yarn that requires but a weak size to lay down the projecting fibers, but it would be detrimental, because of the increased stiffness imparted to the thread. On the other hand, a weak, ragged yarn requires a strong size to give it the required strength for weaving. For a very strong size the glue may be used in the proportion of 2 pounds of glue to 3 gallons of water; a weaker size may be obtained by adding more water. With a little experimenting the exact proportion of glue that will give the best results with a given yarn may easily be found.

Tallow is sometimes added to the sizing compound in order to give the yarn softness, since the tendency of the glue is to render it somewhat stiff; not more than 1 pound of tallow to 50 or 60 gallons of size is necessary. When the proportion of glue in a sizing compound is reduced, corn starch is sometimes added to make up the deficiency. The following recipe has been found to make a good size for woolen yarn: 40 gallons of water, 12 pounds of glue, 7 pounds of corn starch, 1 pound of tallow.

In sizing worsted yarn—an operation that is rarely necessary—many manufacturers do not use any glue in the sizing compound, on account of the structure of a worsted yarn being such that there are practically no projecting fibers to be glued to the body of the thread. A size for a worsted yarn should also be one that may be easily removed from the cloth, as the finishing processes of worsted goods are generally less severe than those applied to woolen goods. The following recipe has been found to produce an excellent size for worsted warps; it may be altered in strength for different yarns by the addition of more or less water, as required: 50 gallons of water, 18 pounds of corn starch, 4 pounds of dextrine, $1\frac{1}{2}$ pounds of tallow.

The amount of sizing that the yarn receives is not only regulated by the strength or viscosity of the size but also by the amount of pressure on the press, or squeeze, roll of the dresser. Referring to Figs. 2 and 3, it will be seen that if the weights f_1 are moved nearer the ends of the levers f, the pressure that the roll p exerts on the yarn will be increased and the amount of size applied decreased, since the greater the pressure the greater will be the amount of size that is squeezed from the yarn and flows back to the size pan.

DRESSING FRAME

12. When warps are made without the application of any sizing compounds, instead of using a dresser and running it without heat and without the sizing arrangement, it is much more economical and convenient to use a **dressing frame.** With the exception of those parts that are necessary for sizing and drying the yarn, the dressing frame, as shown in Fig. 5, has all the essential features of a dresser—

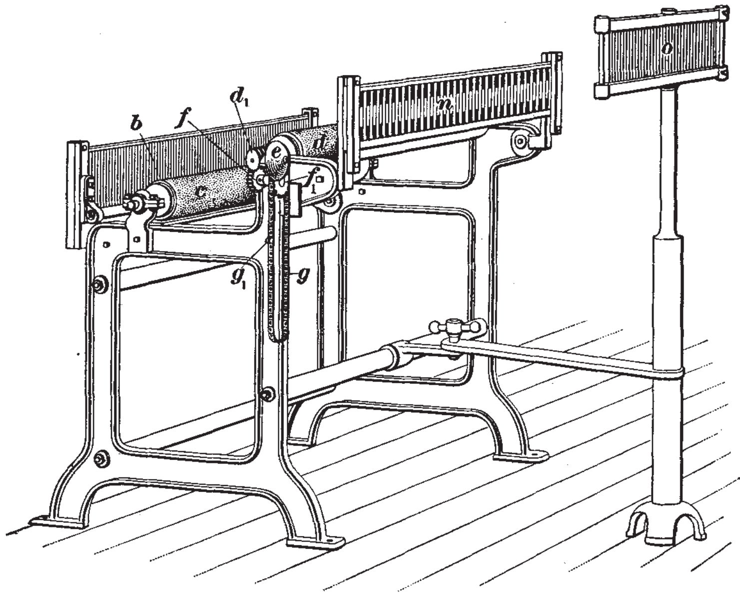


Fig. 5

a tying-in reed *b*, a measuring roll *d*, a lease reed *n*, and a condensing reed *o*. The yarn is taken from the spools in the creel, passed through the tying-in reed, under a leather-covered guide roll *c*, over the leather-covered measuring roll *d*, and through the lease and condensing reeds to the warp reel, upon which the sections are wound. By means of this frame the sections may be made, measured, and leased exactly as though the yarn was run through a dresser.

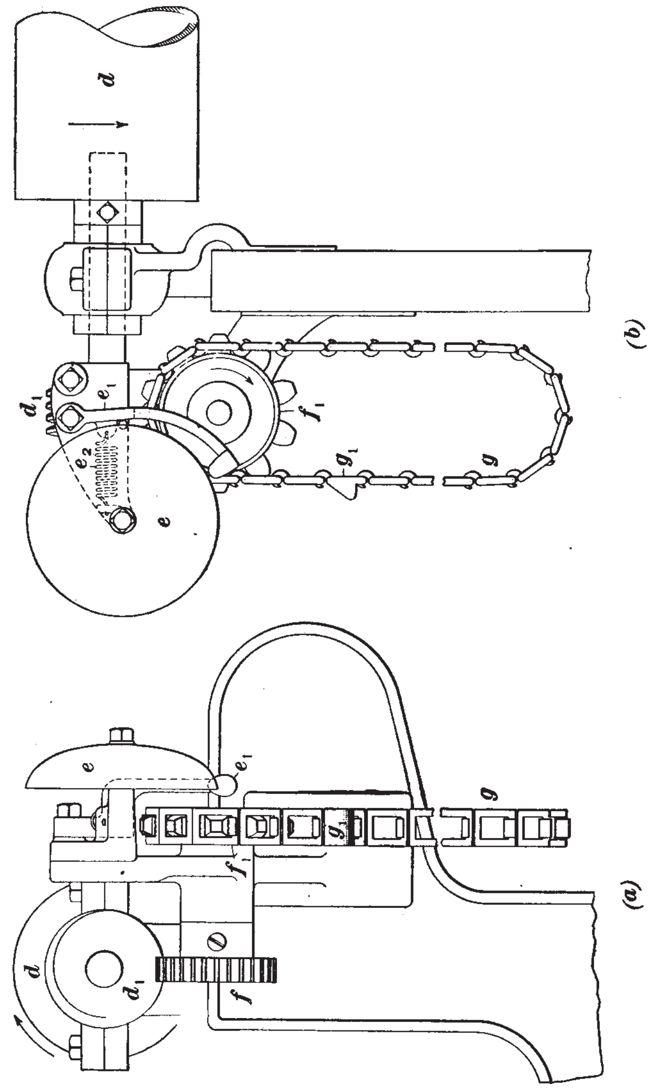


FIG. 6

At the same time, less floor space is occupied, and the machine is cheaper, simpler, and much more easily operated.

The dressing frame is provided with a **link measuring motion** for measuring the length of the sections; it is shown in Fig. 6, (*a*) being a side and (*b*) a front elevation. It is operated by the measuring roll *d*, which is given a rotary motion by the friction of the yarn passing over it. On the end of the measuring-roll shaft is a worm d_1 engaging with a worm-gear *f* fast to a short shaft, on the other end of which a sprocket gear f_1 is fastened. Running over the sprocket gear is a chain *g* composed of any desired number of links and containing one high link g_1, which in passing over the sprocket gear forces back and then releases a hammer e_1, which when released is drawn in contact with a bell *e* by means of a spring e_2. The measuring roll is 12 inches in circumference; the worm is single-threaded; the worm-gear has 30 and the sprocket 10 teeth. Therefore, three revolutions of the measuring roll will move the sprocket one tooth, or the distance of one link. Each link therefore equals 1 yard of yarn passed over the measuring roll; and the number of links in the chain, the number of yards passed through the machine.

SPOOL CREELS

COMMON CREEL

13. Fig. 3 shows a common type of *creel* for holding the spools of yarn made by the spooler. The **creel** consists of a wooden framework suitably constructed for holding the journals of the spools, so that the yarn may be readily unwound from them in being passed through the dresser. The most important point in connection with it is the method of applying friction to the spools so that they will hold the yarn at a suitable tension while it is being unwound. This is accomplished by means of a device consisting of a flat board a_1 from which a movable weight a_2 is suspended. The free end of the board rests on the top of the spool *a*, or rather on the yarn wound on the spool, while the rear end is loosely supported by the creel. The position of the weight determines the amount of friction on the spool, as the nearer it is placed to the spool, the greater will be the friction. This should only be sufficient to prevent the spools from running ahead when the dresser is stopped; yet it should be enough to make a smooth, level section. Instead of having a weight hung on the friction board as shown, the weight is sometimes placed on top of the board and arranged to slide in a groove, being fastened in any desired position by means of a thumbscrew.

Although the creel shown contains twelve spools, creels may be built to contain almost any number. Generally, instead of being semicircular in form as shown, they are built only the width of one spool and are arranged for two banks of spools, one behind the other. This arrangement is to be preferred, as it is more convenient when tying in the section and also mixes the yarn better, since the yarn from each spool can be distributed over the entire width of the section without straining the reed.

IMPROVED CREEL

14. In Fig. 7, a creel, or spool rack, is shown, which, although similar in its essential features to the one described, has a few points of difference. It is constructed entirely of metal, whereas the other was made of wood; the spools are contained in bearings in a double bank, and the yarn on the back spools in passing to the tying-in reed of the dresser is carried on two light-running rolls so that it will not interfere with the spools in the front of the creel. The principal feature of this creel is the method of automatically regulating the friction on the spool. When a spool is nearly full of yarn, it is turned much more easily by the pull of the yarn in unwinding, since the pull is then exerted on a larger diameter than when the spool is nearly empty. It will therefore be seen that in order to govern the friction on the spool so that the same amount of pull will be required to

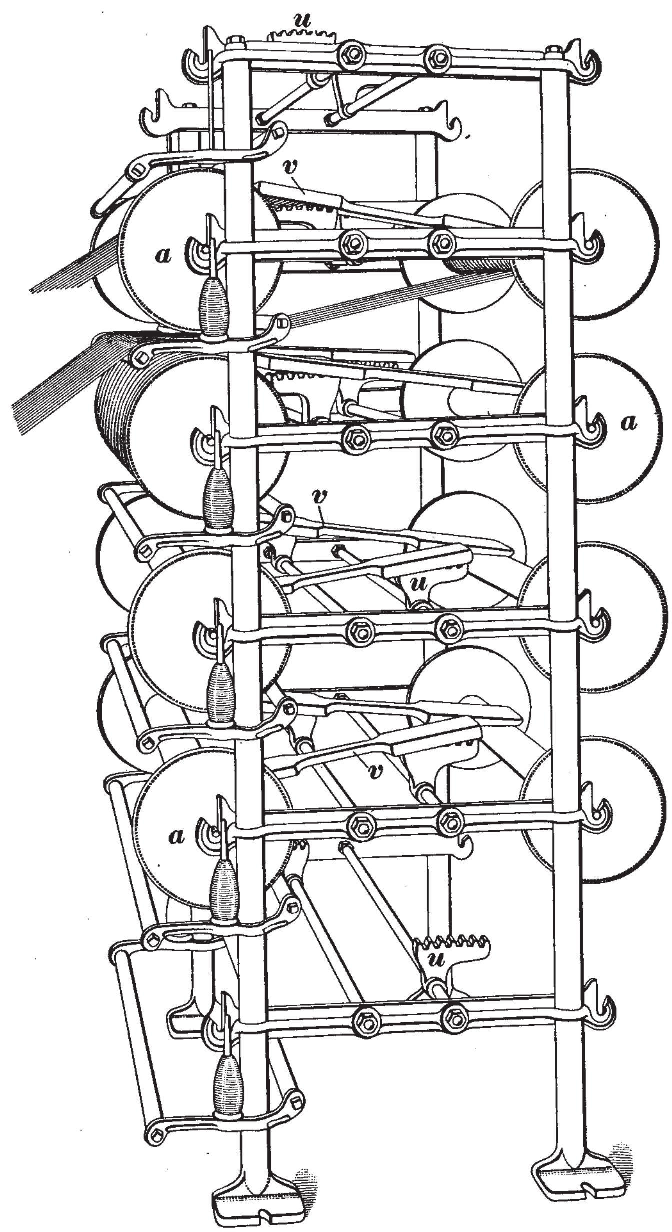


FIG. 7

turn the spool at all times, more friction should be placed on it at the start than when it is nearly empty. This is accomplished by means of a section gear *u*, Fig. 8. The friction lever, or tension paddle, *v* rests at one end on the spool *a* and at the other end on the section gear. Fig. 8 shows the position of the paddle when the spool is full and when it is empty. It will be noticed that in the former case more friction is being placed on the spool, since the tension paddle is then resting on the extreme end of the section gear. As the yarn is unwound from the spool, the fulcrum

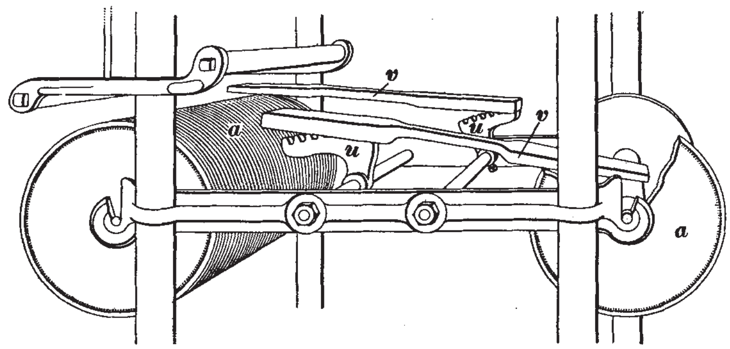


Fig. 8

of the tension paddle is constantly shifted toward the other end of the section gear, so that the friction on the spool is constantly decreasing. This, of course, is accomplished by the heavy-weighted end of the tension paddle counterbalancing the weight of the other end. The amount of tension may be easily regulated by loosening the setscrew that fastens the section gear to the rod and moving the section gear as desired. The tension may also be adjusted by simply taking off the paddle and replacing it in a different position on the section gear.

