wide the space for the waste end rings is $60 - 56\frac{1}{4} = 3\frac{3}{4}$ inches, which allows each waste end ring to be $3\frac{3}{4} \div 2 = 1\frac{7}{8}$ inches wide.

**42. Use of Gauge Stick.**—When the gauge is made for the right number of rings equally spaced, the doffer should be fastened with collars so that it will have no lateral motion, or play, and the gauge should be 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.

**43. Dividing Leathers.**—Strips of leather, as free from grease and dirt as possible, are prepared as wide as the space between the leather parts of the rings and glued or tacked in with the ends butting together. Fillet 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 machine is in operation.

**44. Dividing Rings With Yarn Instead of Leather.**—Another method that may be used for securing the rings 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 backwards and forwards 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.

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### CARDING SURFACE

**45. Number of Sheets.**—The number of sheets required to cover any roller with sheet clothing may be found by means of the following rule:

**Rule.**—*Multiply the diameter of the roller, in inches, by 3·1416 and divide the product by $5\frac{1}{2}$, which represents, in inches, the width of the sheet plus the space between the wire of one sheet and the wire of the next sheet.*

Sheets are made of such a size as to fit the roller for which they are measured and are made as nearly as possible 5 inches wide. It is evident that every time a roller is trued up, the diameter becomes less and so needs a narrower sheet. The last sheet is the one usually made narrower, this being done by plucking out the wire teeth for a sufficient distance; then, by cutting off the superfluous leather, any desired width of sheet can be obtained. About $\frac{1}{2}$ inch is always allowed between the wire of one sheet and the wire of the next sheet for nailing purposes.

EXAMPLE.—Find the number of sheets that would be required to cover a doffer 40 inches in diameter.

SOLUTION.—Applying the rule,

$$\frac{40 \times 3\cdot1416}{5\frac{1}{2}} = 22\cdot84, \text{ or, practically, 23 sheets. Ans.}$$

In this case 22 sheets might be used, each slightly more than 5 in. wide, or 22 sheets and the required part of a sheet.

**46. Square Feet of Carding Surface for Sheets.**—To find the approximate number of square feet of carding surface on any roller covered with sheet clothing, the following rule may be used:

**Rule.**—*Multiply the length of the sheet by the width, in inches, and by the total number of sheets on the roller, and divide the product by 144; the quotient will be the number of square feet of carding surface.*

EXAMPLE.—How many square feet of carding surface has a cylinder that is 66 inches wide and is covered with twenty-eight 5-inch sheets?

SOLUTION.—Applying the rule, the area of carding surface is

$$\frac{66 \times 5 \times 28}{144} = 64{\cdot}17 \text{ sq. ft. Ans.}$$

**47.** The average thickness of card clothing may be taken as $\frac{1}{2}$ inch; consequently the diameter of the roller, measured over the points of the teeth, is 1 inch greater than the diameter of the bare roller. Hence, to find the exact area of carding surface on a roller covered with sheet clothing, the following rule may be used:

**Rule.**—*Add 1 inch to the diameter of the roller, in inches, multiply the sum by 3·1416, and from the product subtract $\frac{1}{2}$ times the number of spaces on the roller; multiply the remainder by the width of the roller, in inches, and divide the product by 144; the quotient will be the number of square feet of carding surface.*

However, in the case of a fancy, the teeth are much longer than for other rollers, and so it is customary to add 2 inches, instead of 1 inch, to the diameter of the bare roller, in finding the carding surface. In the case of feed-rollers, only $\frac{1}{2}$ inch is usually added.

EXAMPLE.—Find the exact area of carding surface on a cylinder 50 inches in diameter and 66 inches wide, covered with 28 sheets.

SOLUTION.—As there are 28 sheets, there must be 28 spaces also; therefore, applying the rule, the exact area of carding surface is

$$\frac{[(50 + 1) \times 3{\cdot}1416 - (\frac{1}{2} \times 28)] \times 66}{144} = \frac{(160{\cdot}22 - 14) \times 66}{144}$$
$$= 67{\cdot}02 \text{ sq. ft. Ans.}$$

**48. Square Feet of Carding Surface for Fillet.**—To find the number of square feet of carding surface on a cylinder or roller covered with fillet the following rule may be employed:

**Rule.**—*Add 1 inch to the diameter of the roller, in inches, multiply the sum by 3·1416 and by its width, in inches, and divide the product thus obtained by 144.*

EXAMPLE.—How many square feet of carding surface is there on a 6-inch angle stripper, the scribbler being 66 inches wide?