WARP REELS

PIN REELS

15. Sectional Warp Reel.—As the yarn leaves the dresser or the dressing frame it passes through a condensing reed and is then wound upon a large reel, as shown in Fig. 2. As only one section of the warp is made at a time, it is the object of the warp reel to arrange each section in regular

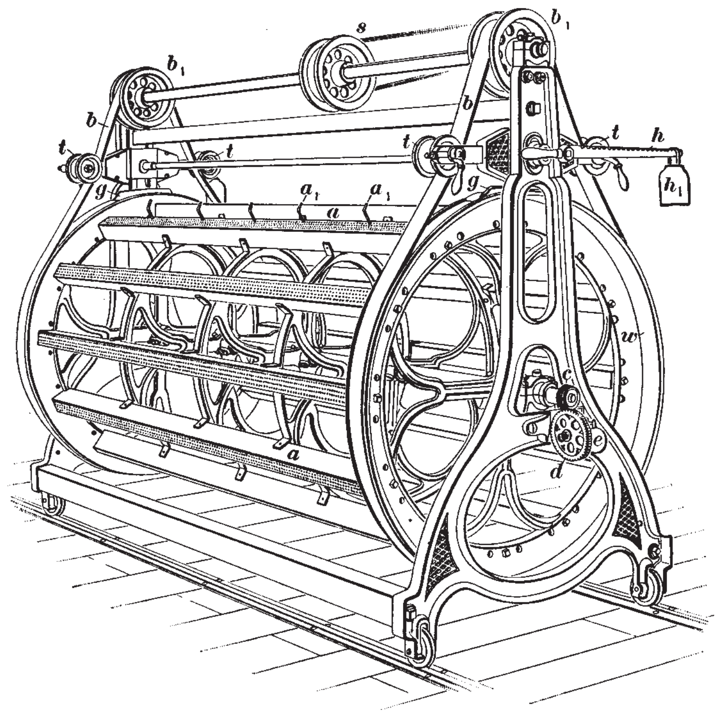


FIG. 9

order side by side until the warp is formed. Fig. 9 shows a sectional warp reel suitable for use in connection with a woolen dresser or dressing frame.

This device consists principally of a large reel *w* composed of twelve bars *a*, each of which is faced with a solid brass plate and drilled with four rows of holes, in which pins a_1 can be inserted for the purpose of separating each section and regulating the width of the section as it is wound on to the reel. The arrangement of the holes is such that an adjustment of $\frac{1}{8}$ inch may be obtained. The reel is driven by means of two belts *b* from the pulleys b_1 on the top shaft of the machine. This shaft, which is key-seated its entire length, receives its motion from a pulley on the dresser that drives the sliding pulley *s* shown in Fig. 9 (see also Fig. 2).

One of the principal features of a good warp reel is the **measuring device,** which measures the length of the sections so that the operator will be able to make each section the same. On the end of the main shaft is a single-threaded worm *c* that meshes with a worm-gear *d* so arranged as to ring a bell *e*, as in the case of similar devices used in connection with the spooler and dresser. The circumference of the reel is 4 yards and the worm is single-threaded; therefore, one tooth of the worm-gear is equal to 4 yards of the section wound on the reel.

One of the most essential features of the warp reel is the device for placing tension on the yarn when the finished warp is being beamed. Referring to Fig. 9, it will be seen that the driving belts *b* on each end of the reel pass under two tension pulleys *t*, which, with the brakes *g* that work on the heads of the reel, are controlled by means of the lever *h* upon which the weight h_1 is attached, as shown in the illustration, the lever and weight being duplicated on the other end of the machine, although not shown. While the sections of the warp are being wound on the reel, the tension pulleys are drawn together, thus tightening the belts and allowing the reel to be driven through the sliding pulley *s* from the dresser. This tightening of the belts is done by raising the weighted levers, which draw together the arms carrying the tension pulleys. When these levers are raised and fastened, the friction brakes are also raised from contact with the reel, both operations being performed by the single movement of the levers.

When, however, it is desired to unwind the yarn from the reel to the loom beam, it is necessary to place friction on the reel in order to obtain the necessary tension for winding the warp firmly. This is done by lowering the levers, which not only loosens the driving belt but also puts

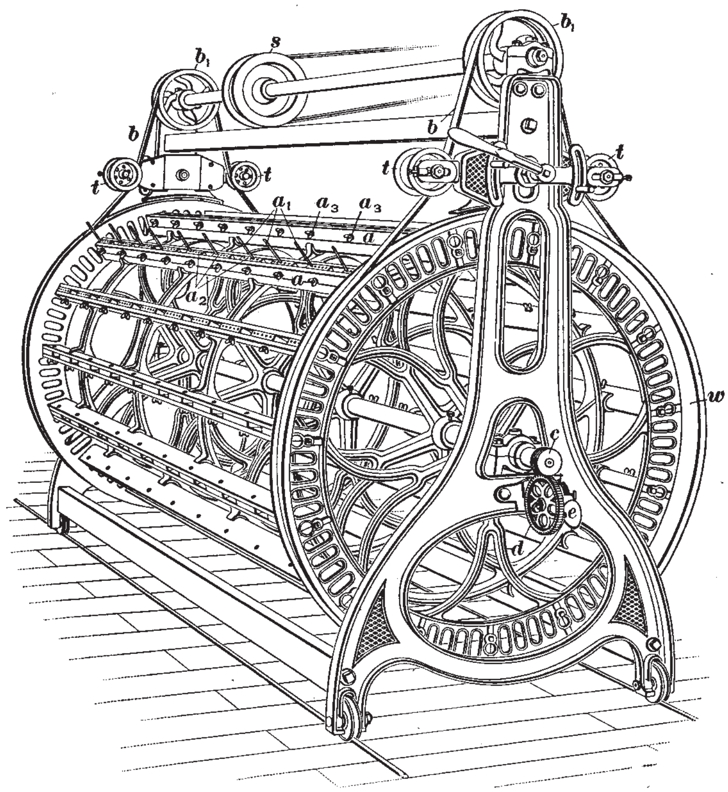


FIG. 10

the friction brakes in contact with the reel. The degree of tension can be regulated with great accuracy by means of the weights on the levers, which may be moved nearer or farther from the fulcrums. On many warp reels the friction, while beaming the warp, is obtained by means of ropes passing over the heads of the reel and having weights attached. This method, while not so convenient as the friction-brake arrangement, gives a more even tension. When beaming a warp, it is desirable to place the greatest tension on the yarn while the first part of the warp is being wound on the beam, in order that the succeeding layers of yarn may have a hard surface on which to rest.

A warp reel is always mounted on rolls or wheels that run on iron rails, so that the reel may be moved after one section of the warp is reeled, for the reception of the next section. The reel shown in Fig. 9 is built in two standard widths, viz., 92 and 111 inches, although other widths are built to order. The sliding driven pulley is $8\frac{3}{8}$ inches in diameter.

16. Patent Sectional Reel.—Fig. 10 shows a warp reel that is especially adapted for fine yarns and fancy patterns. The principal difference between this reel and the one described is in the method of adjusting the pins a_1 for the various sections. In this reel the pins are held in blocks a_2 that slide in grooves cut in the bars a of the reel. These blocks may be fastened in any position by means of thumbscrews a_3, so that the width of the section on the reel may be regulated with great exactness.

Another advantage of this device is that the pins are always in the center of the bar and not on one side; in the latter case the threads are liable to become crossed as the yarn is wound on the reel. When setting the pins on this reel it is convenient to use such a scale as is provided with the machine in obtaining the width of the sections.

PINLESS REEL

17. The **pinless reel** is designed to do away with the use of section pins, which not only require considerable time in being adjusted but also often cause the yarn at the edge of the section to be improperly wound during reeling; this results in the yarn being broken while it is being beamed. The machine shown in Fig. 11 consists of a heavy warp reel c mounted on a track and, in general, very similar to the warp reels described. The reel is driven by a belt running from the dresser to a large drum d instead of to a flange pulley, as is usually the case. Its peculiar feature is in the method of winding the yarn, each section being wound on the reel in a cone-shaped mass that is self-sustaining without the use of pins. Each bar of the reel, as shown in Fig. 12, has mounted at one end an adjustable coning iron b. The first section of yarn is wound on the reel at this end and

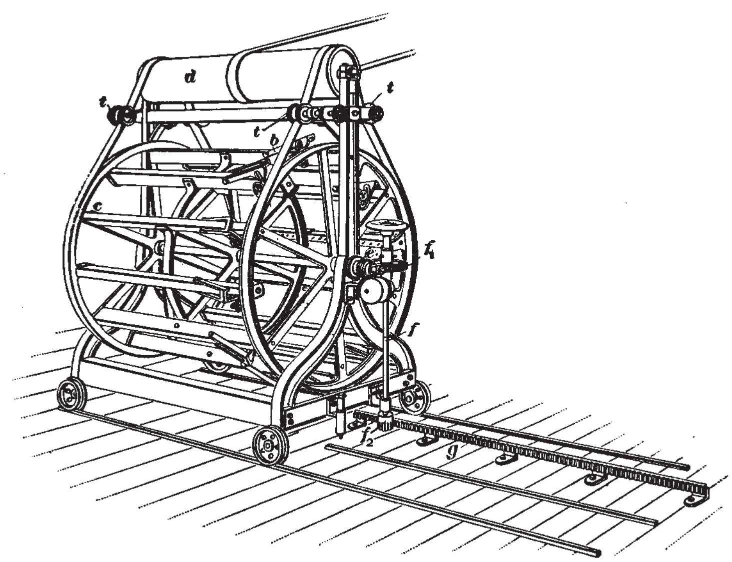


FIG. 11

as the reel is given a positive lateral motion while the section is being wound, the yarn mounts the coning irons and is wound in the shape of a cone. The section is started on the reel between the points x and x_1, but as the reel has a lateral motion to the left, the result will be that each succeeding layer of yarn will be moved slightly to the right, mounting the coning irons until the final layer of the section is wound between the points y and y_1. The position and shape of the first section of yarn wound on the reel is shown at *a*, while the dotted lines show the position of each succeeding section.

The lateral motion of the reel is obtained by means of a worm *e*, Fig. 11, that engages with a worm-gear f_1 fastened to a vertical shaft *f*; on the bottom end of this shaft a pinion gear f_2 engages with a rack *g* attached to the floor. As the reel rotates, this arrangement moves it on the tracks so that the yarn will mount the coning irons. The first section of yarn is built against the coning irons, as explained, but the next section wound on the reel is built against the first

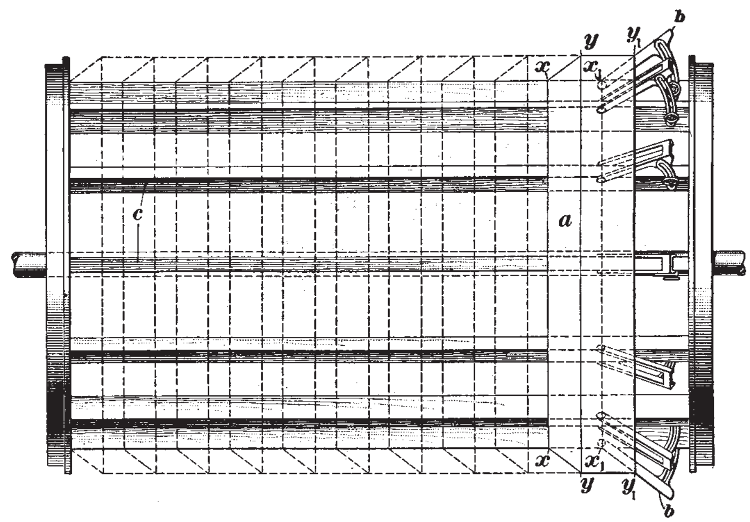


Fig. 12

section, so that each succeeding layer of the second section mounts the inclined or cone-shaped edge of the first section. After the completion of each section, the reel must be disengaged from the rack and moved back to the correct position for starting the next section.

The coning irons on the end of each bar are adjustable, so that the cone may be built at any angle to suit coarse or fine yarn. The pinion on the bottom of the vertical shaft may also be changed to alter the traverse of the reel while a given length of yarn is being reeled.

In beaming, or winding the yarn from the reel to the beam, the reel is revolved in the opposite direction, and the lateral motion of the reel therefore will be reversed, causing the outside threads to remain in line with the beam heads at all times.

LEASING

18. A **lease** is an arrangement of the threads of a warp by means of which the ends are kept in their proper position and entanglements and snarls prevented. A thread lease is one in which the individual ends of the warp are alternately passed above and below two rods or cords; this serves to keep the separate ends of the warp in their proper relative position, which is essential when the warp is being drawn through the harnesses and reed. A thread lease is obtained by means of the lease reed shown in Fig. 13. It is of peculiar construction; every alternate dent is filled with solder for a short distance at the top and also for the same distance at the bottom, thus leaving only the central part of the dent free.

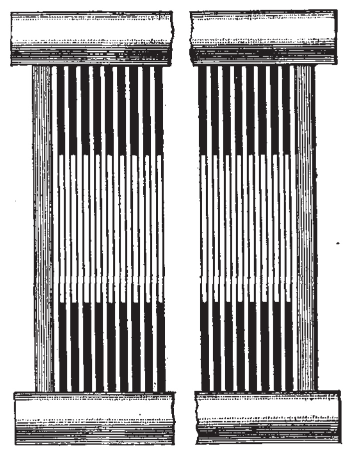


Fig. 13

After the yarn has been attached to the reel, it is first depressed by means of a stick close to the lease reed, thus forming a separation of the ends, owing to every alternate dent being soldered. A string is then run through this division, after which the yarn is raised by means of the stick and another string run through. As one thread is in each dent of the lease reed, this will form a thread lease. The strings, of course, must be placed in front of the condensing reed and securely tied. A lease should be taken when starting each section of the warp on to the reel, so that it will leave the reel at the last end of the warp when the yarn is beamed.

BEAMING

BEAMER

19. After a sufficient number of sections have been placed on the reel to form the entire warp, it becomes necessary to transfer the warp from the reel to the loom beam. The reel in this case is revolved in the opposite direction, and instead of being driven by the belt from the dresser, motion is imparted to it only by the tension of the yarn in being pulled off the reel and wound on the beam. It is necessary, in order to wind the beam with sufficient firmness, to place friction on the warp reel and to disconnect the driving mechanism. The ends of the warp are taken from the reel and attached to an apron that is tacked or otherwise fastened to the loom beam, or in some cases the warp is separated in bunches and tied to ropes or cords fastened to the beam. The beam is given a rotary motion by means of a simple machine known as the **beamer,** made to unwind the warp from the reel to the beam.

Fig. 14 shows an ordinary type of beamer, known as a **double beamer,** since it is designed to beam the warps from two reels at once, if desired, as it is possible to attach a beam to each side of the beamer, so motion will be imparted to both at the same time. The machine consists of a frame carrying tight-and-loose pulleys *a* on the main shaft. On this shaft is a gear *b* engaging with a gear *c* fast to an intermediate shaft. On each end of this intermediate shaft is a gear meshing with the large gears *d*, *e*; one end of the loom beam *f* is fastened to one of these large gears by means of adjustable dogs that fit in slots in the beam head. The other end of the beam is placed in a supporting bracket *g*, which is adjustable on a plate or slide *h* fastened to the floor, so that it may be adjusted for any length of beam. The

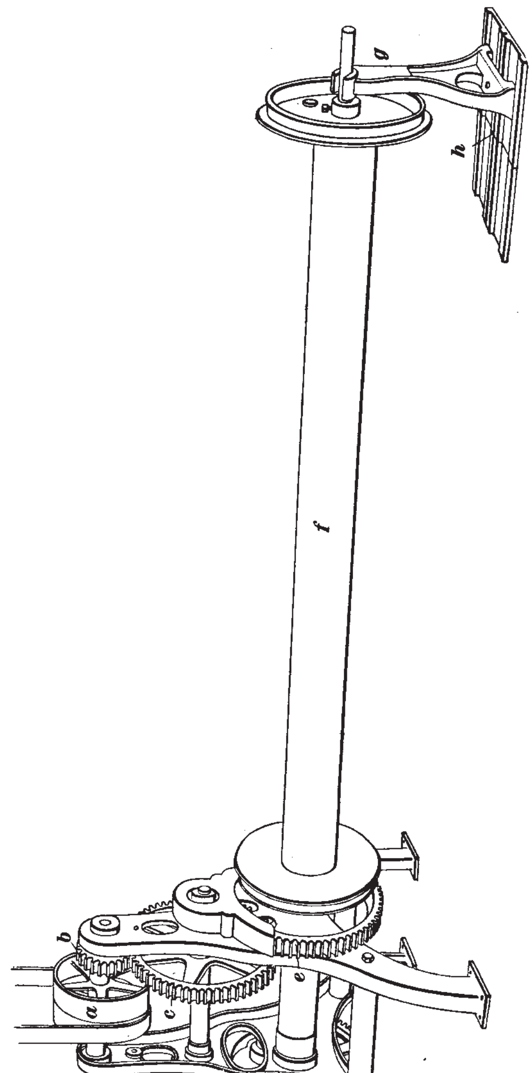


Fig. 14

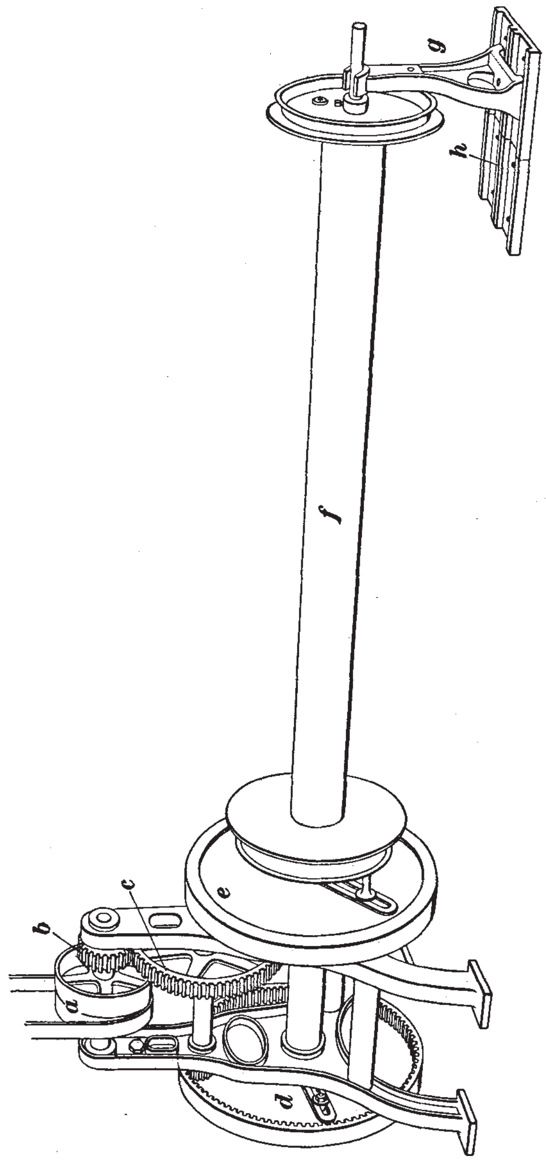


Fig. 15

belt is guided on the tight-and-loose pulleys by means of an adjustable belt guide, so that the belt may be guided to the pulleys from any direction. This belt guide is usually arranged to be fastened in position by means of a thumbscrew. By having the large gears *d*, *e* driven as shown, greater power is obtained, since it is transmitted by two gears instead of one. Guards are placed over these gears as a protection against accidents. Fig. 15 shows another type of double beamer. The only difference is that the gears *d*, *e* are annular gears instead of ordinary spur gears; this makes a very neat and powerful beamer.

The driving pulleys of a beamer are usually about 10 inches in diameter, and the gearing is such that a speed of 150 revolutions per minute of the tight pulley will give the loom beam a speed of about 8 turns per minute, which is sufficient for beaming warps.

A **single beamer** is made similar to a double beamer, except that it has only one gear to which a beam may be attached and is designed to beam the yarn from one reel only.

COMPRESSING WARPS

20. In the ordinary method of warp preparation, the yarn is constantly subjected to tension, both in being spooled and in being beamed from the warp reel to the loom beam, with the result that its elasticity is largely destroyed and the finished goods have a *hungry* appearance. The resulting fabric is hard and boardlike, lacking the full and elastic feel that is so greatly desired in high-grade woolen and worsted fabrics. Owing to the fact that the greater the tension placed on the yarn, the greater is the amount of yarn that can be placed on spools and beams, there is a tendency to increase this tension to such a degree that the elastic limit of the yarn is very nearly reached. Goods made from yarn that has been strained to a great extent in spooling, beaming, and weaving will shrink excessively after being finished; and garments made from such

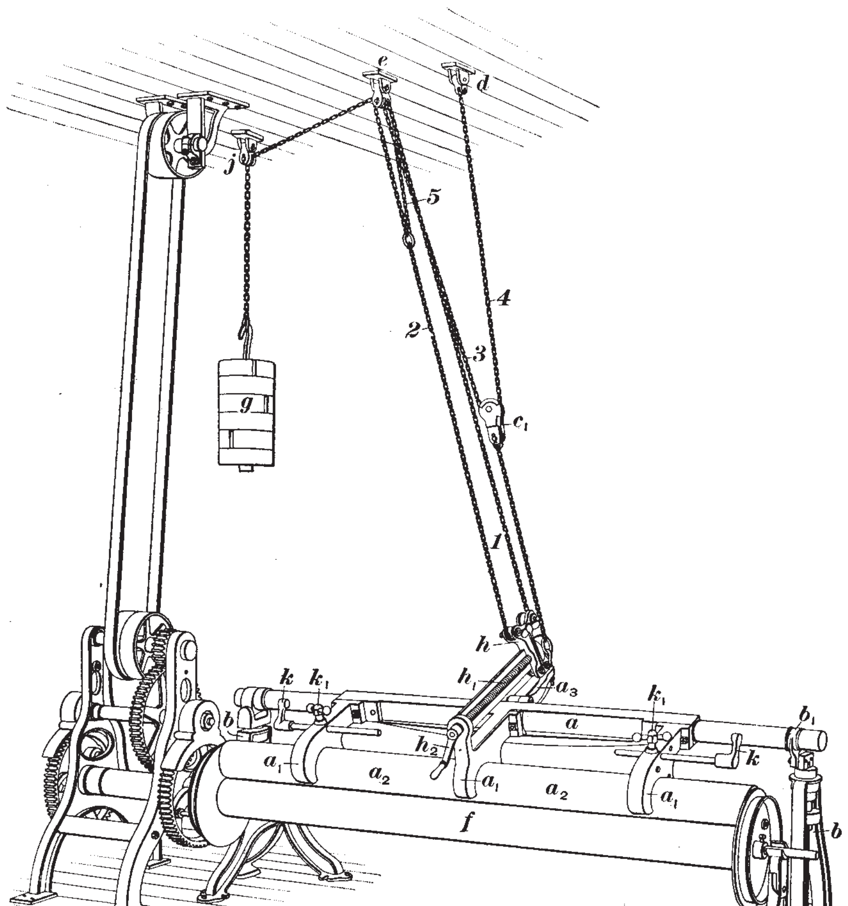


Fig. 16

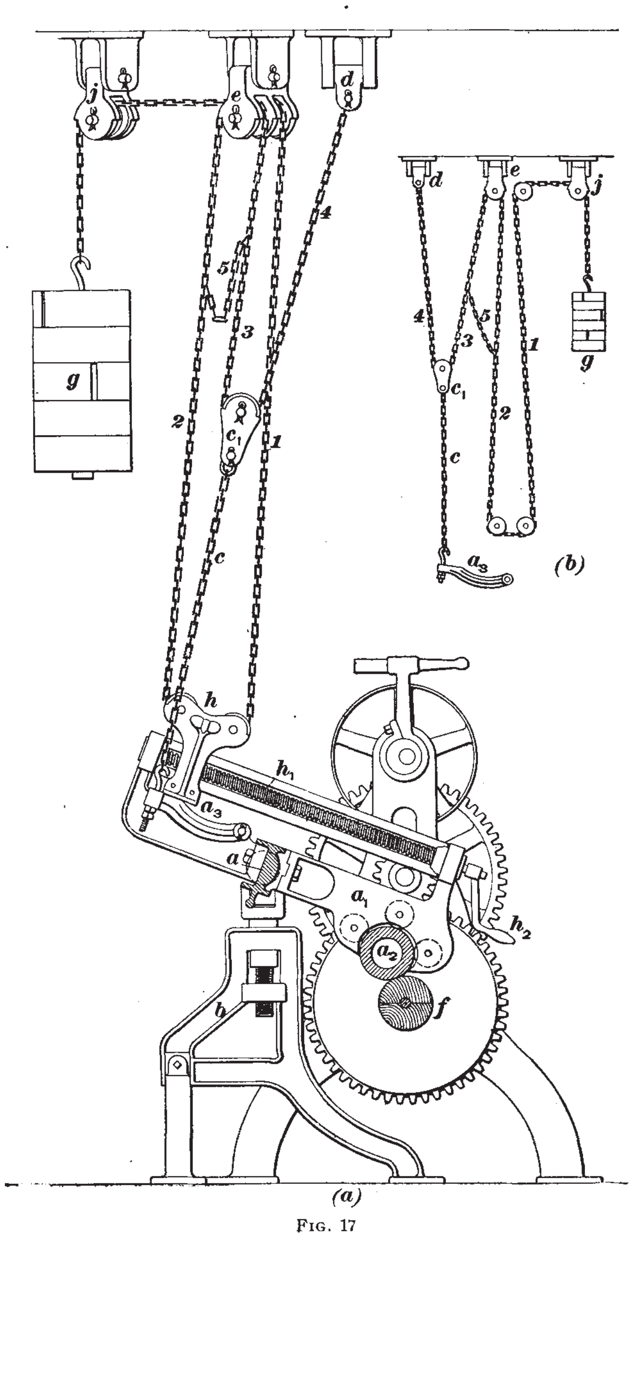


Fig. 17

goods, after being worn for some time, will shrink so that they are much too small for the wearer.