SOLUTION.—Applying the rule,

$$\frac{(6 + 1) \times 3{\cdot}1416 \times 66}{144} = 10{\cdot}08 \text{ sq. ft. Ans.}$$

**49. Increase of Carding Surface.**—The amount of carding surface obtainable in a set of machines has been steadily increased in recent years. This has been effected partly by increasing the width of the machines from 48 inches up to 60 and 72 inches, few machines now being made less than 66 or 72 inches wide. Then, also, the diameters of the rollers have been increased from 48 inches to 52 and 54 inches in the case of cylinders, from 30 and 32 inches to as much as 40 inches in doffers, and from 7 inches to 9 and 10 inches in workers. The increased area of the carding surface is a decided advantage when carding blends

**TABLE IV**

**DIMENSIONS OF SCRIBBLER**

| Name of Roller | Number of Rollers | Diameter of Roller Inches | Width of Roller Inches | Clothing | Carding Surface | |
|---|---|---|---|---|---|---|
| | | | | | Area of Each Roller Square Feet | Total Area Square Feet |
| Cylinder . . | 3 | 50 | 66 | Sheets | 67·02 | 201·06 |
| Doffer . . . | 3 | 36 | 66 | Sheets | 48·69 | 146·07 |
| Fancy . . . | 3 | 13 | 66 | Sheets | 19·99 | 59·97 |
| Worker . . | 12 | 9 | 66 | Sheets | 13·25 | 159·00 |
| Stripper . . | 12 | $4\frac{1}{2}$ | 66 | Fillet | 7·92 | 95·04 |
| Licker-in . . | 1 | 12 | 66 | Fillet | 18·72 | 18·72 |
| Feed-roller . | 3 | $2\frac{1}{2}$ | 66 | Fillet | 4·32 | 12·96 |
| Angle stripper | 3 | 6 | 66 | Fillet | 10·08 | 30·24 |

of shoddy, mungo, or any dirty material, for with smaller rollers it would be found very difficult, if not impossible, to run for a full day without having to dress or fettle the machines, that is, without having to clean the rollers of all dirt, etc. The smaller carding surface would not be able to carry the dirt. This will be fully realized when it is noted that from 24 to 60 pounds of black dirt or grease may be removed from a set of carding machines at one fettling or dressing. The chief advantage to be gained by increasing the diameters of the rollers, however, lies in the fact that the working capacity of the working rollers is increased, and, consequently, a larger production is obtained. By increasing the diameters of the rollers, and thus the carding surface also, the material is brought in working contact with a greater amount of working surface. This is an advantage that cannot be too strongly emphasized, since modern condensers are so made as to condense efficiently as much material as can be supplied to them.

**50. Dimensions of Rollers.**—The dimensions of the rollers and the number of square feet of carding surface for a set of machines are given in Tables IV and V, the first of which is for a scribbler 66 inches wide and the second for a carder 60 inches wide. The calculations of the amount of carding surface of those rollers on which sheets have been used are based on the rule

**TABLE V**

DIMENSIONS OF CARDER

| Name of Roller | Number of Rollers | Diameter of Roller Inches | Width of Roller Inches | Clothing | Carding Surface | |
|---|---|---|---|---|---|---|
| | | | | | Area of Each Roller Square Feet | Total Area Square Feet |
| Cylinder . . | 2 | 50 | 60 | Sheets | 60·93 | 121·86 |
| Doffer . . . | 2 | 36 | 60 | Sheets | 44·27 | 88·54 |
| Fancy . . . | 2 | 13 | 60 | Sheets | 18·18 | 36·36 |
| Worker . . | 8 | 9 | 60 | Sheets | 12·05 | 96·40 |
| Stripper . . | 8 | $4\frac{1}{2}$ | 60 | Fillet | 7·20 | 57·60 |
| Licker-in . . | 1 | 12 | 60 | Fillet | 17·02 | 17·02 |
| Feed-roller . | 3 | $2\frac{1}{2}$ | 60 | Fillet | 3·93 | 11·79 |
| Angle stripper | 2 | 6 | 60 | Fillet | 9·16 | 18·32 |
| Condenser stripper . | 1 | $3\frac{1}{2}$ | 60 | Fillet | 5·89 | 5·89 |

given in Art. **47**, and on the assumption that 28 sheets have been used for each main cylinder or swift, 20 for each doffer, 7 for each fancy, and 5 for each worker.

The total carding surface of the scribbler is 723·06 square feet and that of the carder is 453·78 square feet ; consequently, the total carding surface of the set of machines is 723·06 + 453·78 = 1,176·84 square feet.