It is the object of the compressing system of warp preparation to substitute compression for tension at every point in the preparation of a woolen or worsted warp where it is practicable. The system applied to warps is the same as that adopted in the compressing spooler. By this system the warp is compressed as it is beamed, which results not only in the elasticity of the yarn being retained, but also enables from 20 to 50 per cent., and in extreme cases 60 per cent., more yarn to be placed on the beam. With this system the tension on the reel is reduced as much as is practicable and the required hardness of the beam obtained by a machine known as a *warp compressor*. Compressed warps will weave better and the cloth when finished will have an elastic feeling that cannot be produced in the ordinary way.

WARP COMPRESSOR

21. Fig. 16 shows a **warp compressor** in position for compressing a warp as it is beamed, while Fig. 17 (*a*) is a section of the same machine. The machine consists primarily of a compressing roll a_2 extending the full width of the loom beam f and resting on top of the yarn. This compressing roll is carried in roller bearings at the end of three arms a_1 fastened to a girder shaft a so constructed as to withstand the great transverse strain that is necessary in order to obtain sufficient pressure to compress the warp. The compressing roll is constructed of a piece of steel tubing 64 inches in length, and by means of 10-inch, 2-inch, 1-inch, $\frac{3}{4}$-inch, and $\frac{1}{2}$-inch sections, which may be added to the end of the roll and fastened securely by means of a screw; its length may be increased so that it will fit beams from 64 up to 104 inches in width. By having the sections of the different widths above stated, $\frac{1}{4}$-inch adjustments may be obtained, so that the roll will compress the warp on any beam between the above limits. The shaft a is carried in bearings supported by stands b, and the power for compression is obtained by means of a weight g, which is hung on a chain connected with the compressor.

The central arm, in which a bearing of the compressing roll is placed, is constructed somewhat differently from the other two arms as it extends behind the shaft a, which is the fulcrum of the compressing device. A screw h_1 mounted on this arm is turned by means of the handle h_2 and carries an adjustable block h, which contains two pulleys, around which passes a chain by means of which the compressing force is transmitted to the compressing roll. Attached to a lever a_3, loose on a stud in the arm a_1, is a chain c, to the end of which a block c_1 is attached. The weight chain is attached with one end to a casting d fastened to the ceiling and passes around the pulley in the block c_1, over a pulley in a double block e, then around both pulleys in the block h, over the other pulley in the block e, over the pulley in another block j, and has attached to its free end the weight g. While the warp is being compressed, the block h is screwed back to the position shown. Under these conditions the weight g acts through four lengths of chain *1*, *2*, *3*, *4* so that the amount of power exerted at h and transmitted to the compressing rolls is equal to four times the amount of weight g; for instance, if the suspended weight g is 80 pounds, then 320 pounds is exerted at the end of the arm a_1.

When a new beam is to be started or a full one removed, the compressor may be readily raised out of the way by simply releasing the collar b_1 on the shaft a from the stand b, whereupon the weight g will lift the compressor on the swivel bearing at the other end of the shaft a and raise it out of the way. It will be seen, however, that in order to do this, it is necessary that there should not be too great a strain on the machine; otherwise, when the collar b_1 is released, the compressor will rise with such great force that it cannot be checked. In order to relieve the strain of the weight, therefore, a short length of chain *5* is inserted between lengths *3* and *2* of the chain. When it is desired to raise the compressor, the block h is screwed forwards; this allows the lever a_3 to rise and the short length of chain *5* to be tightened.

When this is done, the weight will act through only two lengths of chain—*1* and *2*—the loop formed by the short length of chain hanging over the pulley *e* and acting exactly as though it were simply fastened to it. The pressure exerted on the compressor in this case will only be one-half as great as that exerted while the warp is being compressed, so that the machine can be more easily handled. This arrangement is shown somewhat more clearly in Fig 17 (*b*). Two pieces *k*, Fig. 16, which may be fastened in any position by means of handscrews k_1, are used to hold the compressing roll from slipping out lengthwise when the compressor is raised.

FORMATION OF WARPS

PLAIN WARPS

22. To illustrate the simplest possible operation of making a warp, suppose that a plain warp containing three cuts of 72 yards each is required. The warp is to contain 2,400 ends plus 20 ends on each side for selvage and is to be beamed 56 inches wide, this being the width of the loom beam between the heads.

23. Spooling the Yarn.—The first operation is to find out how many spools will be needed for one section of the warp. Suppose that the creel behind the dresser will hold only twelve spools and that the construction of the spooler is such that 40 ends are placed on each spool. Then it will be impossible to use more than 480 ends (12×40) in one section of the warp. As the warp contains 2,400 ends, five sections can be used, which will give exactly 480 ends in a section. It will be necessary, therefore, to have twelve spools made, but the length of yarn to be placed on each spool must be ascertained. The warp is to contain three cuts of 72 yards each, or 216 yards in all, and as there are five sections of the warp to be run, then each spool will have to contain five times 216 yards, or 1,080 yards.

In order to be sure of enough yarn being left in the dresser for tying the next warp, several yards more should be wound upon each spool. It is not always possible to place sufficient yarn upon a spool to run the entire warp, in which case it will be necessary to tie in extra spools during the process of making the warp.

24. Tying in.—The term **tying in** is used to designate the operation of tying the yarn on the spools to the yarn that is left in the dresser from the last warp especially for this purpose. When the spools are made for a warp, it is always planned to have enough yarn left in the dresser to which the new spools for another warp can be tied and then drawn through the dresser, for it is quite a difficult task to draw the yarn through the tying-in reed *b* and the lease reed *n*, shown in Fig. 1, as it is necessary for each end of the section to pass from the tying-in reed through the dresser to the lease reed without crossing other ends; that is, each dent of the lease reed has a corresponding dent in the tying-in reed. It is necessary for the ends to be drawn through the dresser straight; otherwise, if a fancy pattern were arranged correctly at the tying-in reed, it would not be correct at the lease reed and, consequently, in the warp.

25. In the plain warp under consideration, after having obtained the twelve spools, it is next necessary to arrange for tying them to the yarn that is left in the dresser from the previous warp and that is cut off about $\frac{1}{2}$ yard in front of the tying-in reed *b*, Fig. 1. To do this, first count out 480 ends in front of the tying-in reed, as there are to be 480 ends in a section. Then, beginning at one end of the reed with the first end of the 480, cast it up over the top of the reed; then skip 11 ends and cast up another end, and so on for the full width of the reed. When finished, 40 ends ($480 \div 12$) will be cast up over the reed. These are then knotted together and left lying over the top of the reed, being the ends to which one spool will be tied. Then proceed in like manner for the other spools as follows:

For the second spool, take one end and skip ten.
For the third spool, take one end and skip nine.
For the fourth spool, take one end and skip eight.
For the fifth spool, take one end and skip seven.
For the sixth spool, take one end and skip six.
For the seventh spool, take one end and skip five.
For the eighth spool, take one end and skip four.
For the ninth spool, take one end and skip three.
For the tenth spool, take one end and skip two.
For the eleventh spool, take one end and skip one.
For the twelfth spool, take one end and skip none.

After the eleventh spool is picked up, the remaining ends will be for the twelfth spool.

The next operation is to tie in the spools. Take the last bunch of ends that was picked in the reed and to it tie the ends of the bottom spool in the creel. Then take the next spool and tie each end to an end of the bunch that was picked from the reed next to the last. When tying in each spool, the operation should be begun at the left of the reed and each end on the spool and in the reed tied in regular order; that is, no crossed ends should be allowed. After all of the spools are tied in, the friction boards should be placed on the spools and the yarn drawn through the dresser by carefully pulling on the yarn from the front of the machine.

Sometimes when left-twist yarn is tied on to right-twist, or vice versa, great difficulty is found in pulling the yarn through the dresser, since one yarn will untwist the other. Especially is this true if one yarn contains more twist than the other. When this happens it is sometimes best not to place any friction on the spools until the new yarn is drawn through the lease reed; and also to be very careful in pulling it through.

26. Reeding the Sections.—After the section is pulled through the lease reed, it is necessary to determine the width of each section in order to determine the number of ends that must be drawn in one dent of the **condensing,** or **hack, reed** so that the sections will be wound on the warp reel the required width. The warp is to be beamed 56 inches wide, which when divided by five sections gives 11 inches as the width of each section with 1 inch over. This 1 inch may be utilized by adding $\frac{1}{2}$ inch to the first and last sections for selvages, setting the pins so that these sections will be $11\frac{1}{2}$ inches wide on the warp reel, while the other three sections will be but 11 inches. Or, five sections 11 inches wide may be made and the selvages run outside of the pins. The width of the sections, of course, regulates both the width that the pins are set apart on the warp reel and also that of the section in the condensing reed.

Supposing that the condensing reed is a No, 15; that is, it contains 15 dents per inch. Then there will be 165 dents in 11 inches (11×15). If 480 threads, which is the number of ends in one section, are drawn 3 in a dent, they will occupy 160 dents, which is practically near enough; but by drawing only 2 threads in some dents, the sections can be made exactly 11 inches wide in the condensing reed. Each section, of course, is the same length on the reel, i. e., 216 yards, and after the reed has received the five sections it is only necessary to loosen the belts and place the friction on the reel, when the warp can be beamed. It is important to take a lease in the warp by means of the lease reed before reeling each section, as previously explained.

27. Selvages.—When winding the first section on the reel, 20 ends should be drawn through the lease and condensing reeds at one side of the section for selvage, but after the first section is wound they should be broken out and ignored until the last section of the warp is reeled, when they should be crossed over and drawn in on the other side of the section so as to form the selvage on the other side of the warp. These 20 ends for the selvage on each side may be run from bobbins that are placed on pins on the dresser.

FANCY WARPS

28. When a fancy pattern consisting of colored yarns is to be tied in, the operation of picking the ends for the spools is somewhat more difficult, since not only the spools but the pattern also must be considered. To illustrate the method of picking a fancy pattern, a pattern will be taken and the method described with reference to it. Suppose that a warp is to be made to contain 2,760 ends plus 30 ends on each side for the selvage; it is to contain five cuts, each 72 yards long, and is to be beamed 58 inches wide. The pattern of the warp is to be as follows:

WARP PATTERN

Black	20		20		20									10		10									80
Red		4				4							8		8		8		4		4				40
White				4				4				4						4		4					20
Brown							20		20		20											10		10	80
Fawn										4													6		10
Total number of ends in pattern																									230

29. Spooling the Yarn.—The first operation is to determine the number of warp patterns in one section of the warp and if (as in the previous case) the creel behind the dresser will contain only 480 ends, it is obvious that the section can contain only two patterns, or 460 ends (230×2). It is, of course, always necessary to have even patterns in each section of the warp; otherwise, there will be broken patterns in the finished warp, which will make it useless. As the warp is to contain 2,760 ends, there will be six sections in the warp ($2,760 \div 460$). It is always necessary to have the number of ends in the section divisible by the ends in a pattern and always best to have the number of ends in the warp (exclusive of selvage) divisible by the ends in a section, although it is possible when running the last section to break out some of the ends if they are not desired.

It is next necessary to find the number of spools of each color of yarn required and also the length of yarn that must be spooled. To find the number of spools of each color required in a fancy pattern:

Rule.—*Multiply the number of ends of each color in one pattern by the number of patterns in a section and divide by the number of ends on one spool (generally 40). The result in each instance will be the number of spools required of that particular color.*

Applying the above rule to the pattern under consideration,

$$\frac{80 \text{ ends} \times 2 \text{ (patterns)}}{40} = 4 \text{ spools black}$$

$$\frac{40 \text{ ends} \times 2 \text{ (patterns)}}{40} = 2 \text{ spools red}$$

$$\frac{20 \text{ ends} \times 2 \text{ (patterns)}}{40} = 1 \text{ spool white}$$

$$\frac{80 \text{ ends} \times 2 \text{ (patterns)}}{40} = 4 \text{ spools brown}$$

There are only 10 ends of fawn in one pattern or 20 ends (10×2) in one section. There are not enough for a full spool but it will be better to wind them on a spool and run them with a little less friction on that spool rather than to run them from bobbins, although this can be done. There are 12 spools ($4 + 2 + 1 + 4 + 1$), therefore, required for the section, which will just fill the creel at the back of the dresser.

30. It is next desired to find the number of yards to be spooled in order to make a warp of the required length. To find the number of yards to be spooled:

Rule.—*Multiply the number of cuts of warp by the length of a cut and by the number of sections in the warp.*

Applying the above to this particular pattern gives the following result:

$$72 \text{ yd.} \times 5 \text{ (cuts)} \times 6 \text{ (sections)} = 2{,}160 \text{ yd.}$$

From this it will be seen that there are 2,160 yards of each color required, with several yards extra to be left in the dresser for the next pattern. Unless the pattern consists of very fine yarn, this length cannot be spooled on a single spool and must therefore be wound on two or more spools, thus necessitating an extra tying in before the warp is finished. In this connection, however, it should be noticed that a single spool of fawn can be spooled containing the full number, or 40 ends, but only half the length, thus allowing 20 ends to be dressed first and afterwards the next 20 ends without removing the spool from the dresser creel.

The spools of different colors being obtained, the fawn will be placed in the bottom of the creel, then the brown, white, and red, finishing with the black in the top of the creel.

31. Picking a Fancy Pattern.—Having decided on 460 ends in the section, it is now necessary to count out 460 ends from those in the tying-in reed, after which the pattern can be picked as follows: Beginning at the left-hand end of the tying-in reed, or rather of the 460 ends counted, first pick the black, or top, row in the pattern. Pick 20 ends, then skip 4 ends for the red; then pick 20 ends and skip 4 ends for the white; pick 20 ends and skip 84 ends for the red, white, brown, and fawn, as shown by the pattern; then pick 10 ends and skip 8 for the red; then pick 10 and skip 50 ends for the other colors. As the section contains two repeats, it is necessary to repeat this operation. When this is finished, there will be 160 ends, which should be knotted together and cast over the top of the tying-in reed. These ends are the ones to which the black yarn will be tied.

It is next necessary to pick the ends for the red, which is done as follows: Beginning at the left, pick 4 ends and skip 4; pick 4 and skip 72; pick 24 ends (the black has already been thrown over the top of the reed) and skip 4; pick 4 and skip 4; pick 4 and skip 26. This operation is, of course, repeated as when picking the black.

The white is then picked as follows: Beginning at the left, pick 4 and skip 20; pick 4 and skip 44; pick 12 (the red and black are already cast over the reed) and skip 26. Repeat this operation as many times as there are repeats of the pattern in the section.

The brown is picked as follows: Beginning at the left, pick 40 and skip 4; pick 30 and skip 6; pick 10. Repeat this operation twice. The ends remaining in the reed, that is, those that are not cast over the top, will be the ends to which the fawn is to be tied.

Many dressers pick a pattern from right to left of the draft and work from right to left of the tying-in reed.

32. Tying in a Fancy Pattern.—The pattern is now picked, but as each spool is tied in separately, there is one more point that must be considered; that is, the dividing of the yarn that has been cast up for each color into sections of 40 ends each. This is done by taking each bunch of threads representing one color and picking out 40 ends as many times as possible. These 40 ends are then knotted together and thrown over the reed. It is not necessary to take these ends in any particular order, since the same color of yarn will be tied to each of them, but simply to make a selection of ends for each spool extending across the full width of the reed.

For instance, in this pattern all the ends will be thrown down and the bunch of 160 ends representing the black yarn will be picked up and 40 ends selected for each spool, each selection being made somewhat at random, but still selected so that the ends from each spool will be spread across the width of the reed. The ends for each spool can, however, be picked after the same manner as a plain warp if it is desired to have the yarn absolutely straight. The same operation is then carried out with the bunches of yarn to which the other colors are to be tied, and after completion the ends are thrown back over the reed, the ends for each spool being knotted together.

The section is now ready to be tied in, which is accomplished as follows: Take the first bunch of ends laid over the reed, which of course will be the last color picked, or the 20 ends of fawn, and tie each end to the ends of fawn on the bottom spool in regular order. There will, of course, be only 20 ends taken from this spool. Then take the next bunch of threads and tie in the next spool, which is brown. This operation is continued until all the spools are tied in, remembering to tie each bunch of threads to its proper color; thus, in this pattern they will be tied in the following order, commencing at the bottom of the creel and working up: 20 ends of fawn on one spool, four spools of brown, one spool of white, two spools of red, and four spools of black.

33. Reeding the Sections.—After the spools are tied in with secure knots, the method of making the warp is the same as that employed in making a plain warp. As the warp is to be beamed 58 inches wide and contain six sections, four sections will be made $9\frac{1}{2}$ inches wide and the two end sections, which contain selvages, will be 10 inches wide. These widths regulate the setting of the pins on the reel. Suppose that the condensing reed is a No. 12. In $9\frac{1}{2}$ inches there will be 114 dents, while 460 ends, if drawn 4 in a dent, will occupy 115 dents. This is only 1 dent out of the way, which is near enough for practical purposes, although the section may be made to occupy exactly 114 dents by drawing 5 ends in 4 of the dents of the reed. The selvages, of course, will be drawn in as previously explained and the sections leased and then reeled, each section being 360 yards long (72 × 5).

SUMMARY

34. The following is a summary of the calculation of this fancy pattern and shows the data that the boss dresser will have collected for making the warp. The pattern of the warp is shown in Art. **28**, while the figuring is as follows: 230 ends × 2 (patterns) = 460 ends in section; 460 ends × 6 (sections) = 2,760 ends in warp; 30 ends on each side for selvage; [80 ends × 2 (patterns)] ÷ 40 = 4 spools of black; [40 ends × 2 (patterns)] ÷ 40 = 2 spools of red;

[20 ends × 2 (patterns)] ÷ 40 = 1 spool of white; [80 ends × 2 (patterns)] ÷ 40 = 4 spools of brown; 10 ends × 2 (patterns) = 20 ends of fawn; 72 yards × 5 (cuts) = 360 yards, length of each section; 360 yards × 6 (sections) = 2,160 yards of each color spooled; 58 inches wide on the beam; 4 sections, 9½ inches wide on the reel; 2 sections, 10 inches wide on the reel; 9½ inches in condensing reed; 4 ends per dent (5 ends in 4 of the dents).

On many fancy patterns considerable ingenuity must be exercised and often colors must be run from bobbins. Sometimes, when only a few threads of some colors are used, these colors can be wound together on one spool. However, no specific rules can be laid down for these items, since it may be said that no two fancy patterns are formed in the same manner

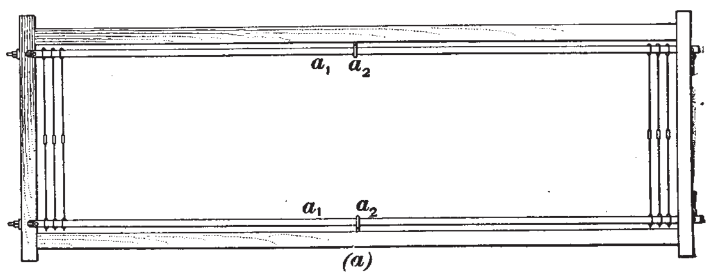
DRAWING IN AND REEDING

DRAWING IN

35. After a warp has been beamed it must first be drawn through the heddles of the loom harnesses, according to the drawing-in draft, and afterwards through the reed, according to the reeding particulars furnished by the designer. These operations complete the preparation of the warp and it is then ready to be placed in the loom and woven.

The **harness**, Fig. 18 (*a*), is a wooden frame attached to the shedding mechanism of the loom by means of which it may be raised and lowered to form an opening, or shed, in the warp through which the shuttle carrying the filling yarn can be thrown. At the top and bottom of the harness frame two steel heddle bars a_1, a_1 are placed; these bars are usually fastened at one end by means of threaded stretcher hooks and nuts, while at the other end they pass through a slot in the harness frame and are secured by hooks that engage with holes in the heddle bars. Heddles, Fig. 18 (*b*), twisted from wire are threaded on the heddle bars, and in addition to the eyes required at each end for this purpose are made with an eye at the center through which an end of the warp may be drawn. Any reasonable number of heddles may be placed on the harness frame, the number required depending on the number of ends in the warp and the number of harnesses to be used. The drawing-in draft also may require more heddles on some harnesses than others, but extremes should be avoided, since if the heddles are too crowded the warp will run poorly in the loom. When the harnesses are very wide, hooks a_2, Fig. 18 (a), are inserted in the frame to support and stiffen the heddle bars.

36. Drawing-In Frame.—In order that the warp may be drawn through the harnesses in the most convenient



(a)

(b)

Fig. 18

manner, a drawing-in frame similar in principle to that shown in Fig. 19 is necessary. An iron drawing-in frame may be purchased, but it is usual for the mill to construct its own drawing-in frames, since a very simple arrangement is all that is necessary. As shown in Fig. 19, the essential features are two stands a for supporting the beam and a framework b over which the warp may he drawn. The two arms b_1 bolted to this frame support the harnesses, while the lease of the warp hangs from the supporting beam b_2 directly behind the heddle eyes of the harness. The strings that have retained the lease in the warp are replaced by two lease rods c that are placed through the lease and tied together at each end, after which the lease strings may be withdrawn.

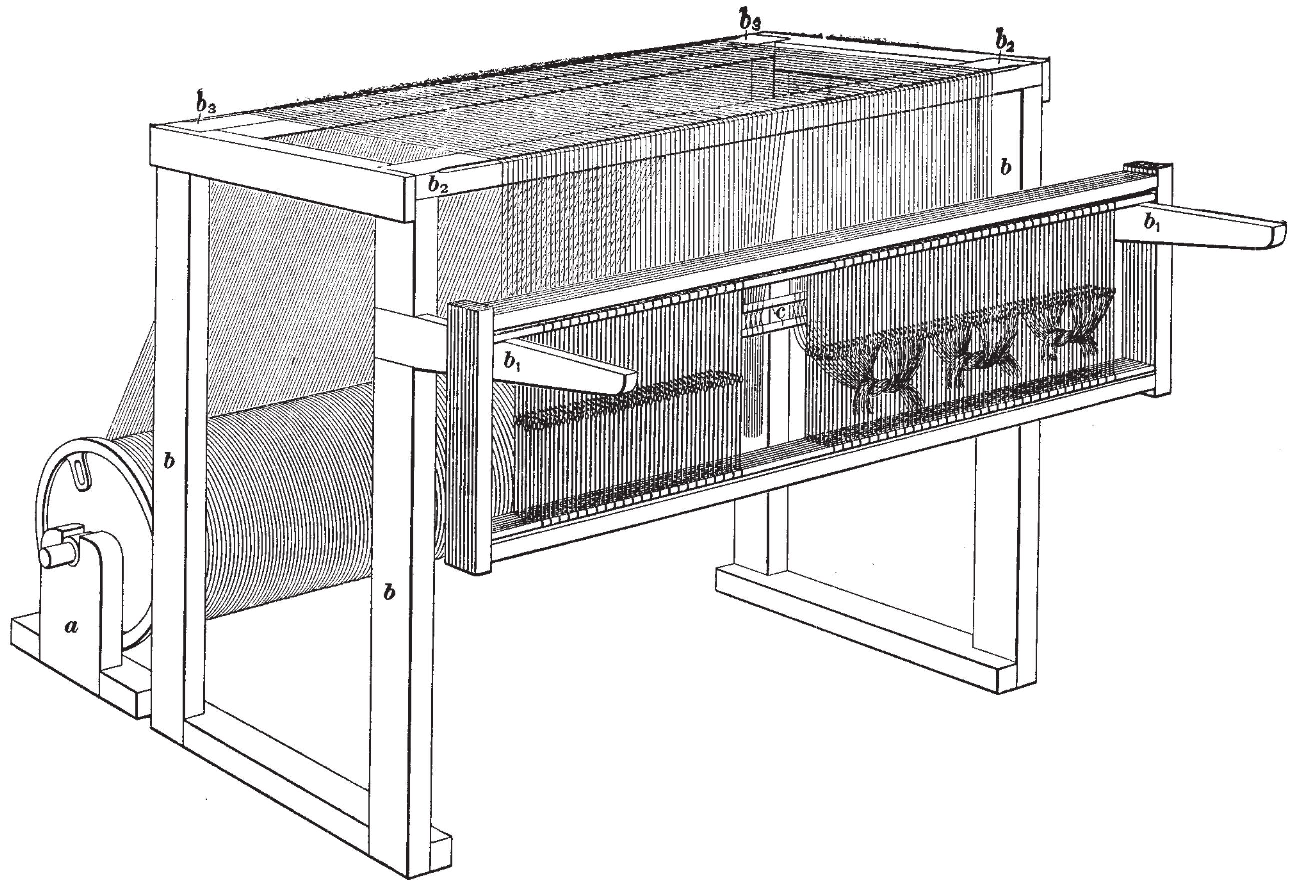


Fig. 19

37. Method of Drawing in a Warp.—The operation of drawing in a warp is as follows: The order in which the ends are to be drawn through the harnesses is usually indicated by a draft similar to that shown in Fig. 20, furnished by the designer. In this draft the horizontal rows of squares represent the harnesses as indicated, the draft being made in this case for a warp that is to be drawn in on eight harnesses. The vertical rows of squares indicate the warp ends, and the figures on these vertical rows of squares indicate through which harness each end is to be drawn. When drawing in, the operator commences at the right of the warp and of the harness frames and draws in the first end of the warp on the harness indicated on the first vertical row of squares at the right of the drawing-in draft. This operation is then repeated