# CARE OF CARDING MACHINES

## GRINDING

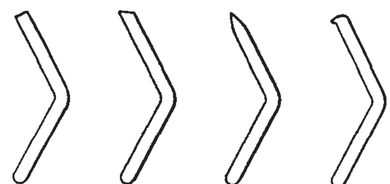
### IMPORTANT CONSIDERATIONS

**51. Evils of Overgrinding.**—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 occasionally the rollers of a carding machine need grinding to replace the points of the teeth that have become worn or dull by abrasion or accident. Carding machines are usually ground too often where hardened and tempered wire is used; more frequent grinding is necessary on machines covered with mild-steel wire, which is soft. Some carding engineers never grind the rollers, except in case of accident, after the first grinding, when the clothing is new.

In some districts of Europe it is customary to grind the rollers 2 or 3 times a month. This is wrong, for if the rollers are properly set and cared for, there should be no necessity for grinding oftener than once in 12 months, and many times a machine will run 2 or 3 years, or even longer, without being ground. More card clothing is spoiled by grinding than work is spoiled by dull points on the roller. Further, a greater amount of card clothing is actually worn away by grinding than is used in the necessary carding or working of the material. In some cases the temper of the wire is destroyed; for if the rollers are set hard against the grinding roller for too long a time they become heated, and if this becomes excessive the temper of the wire is destroyed.

**52. Chisel and Needle Points.**—Two kinds of points can be obtained by grinding. The **chisel point** is produced as shown in

Fig. 16, in which (*a*) gives the appearance of the end of the wire as it is cut off when the clothing is made, and (*b*) illustrates the chisel point produced by grinding. This kind of point is formed by a roller emery grinder that has no traverse and that grinds down the top of the tooth to a flat, or chisel, edge. What is known as the **needle point,** Fig. 16 (*c*), is formed by a traverse grinder that grinds the teeth on each side as well as on the top. The grinding at the sides is accomplished by covering the grinding wheel with coarse emery, or emery fillet; in many cases a type of grooved emery fillet is used with a view to obtaining the desired result more quickly and more satisfactorily. It may be mentioned that new clothing is generally delivered by the makers ready ground.



(*a*) (*b*) (*c*) (*d*)

Fig. 16

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. Before the manufacture of card clothing had reached its present state of perfection it was necessary to grind on the face side or against the point of the wire, so as to ensure perfect evenness of length of all the teeth. This is a delicate and risky operation and is no longer necessary, all grinding at the present time being on the back of the tooth, in a direction from the knee toward the point.

**53. Condition of Point.**—While it is important that the clothing shall be sharp, it is also important that the point shall be smooth, since any roughness of the tooth is liable to cause it to catch and break the fibres. One of the worst things that can happen to clothing is the formation of a **hook,** or **burr, point,** as shown in Fig. 16 (*d*). This sometimes happens when the grinding is continued too long or when the grinding roller 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 roller of the machine to another and the fancy also lifts the material 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. A point formed by grinding is always more or less rough, since the grinding agent, which usually is emery, is of a fine granular nature, and so leaves a roughness on the point of the wire. The point thus formed, although it may be sharp, is not in condition ; that is, it lacks the smoothness and sharpness acquired by a point in working.

**54. Care of Main Cylinder.**—The different rollers of a machine need varying degrees of attention in regard to grinding ; some rollers need to be sharper and in better condition than others, which may require only smoothness to perform their functions. The main cylinder or cylinders of a machine, 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 rubbing 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 material instead of allowing it to be transferred to those rollers.

**55. Care of Fancy.**—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 material from the main cylinder, thus making an increased percentage of waste in the form of *flyings*, also termed fly. Great care should be taken in grinding the fancy, and the grinding roller 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 machine and set into the main cylinder about $\frac{1}{8}$ inch. After being allowed to run into the cylinder in this manner for about 1 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.

**56. Sharpening Action of Fancy and Cylinder.**—The fancy and the cylinder keep each other sharp and in good working condition because the fancy wire runs knee or back first through the wire of the cylinder. This is the ideal method, because, as the fancy is revolving at a greater surface speed than the cylinder, its wire rubs through the wire of the cylinder from the knee toward the point, and not, as in the case of strippers, relative to the worker, from the point toward the knee where the stripper keeps the worker wire in good condition by reason of its excess of speed, but in so doing it gradually blunts, or loses, its own point. Some fancy clothing, being made with a straight tooth with no bend at the knee, requires special care in grinding in order that the teeth will not be bent or injured.