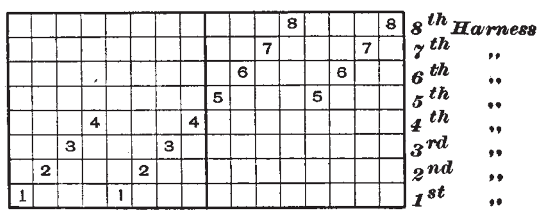


FIG. 20

with the next end, and so on, the warp being drawn from right to left. For instance, according to the draft in Fig. 20, the first end of the warp on the right will be drawn through the eighth, or back, harness, the second end through the seventh harness, the third end through the sixth harness, the fourth end through the fifth harness, the fifth end through the eighth, and so on throughout the draft. When the last end of the draft is drawn in, the whole operation is repeated, commencing again at the right of the draft. When the ends are drawn through the harnesses in regular order from back to front or front to back, the draft is said to be a *straight draw*, but when the ends are drawn in any other order, the draft is is said to be a *cross-draw*. The operation of drawing in is generally performed by a girl, called a *drawer-in*, and in cases where a large number of harnesses are used or where the drawing-in draft is quite complicated, another girl, called a *hander-in*, assists. The drawer-in grasps the required heddles in her left hand and inserts a hook, called a *reed*, or *drawing-in, hook*, Fig. 21, in the eye of the heddle, while the hander-in hooks the required thread, as indicated by the lease, in the eye of the hook; the drawer-in then draws the thread through the heddle eye and inserts the hook in the next heddle, and so on. The drawer-in sits in front of the harness frame, Fig. 19, while the hander-in sits in the rear,

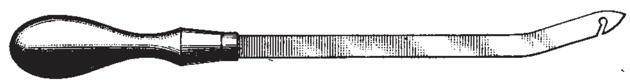


FIG. 21

underneath the yarn; this is the reason for building the drawing-in frame with two bars b_2, b_3 over which the warp is passed. In cases where no hander-in is required, the drawing-in frame may be constructed with only one bar b_2. As fast as a number of ends are drawn through the heddles, the drawer-in makes two bunches of the yarn and ties a half knot in front of the heddles so as to prevent the ends from being accidentally pulled out.

REEDING

38. After the ends of the warp have been drawn through the harnesses they must be drawn through the **reed,** which is a gratelike device placed in the lay of the loom for the purpose of beating up each pick of filling as it is inserted in the cloth; it also separates and distributes the warp ends across the width of the cloth. A reed is constructed of thin, flat strips of steel set edgewise in two pieces of wood called **ribs,** as shown in Fig. 22. Each rib is made in two parts that are wound with waxed cord in order to space the strips and make the whole reed firm. The space between two adjoining strips of steel in the reed is called a **split,** or **dent,** the latter being the term generally employed. The number of dents in a given space is largely determined by the size of the waxed cord with which the ribs are wound, since the thicker the cord, the greater will be the space between the strips. The number of dents in a given space determines the number of the reed. The general custom is to use for this given space 1 inch; thus, a 10s reed contains 10 dents per inch. In the English woolen trade $\frac{1}{4}$ yard, or 9 inches, is sometimes used; thus a 90s reed of this system is the same as a 10s reed of the American system. Sometimes, especially in the cotton trade, the number of dents in a given number of inches is used to designate the number of the reed; thus, a 1,200 — 30 reed, which indicates that there are 1,200 dents in 30 inches, is equal to a 40s reed. The height of the reed, or the length of the steel strips measured between the ribs, is governed by the class of fabric to be woven and the kind of loom for which it is designed. For instance, for cotton a $3\frac{1}{2}$-inch reed is high enough, while woolen and worsted require from a $4\frac{1}{2}$- to a 6-inch reed. Carpets and other heavy fabrics often require as high as from 8 to 9 inches. The coarser the reed, the less friction to a certain extent will there be on the warp; on the other hand, the finer the reed, the smoother will be the fabric. Reeds that have become bent or otherwise damaged by careless handling produce stripes in the cloth, known as **reed marks,** owing to the imperfect spacing of the warp. Sometimes if too many of the warp ends are drawn in one dent of the reed they will roll or ride each other. This may be remedied by using a finer reed and drawing less ends in one dent.

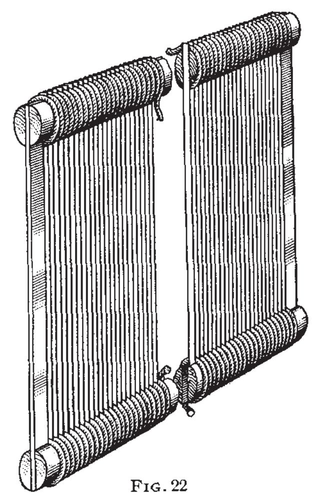


FIG. 22

Reeding is usually accomplished by means of a hook somewhat different from the one employed in drawing a warp through the harnesses, as shown in Fig. 23. The hook is passed through a dent of the reed and a number of ends, depending on the number to be drawn through this particular dent, are engaged and drawn through the reed as the hook is withdrawn. The hook is then inserted in the next dent and the ends drawn through in a similar manner. The number of ends drawn through a dent of the reed may vary in different cases, and sometimes with the same warp the reeding particulars may call for a different number of ends in some of

FIG. 23

the dents; but in any case the ends must be reeded in the same order as they are drawn through the harnesses. When reeding, the operator works from right to left in the same manner as when drawing in the warp, and ties the warp in half knots in front of the reed so that there will be no danger of the ends being pulled out of the reed.

TWISTING IN

39. After a warp has been nearly woven out in the loom, if the new warp that is to replace it has the same number of ends and is to be woven with the same drawing-in draft, considerable time and labor may be saved by twisting it in. When this can be conveniently performed in the loom, a lease is made in the old warp by raising every alternate harness and inserting one lease rod, and then depressing these harnesses, raising the others, and placing another rod in the shed. This forms the lease, which facilitates the twisting in of the ends in their proper order. The new warp is then placed in the loom and the ends twisted to those of the old warp. This is done by taking the threads of the two warps in the proper order with the right hand, and taking out the twist with the left hand, and then laying back the two ends and rolling them firmly together. Each end of the new warp is twisted to the corresponding end of the old warp in this manner, and the new warp is then carefully drawn through the harnesses and reed. While the twist is not sufficiently strong for weaving, it is strong enough to enable the new warp to be drawn through the harness and reed without difficulty if care is taken. When twisting in, the operative generally dips his fingers in whiting and oil, which allows the threads to be more firmly secured.

40. Twisting-In Frame.—When it is not convenient to twist in the new warp in the loom, a frame, made especially for the process of **twisting in,** must be provided. This frame, Fig. 24, consists of stands *a* for supporting the warp beam *c*, and a stand *b* for carrying the harnesses *d* and the reed *e*, which is usually tied to the harnesses in order that it may be held securely in place. The old warp is cut out of the

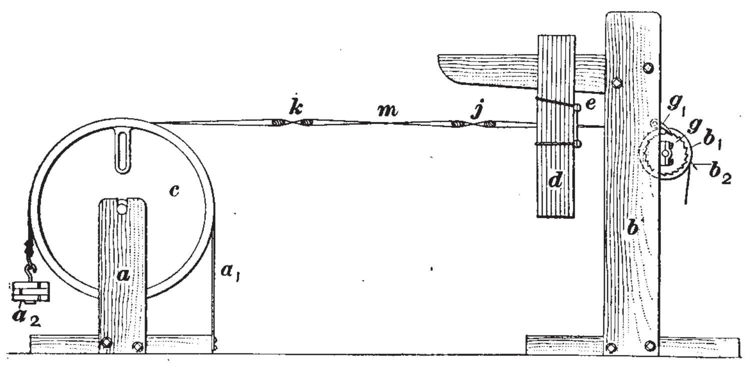


FIG. 24

loom, after a lease *j* has been taken, with a small piece of the woven cloth attached. This cloth is secured to a drum b_1 by means of pins b_2. A ratchet *g* and pawl g_1 prevent this drum from turning and slackening the warp while it is being twisted in. The new warp having a lease at *k* is placed in its stands and each end twisted to an end of the old warp at *m*. A strap a_1 and weight a_2 prevent the beam from turning. After the warp is all twisted, the friction is taken off the beam and the drum b_1 rotated until the new warp is drawn through the harnesses and reed, after which the old warp is broken. The ends of the new warp may now be knotted loosely in front of the reed and the warp placed in the loom.

A SERIES OF QUESTIONS

Relating to the Subjects
Treated of in This Volume.

It will be noticed that the questions contained in the following pages are divided into sections corresponding to the sections of the text of the preceding pages, so that each section has a headline that is the same as the headline of the section to which the questions refer. No attempt should be made to answer any of the questions until the corresponding part of the text has been carefully studied.

WOOL

EXAMINATION QUESTIONS

(1) What are the two great classes of textile fibers and what are the special characteristics of each?

(2) What can be said of the appearance of the wool fiber when viewed through a microscope?

(3) Into what two great classes may sheep be divided with regard to the length of staple of their wool, and what are the characteristics of each?

(4) Discuss, fully, the felting property of the wool fiber.

(5) Explain what is meant by the following terms when used in connection with wool: (*a*) elasticity; (*b*) softness; (*c*) fineness; (*d*) luster; (*e*) crimp; (*f*) color.

(6) What are some of the causes of tender staple?

(7) What can be said of the hygroscopic property of wool?

(8) (*a*) What is shoddy? (*b*) What is mungo? (*c*) What is extract?

(9) (*a*) What is mohair, from what animal is it obtained, and what is the character of the fibers? (*b*) From what other animals than sheep are fibers obtained that are valuable for textile purposes?

(10) What are the diameters of fibers of the following wools and about how many serrations per inch do they contain: (*a*) Saxony? (*b*) Australian merino? (*c*) Southdown?

(11) Explain fully what is meant by the term kemps.

(12) Explain what is meant by the term staple as applied to wools.

(13) What is the average weight of American fleeces?

(14) From what states are the so-called territory wools obtained?

(15) What is wool sorting and how is the operation performed?

(16) What is the cause of the paint and tarry marks frequently found on wool?

(17) (*a*) What are clothing wools? (*b*) What are combing wools?

(18) What can be said about the number of sorts that are usually made in sorting wool and also the largest number that it is possible to make?

(19) Draw a rough sketch of a sheep and explain where the different qualities of wool occur and what the character is of the wool growing in each position.

(20) Explain the following terms: (*a*) skirts, or skirtings; (*b*) hog fleece; (*c*) shurled hogget; (*d*) wether fleece; (*e*) buck fleece; (*f*) pulled wool; (*g*) shearlings; (*h*) cots; (*i*) casts; (*j*) tags; (*k*) toppings; (*l*) yearlings; (*m*) noils; (*n*) lamb's wool; (*o*) yolk; (*p*) britch; (*q*) braid wool; (*r*) brokes; (*s*) flocks; (*t*) unmerchantable wool.

WOOL SCOURING

EXAMINATION QUESTIONS

(1) What are the objects of wool scouring?

(2) Define the terms yolk and suint.

(3) What compounds are obtained from wool by steeping in water, and in what quantities?

(4) What is meant by the term pitchy, as applied to wools?

(5) What would be considered an average shrinkage from a fleece to a scoured basis?

(6) Name some of the scouring materials that can be used to scour wool and state what particular one you would use: (*a*) for a coarse, strong-fibered wool; (*b*) for a fine wool.

(7) (*a*) What is the principal constituent of soda ash? (*b*) How can the presence of caustic alkali be ascertained in soda ash? (*c*) What is the danger of caustic alkali in the scouring liquor?

(8) (*a*) How can soap be tested for resin and other adulterations? (*b*) How can the amount of water contained in a soda soap be determined?

(9) (*a*) What can be said in regard to the proper temperature of a scouring liquor? (*b*) If luster is an important object, what can be said of the temperature of the liquor?

(10) In what manner is hard water detrimental to wool scouring?

(11) (*a*) What is the nature of temporary hardness? (*b*) What substances make water permanently hard? (*c*) What is a good method of softening water for scouring?

(12) (*a*) What is the solvent process of scouring wool? (*b*) What are some of the advantages claimed for it?

(13) (*a*) What is the object of dusting grease wools? (*b*) Give a short description of a cone duster.

(14) How does a square duster differ from a cone duster?

(15) What is the advantage of a parallel-rake motion over a motion that moves the rakes in the arc of a circle?

(16) Describe the operation of a parallel-rake wool washer, explaining the functions of the ducker, rakes, perforated false bottom, carrier, squeeze rolls, etc.

(17) What is the meaning of the terms two-bowl combination, three-bowl combination, etc.?

(18) (*a*) What can be said of the proper strength of the scouring liquor? (*b*) What is the effect of too strong or too hot liquor on the fiber?

(19) Name three methods of feeding a scouring machine.

(20) Give a brief description of a self-feed suitable for a wool washer.

WOOL DRYING

EXAMINATION QUESTIONS

(1) What can be said concerning the importance of using proper methods of drying wool?

(2) What two general processes are there for drying wool and what are the advantages and disadvantages of each?

(3) (*a*) Describe a cold-air table dryer. (*b*) Is this type of dryer ever used as a hot-air dryer, and if so, how is it arranged?

(4) (*a*) What is meant by the term multiple-apron construction as applied to dryers? (*b*) What is a disadvantage of this type of dryer?

(5) What is the disadvantage of a hot-air dryer without fans?

(6) What is a good temperature to use when drying wool in a one-compartment dryer?

(7) What two conditions in drying wool produce a harshness of the fiber?

(8) What are the advantages of a sectional dryer?

(9) In a two-compartment dryer, what temperatures will give good results?

(10) Explain the operation of the two-section dryer shown in Fig. 4, and state the method of heating and the mode of circulation of the air.

(11) What is the best kind of apron for a dryer? Why?

(12) Why is it necessary to make some provision for vibration in hydro-extractors?

(13) Why is the basket of a hydro-extractor made perforated?

(14) Describe the type of hydro-extractor shown in Fig. 6.

(15) What is a disadvantage of the self-balancing hydro-extractor?

BURR PICKING

EXAMINATION QUESTIONS

(1) (*a*) What are the objects of burr picking? (*b*) What would be the result if the burrs were not removed?

(2) Give a description of the Parkhurst burr picker and its operation on the stock.

(3) Perform the calculations necessary to find the speed of the beaters on the Parkhurst picker.

(4) Suppose that it was desired to increase the speed of the rear burr guard on a Parkhurst picker to 1,700 revolutions per minute, what size pulley would be required on the rear burr-guard shaft? Ans. $4\frac{1}{2}$ in. in diameter

(5) If the draft of the blower of a Parkhurst picker were not sufficient to draw off the dust and a 5-inch pulley should be placed on the blower shaft to remedy the defect, what would then be the speed of the blower?

Ans. 1,530 rev. per min.

(6) Show the calculations for finding the speeds of the brush and burr cylinders of a Parkhurst picker.

(7) (*a*) How are the burr cylinders and guards in the Parkhurst picker exposed for cleaning? (*b*) Why are sliding brushes placed under the beater screens and over the screen at the rear of the picking cylinder?

(8) Are the burr cylinders placed in the same position regarding the picking cylinder in the Sargent picker as in the Parkhurst?

(9) Explain the device by which the feed-apron and feed-rolls are stopped independently of the rest of the machine on the Parkhurst picker.

(10) How does the arrangement of burr cylinders in the Curtis and Marble machine differ from other pickers?

(11) What is the average daily production of a 48-inch Parkhurst picker?

(12) Explain the difference between the steel-ring burr rolls and wire-wound rolls.

(13) For what kinds of stock are beaters especially adapted?

(14) What is the object of the steel straightedge shown at f_3, Fig. 3?

(15) What can be said in regard to the management of burr pickers?

CARBONIZING

EXAMINATION QUESTIONS

(1) (*a*) What is understood by the term carbonizing, or extraction? (*b*) What can be said of the relative advantages of mechanical and chemical burr extraction?

(2) Why are alkalies unsuitable for carbonizing?

(3) What are the two principal agents employed for carbonizing wool?

(4) Explain, fully, the sulphuric-acid process of carbonizing, stating the strength of the acid solution, etc.

(5) What is meant by the term neutralizing when used in connection with the carbonizing process?

(6) What form of wooden soaking tubs gives the best service?

(7) Explain the aluminum-chloride process of carbonization, and explain some of its advantages and disadvantages.

(8) Discuss the drying of carbonized stock.

(9) What is meant by dry extracting, and why is the process unsuitable for carbonizing wool?

(10) What can be said about the method of preparing the sulphuric-acid solution for carbonizing?

(11) Why is a galvanized apron in the dryer necessary for drying stock carbonized with sulphuric acid?

(12) What can be said in regard to poling the stock while in the soaking tubs?

(13) Do wools gain in weight if stored after carbonization? Explain.

(14) Describe the operation of a carbonizing duster on the stock, stating the proper speed for the cylinder.

(15) What is the best arrangement of crushing rolls in a duster?

WOOL MIXING

EXAMINATION QUESTIONS

(1) What is mixing and for what purpose is it resorted to?

(2) State, fully, the method of laying out a mix.

(3) Make a sketch of a mix containing three materials or colors, the proportion of the ingredients being 50, 25, and 25 per cent.

(4) What precaution must be observed in taking the blended stock from the pile to pass it through the mixing picker? Why?

(5) If a mix containing only 10 per cent. of one color is to be made, what precaution should be taken in order to insure the uniform distribution of this color throughout the batch?

(6) In white cotton-and-wool mixes that contain a large percentage of cotton, what remedy is there for the chalky white appearance of the resulting yarn?

(7) If an Oxford mix containing only 3 per cent. of white stock is to be made, what precaution should be taken in regard to the white stock in order to insure its uniform distribution?

(8) What is the effect of imperfect mixing?

(9) What is the cost per pound of a mix composed of 70 pounds of wool at 26 cents per pound, 18 pounds of shoddy at 11 cents per pound, and 12 pounds of cotton at $8\frac{1}{2}$ cents per pound? Ans. $21\frac{1}{5}$ ct.

(10) If a mix is to be made containing 50 per cent. of black and 50 per cent. of white stock and it is to be composed of wool and cotton in equal proportions, should all black cotton or all black wool be used?

(11) (*a*) How many pounds of each of the following materials will be required to make a mix of 440 pounds, costing 15 cents per pound: A at 23 cents, B at 19 cents, C at 11 cents, and D at 9 cents per pound? (*b*) Vary the proportions of the materials, still keeping the average cost at 15 cents per pound, and state how many pounds of each will then be required to make the mix.

Ans. (*a*) { A, 80 lb.; B, 120 lb.; C, 160 lb.; D, 80 lb. } (*b*) { A, 120 lb.; B, 80 lb.; C, 80 lb.; D, 160 lb. }

(12) Describe the operation of a mixing picker.

(13) What peculiar arrangement is there for feeding the stock to the main cylinder on the Davis & Furber picker?

(14) What is the object of allowing a slight vertical motion to the top feed-rolls of mixing pickers?

(15) Explain the drafting action of the feed-rolls on the Atlas picker.

(16) Describe the Fearnaught and state how its action compares with that of the mixing picker.

(17) Three materials are to be mixed: A costing 28 cents, B 18 cents, and C 13 cents per pound; how many pounds of each will be required to make a mix of 500 pounds costing 20 cents per pound?

Ans. { A, 180 lb.; B, 160 lb.; C, 160 lb. }

(18) A mill has 520 pounds of wool on hand worth 20 cents per pound; how much cotton at 8 cents per pound must be purchased to mix with this wool in such a proportion that the mixture will be worth 16 cents per pound?

Ans. 260 lb.

(19) What are the best methods to employ in making cotton and wool mixes?

(20) Describe the comb mechanism that is used on the Bramwell picker feed to render the feeding of the stock uniform.

WOOL OILING

EXAMINATION QUESTIONS

(1) Explain fully why the application of oil or emulsion to wool is necessary.

(2) (*a*) Name some of the oils commonly used for oiling wool. (*b*) What is the best oil to use on the finest grades of wool?

(3) Give an olive-oil emulsion suitable for fine wool and state how many pounds of wool a given quantity will lubricate.

(4) (*a*) How is oleine obtained? (*b*) When impure, what does oleine contain? (*c*) Is the presence of this substance detrimental? If so, why?

(5) State how oleine may be tested to determine if sulphuric acid is present.

(6) (*a*) For an ordinary wool, about how many quarts of lard oil would be applied per hundred pounds of wool? (*b*) Under what conditions would this proportion be varied?

(7) State the best method of making an emulsion.

(8) (*a*) In making an emulsion for oiling wool, what is the object of adding ammonia or borax to the hot water? (*b*) Which is to be preferred, and why?

(9) If an oil of unknown quality were on hand, how could its value as a lubricant for wool be determined?

(10) (*a*) What is the usual method employed in applying oil or emulsion to wool? (*b*) What is the object of beating the stock with poles after each oiling?

(11) In a cotton-and-wool or silk-and-wool mix, what precautions in regard to oiling should be taken?

(12) What is the specific gravity of: (*a*) oleine? (*b*) hot-pressed olive oil?

(13) Name some of the characteristics that should be possessed by an oil suitable for lubricating wool.

(14) Suppose that stock is being oiled with a Spencer oiler and that it is desired to increase the amount of oil applied. After opening the supply valve *h*, Fig. 1, it is found that the reservoir *f* becomes empty; what is the proper remedy for this defect?

(15) How can the amount of oil applied to the stock be increased when using a Sargent oiler?

WOOLEN CARDING

(PART 1)

EXAMINATION QUESTIONS

(1) In what condition should wool come to the cards in order that the best results may be obtained in carding?

(2) What are the principal objects of woolen carding?

(3) (*a*) What is considered as a set of woolen cards? (*b*) Name the principal working parts of the first breaker card.

(4) (*a*) Explain the method of driving the workers. (*b*) How are strippers driven?

(5) What are the functions of: (*a*) workers? (*b*) strippers? (*c*) fancies?

(6) What advantage is there in planing the arches and frames of cards in pairs?

(7) Make a sketch of a first breaker card, showing the working parts, their direction of rotation, and the direction of the points, or inclination of the teeth, of the clothing.

(8) If the main driven pulleys of a card are 24 inches in diameter and the line shaft of the room makes 160 revolutions per minute, how large a driving pulley is necessary to give the card a speed of 80 revolutions per minute?

Ans. 12-in. pulley

(9) Should a doffer comb be run faster on short or on long stock?

(10) What are ring doffers and what object do they accomplish?

(11) Explain the mechanism by means of which the doffer comb is given a vibratory motion.

(12) What would be considered as a fair speed for a woolen card having a main cylinder 48 inches in diameter?

(13) What is the surface velocity of a main cylinder 48 inches in diameter making 85 revolutions per minute?

Ans. 1,084.833 ft. per min.

(14) (*a*) What is the average weight of a set of woolen cards? (*b*) What is the usual and best arrangement of cards in the card room?

(15) A 60-inch main cylinder makes 72 revolutions per minute; if an 8-inch worker working in connection with it makes 14 revolutions per minute, how many feet per minute of clothing on the main cylinder pass the clothing on the worker?

Ans. 1,113.0427 ft. per min.

NOTE.—Add $\frac{3}{4}$ inch to the diameters.

(16) (*a*) Explain the terms roll condenser and apron condenser. (*b*) Give a description of an apron condenser, explaining the different parts and their operation on the stock.

(17) If low stock is being carded, will a roll or apron condenser work better?

(18) How are feed-rolls of a card driven?

(19) What is the object of a licker-in fancy?

(20) In what direction are the workers sometimes run on finisher cards? Why?

WOOLEN CARDING

(PART 2)

EXAMINATION QUESTIONS

(1) What is the object of automatic first breaker feeds?

(2) Explain the mechanism by means of which the lifting and stripping aprons of the Bramwell feed are stopped when a certain weight of wool is ready to be placed on the feed-apron of the card.

(3) After the wool is weighed in a Bramwell feed, how is the pan emptied and the lifting apron started again?

(4) (*a*) What effect would be produced on the speed of the feed-rolls of the card and feed-apron and dumping arrangement of the Bramwell feed if a larger gear were placed on the doffer shaft of the card? (*b*) What effect would this have on the side drawing?

(5) What is the object of the push board and dabber on a Bramwell feed?

(6) (*a*) How is a full spool removed from the Torrance balling machine? (*b*) What is the advantage of a creel feed?

(7) How is the size of the ball regulated with a Torrance balling machine?

(8) (*a*) What is the object of the rods *l*, Fig. 8? (*b*) What is the disadvantage of a creel feed for a finisher card?

(9) Describe the operation of the Apperly feed.

(10) If the side drawing from the second breaker were crowded on an Apperly feeder, how would the defect be remedied?

(11) (*a*) What is the object of a metallic breast? (*b*) About what is a good speed for a breast cylinder?

(12) How does the customary English method of carding woolen yarns differ from the American system?

(13) How does the object of worsted carding differ from the object of woolen carding?

(14) If a 32-tooth gear on the second breaker doffer shaft is giving $1\frac{7}{8}$-run roving and it is desired to make 2-run roving, what size gear should be used? Ans. 30-tooth gear

(15) Describe the passage of the stock through a set of cards.

(8) (*a*) What is the difference between sheet and fillet clothing, and on what cylinders is the former used? (*b*) What is meant by the crown of a card tooth? (*c*) What is a nogg?

(9) The clothing on a 48 in. × 48 in. main cylinder has 4 crowns per inch (8-crown clothing), 20 noggs per inch, and 3 teeth per nogg; the cylinder is covered with filleting; what is the number of points on the cylinder? (Do not add $\frac{3}{4}$ inch to the diameter of the cylinder.) Ans. 3,474,358 points

(10) At what points on woolen cards is setting necessary?

(11) (*a*) How would it be possible to tell whether a card was set too open or too close? (*b*) How is the fancy usually set? (*c*) Should the finisher card be set closer than the first or second breakers? Why?

(12) (*a*) On ordinary work, such as territory wool, how close should the workers be set to the main cylinder on the first breaker? (*b*) on the finisher? (*c*) How are gauges numbered? (*d*) What is the thickness of a No. 28 Brown & Sharpe gauge?

(13) Do gauges, especially thin ones, ever become bent, and if so what error is liable to occur in the setting?

(14) What is meant by stripping cards, and how is it accomplished?

(15) (*a*) What can be said with regard to the frequency of stripping? (*b*) Why does the first breaker need more cleaning than the finisher card?

(16) (*a*) How long should a card run after the stock is on it before the wool is allowed to make roving for spinning? (*b*) Should the stock be put through the card immediately after cleaning?

(17) (*a*) What is meant by grinding? (*b*) What are the two kinds of points obtained by grinding and which is the better? (*c*) Why is a grinder covered with coarse emery better than one covered with fine emery?

(18) What speed and how many traverse motions per minute of the grinding wheel are suitable to grind a good point on a 48-inch card?

(19) (*a*) Which is to be preferred, a cylinder with smooth or very sharp clothing? (*b*) Should the doffer clothing have a sharper point than the clothing on the main cylinder? Why?

(20) (*a*) When grinding, does the grinding roll run against the back of the tooth or its point? (*b*) What is meant by a hooked, or burr, point? (*c*) Which is better, light and fast or heavy and slow grinding?

(21) (*a*) After grinding a fancy, why is it set hard into the main cylinder and allowed to run thus for $\frac{1}{2}$ hour? (*b*) What is the object of setting strippers so that they will run into the workers?

(22) Explain a device on a grinder for tightening the grinding wheel when it becomes loose on the shell through wear.

(23) (*a*) Find the length of $1\frac{1}{2}$-inch filleting required to cover a 7-inch worker on a 48-inch card. (*b*) How many square feet of carding surface are there on a main cylinder 40 inches wide and covered with 24 sheets?

Ans. { (*a*) 58.64 ft.
(*b*) $33\frac{1}{3}$ sq. ft.

(24) Suppose that it is desired on fine work to take 48 ends and 2 waste ends from a 40-inch card; how wide will the top and bottom rings be, allowing 2 inches on each doffer for the waste ends?

(25) (*a*) Is there any difficulty with electricity in card rooms and if so what may be done to relieve it? (*b*) What points should be observed in the management of card rooms? (*c*) What gear can be readily changed on a woolen card to change the production of the card and what effect will it have on the doffer and on the feed-rolls if increased in size?

WOOLEN SPINNING

EXAMINATION QUESTIONS

(1) What two actions on a woolen mule, when in combination, aid in imparting to the thread its distinctively woolen formation?

(2) What is the object of inclining the spindles of a mule toward the delivery roll, and how does the inclination of the spindles accomplish this result?

(3) A mule is spinning 40 inches of $2\frac{1}{2}$-run roving into 72 inches of yarn; what run is the yarn? Ans. $4\frac{1}{2}$-run

(4) (*a*) Why is a variable speed necessary in drawing out the carriage of the mule? (*b*) How is the motion obtained?

(5) (*a*) If it is desired to spin $3\frac{1}{4}$-run yarn with the mule letting out 44 inches of roving and having a stretch of 72 inches, what should be the size of the roving? (*b*) 40 yards of yarn from a mule weighs 28 grains; what is the run of the yarn?

Ans. { (*a*) 2-run (practically)
{ (*b*) $6\frac{1}{4}$-run

(6) What is taking place when the belt is on the fourth pulley?

(7) With the belt on the fourth pulley, which is loose on the shaft, how is the small bevel gear e_9 that drives the twist motion being driven?

(8) What is the function: (*a*) of the winding faller? (*b*) of the counter, or tension, faller?

(9) What is meant by a double rim band?

(10) The main shaft of a mule is driven 320 revolutions per minute; the grooved pulleys on the main shaft are 17 and 21 inches in diameter; the grooved pulley on the center shaft of the carriage is 10 inches; the spindle-band drum is $6\frac{1}{4}$ inches in diameter; the whorl is 1 inch in diameter. (*a*) Find the speed of the spindles while the carriage is coming out. (Subtract 5 per cent.) (*b*) Find the accelerated speed of the spindles. (Subtract 5 per cent.)

Ans. { (*a*) 3,230 rev. per min.
(*b*) 3,990 rev. per min.

(11) Explain, fully, the object of the easing-up motion.

(12) State the use of squaring bands.

(13) What is the object of the backing-off motion?

(14) Is the direction of the rim band reversed during the backing off of the spindles? If so, how is it accomplished?

(15) (*a*) Explain the action of the quadrant during the formation of the base of the bobbin. (*b*) How is the position of the quadrant-chain pulley automatically regulated?

(16) How may the hardness of the bobbin be changed?

(17) (*a*) What effect does the check-band have at the end of the inward run of the carriage? (*b*) If the carriage bangs in too hard, how can the difficulty be remedied?

(18) How is the belt lever shipped from the fourth to the second pulley?

(19) If while the mule is in operation the sliding rod on the front of the carriage is moved to the right of the spinner, what will take place?

(20) Describe the movement of the winding faller while the carriage is running in.

(21) How is the quadrant chain rewound on the drum after being pulled off in winding the yarn on the spindles?

(22) What would happen if, through any cause, the quadrant-chain pulley should fail to be raised while the cone of the bobbin was being built?

(23) (*a*) How should the speed of the carriage be altered if, after spinning short stock, a batch of longer-fibered stock were to be spun? (*b*) How may the above change be accomplished?

(24) State two methods of altering the size of the bobbins being spun on the mule, and state how each method will affect the size.

(25) What would you consider the cause of the ends breaking down badly close to the delivery rolls?

(26) What stops the carriage at the end of its outward motion?

(27) What would be the effect on the bobbin if the ratchet p_{19}, Fig. 24, should become fast so that it would not turn on its axis?

(28) What is the object: (*a*) of the screw r_{11}, Fig. 26 (*a*)? (*b*) of the lever w_8, Fig. 32?

(29) Is there any better way of holding the bobbins on the spindle than by packing the spindles with yarn? If so, explain it.

(30) What method would you employ in taking care of the waste in a spinning room?

WOOLEN AND WORSTED WARP PREPARATION

(PART 1)

EXAMINATION QUESTIONS

(1) What four operations are necessary in preparing a warp?

(2) Explain, fully, why all the threads of a warp should have the same tension.

(3) What is the object of a spooler?

(4) How many yards are spooled while the dial gear of a spooler moves 17 teeth? Ans. 510 yd.

(5) What is the reason for giving the guide bar *f*, Fig. 7 (*a*), a reciprocating movement?

(6) What is the object of the tension rolls on the spooler shown in Fig. 1?

(7) What is the usual number of threads wound on a spool?

(8) How is motion imparted to the spool in a spooler of the usual construction?

(9) Explain how the mechanism shown in Fig. 5 stops the spooler when a thread breaks or runs out.

(10) What advantages does the compressing spooler have over a spooler of the ordinary type?

(11) Describe the principle of the compressing spooler.

(12) What is the object of having the block d_1, Fig. 8, movable on the screw?

(13) Describe the stop-motion on the compressing spooler.

(14) What length of yarn is required to make the traverse (*a*) on the compressing spooler? (*b*) on the ordinary spooler?

(15) What would happen if a thread was placed in the wrong groove of the compressing roll?

(16) Why is it unnecessary to run extra ends on each side if only a few ends are to be spooled on a compressing spooler?

(17) Describe the slow-motion arrangement.

(18) What is the weight of the yarn on a spool containing 40 ends, if 2,400 yards has been spooled, the yarn being 2/40s worsted? Ans. $8\frac{4}{7}$ lb.

(19) A spool of woolen yarn contains 40 ends 960 yards long. The spool and yarn together weigh $10\frac{1}{2}$ pounds, the known weight of the spool being $2\frac{1}{2}$ pounds. What run is the yarn? Ans. 3-run

(20) A spooler tender spooling 4-run yarn, 40 ends on a spool, is paid $\frac{3}{4}$ cent per pound. If an average of 2,400 yards per hour is spooled, how much will the tender earn in a week of 58 hours? Ans. $6.53

WOOLEN AND WORSTED WARP PREPARATION

(PART 2)

EXAMINATION QUESTIONS

(1) Name three types of dressers employing different arrangements for drying the yarn, and state the essential features of difference.

(2) Describe the link measuring motion on a dressing frame.

(3) (*a*) Give a good size for a woolen yarn. (*b*) How is the size applied to the yarn?

(4) (*a*) State two methods of heating the size in a woolen dresser. (*b*) Is size always applied on woolen warps? (*c*) Why is it necessary in some warps?

(5) How many pounds steam pressure is suitable for a dresser?

(6) What is the object of using skeleton rolls on a dresser?

(7) How many yards pass over the measuring roll of the dresser to one revolution of the clock gear?

(8) (*a*) Explain the object of the lease reed and state how it is constructed. (*b*) How is a lease taken with the lease reed?

(9) Describe the passage of the yarn through the dresser shown in Fig. 2.

(10) Why does not the copper cylinder of the dresser collapse when the steam is turned off and a vacuum formed by condensation?

(11) Describe a sectional warp reel, and state how it is driven.

(12) What alteration is necessary to the warp reel before beaming the warp?

(13) Describe the principle of the pinless warp reel.

(14) Describe a beamer.

(15) What advantages are obtained by compressing warps?

(16) Give a brief description of a warp compressor.

(17) Describe, briefly, the operation of drawing in and reeding a warp.

(18) A plain white warp is to be made and there are ten spools of 40 ends each in the creel. State how many ends there will be in a section and how they will be tied in.

(19) Give a detailed description of how you would pick the following pattern:

WARP PATTERN

Olive .	20		20									10		10						60
White .		2		2				2					5		5		2		2	20
Red . .					30		30		30		30									120
Black .						10				10						10		10		40
Total number of ends in pattern																				240

(20) A warp is to be made with the pattern given in question 19; it is to contain 2,880 ends plus 24 ends on each side for selvage, and is to be beamed 61 inches wide and

will be 120 yards in length. The condensing reed contains 12 dents per inch. Give full particulars for dressing the warp, including the number of spools of each color required for the creel, the number of sections, the patterns in a section, the length of yarn on each spool, the width of a section, the ends per dent in the condensing reed, the method of running the selvages, etc.

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