**57. Care of Workers.**—Workers must be kept sharp and true in order to card and open the wool, and also in order to take the material from the main cylinder. The worker should always have a sharper point than the cylinder for this reason. It is customary to set the strippers into the workers until a faint whizzing sound is heard. This action blunts the point of the stripper; but if the stripper is properly set, its point is made smooth and the worker develops a fine carding or working point, while, if the setting is overdone, the points of the stripper wire are turned up or develop what is known as a point or lip behind. When such a point is formed, the strippers, instead of stripping or straightening the material, cause it to roll, while the teeth on the workers are loosened in the foundation. When grinding workers, care should be taken to avoid forming a burr on the wire, the tendency being to overgrind the roller while endeavouring to obtain as sharp a point as possible.

**58. Care of Strippers and Doffer.**—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 $4\frac{1}{2}$ inches in diameter, and owing to this comparatively small diameter, the teeth are spread apart more by being projected from a surface bent round so small a circle. This makes it necessary to exercise some care in grinding, or the teeth will be bent out of shape.

The doffer is one of the most important parts of a carding machine and should always be kept sharp and in good condition. This is done by setting the angle stripper into the doffer in a manner exactly like that practised in obtaining and keeping a satisfactory working point on the worker. Point is kept on the last scribbler doffer by the dicky stripper, and on the ring doffer or doffers by the condenser stripper or strippers. The points on the ring doffer should always be smooth and sharp, and the nearer the ring doffer 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.

**59. Advantages of Keeping Point by Setting.**—The time saved by setting the rollers to keep point is quite considerable, for there are from seventy to one hundred rollers in a set of machines, which otherwise would have to be ground frequently ; further, the life of the card clothing is much more than doubled, as the wire is not ground to waste. Seeing that the rollers which are set into each other revolve at rapid rates, it might be thought that the friction would heat the wire, but the oil in the material which is being carded obviates any tendency in this direction. Before grinding, the carding machine 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 GRINDING

**60. Simultaneous Grinding of Cylinder and Doffer.**—The main cylinder and doffer may be ground at the same time, and without being removed from the machine, by means of a **traverse grinder**

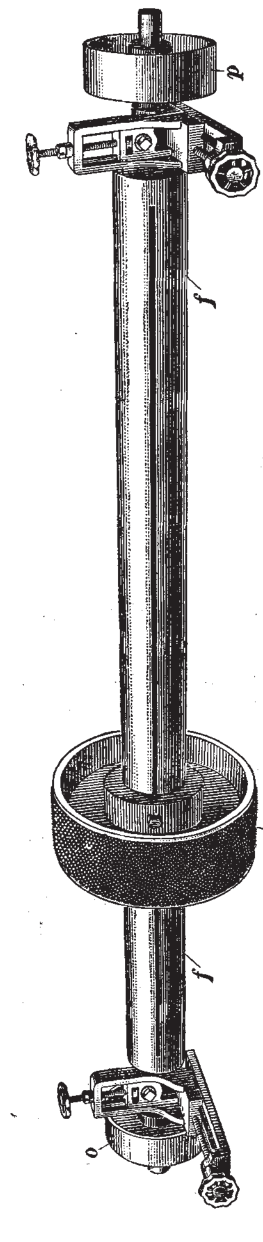



Fig. 17

similar to that shown in Figs. 17 and 18, the former of which is a perspective view and the latter a section, the same reference letters being used in both views to designate the same parts. Fig. 18 shows that the grinder 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 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 shaft *j* that passes through a sleeve formed in one piece with the head of the shell. Attached to this shaft is a bevel gear-wheel *e* that drives a wheel *d* driving another wheel to which is attached the sprocket wheel *c* round which the chain passes. At the other end of the shell is a flanged tension pulley *r* round 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 motion is imparted to the grinding wheel by the pulley *o* attached to a shaft forged solid with the other head of the shell. This pulley rotates the shell; and as the **T** piece projects through the slot, the motion is also imparted to the grinding wheel. A steel plate *l* guides the chain.

**61. Emery as Grinding Medium.**—The grinding wheel is an iron pulley covered with twine and afterwards having coarse emery glued upon it. Special *emery fillet* is now generally used for covering grinding wheels and rollers. This has been adopted after much experiment, experience having shown it to be the most suitable material. **Emery** is extremely hard and is black or greyish in colour. If examined under a fairly powerful microscope it will be seen to have an irregular granular structure, the grains having small needle-like points which give to the material its grinding powers. When the emery has been in use for a considerable time these points become worn, and the emery must be replaced, for its action is then one of polishing rather than grinding. The best kind of emery is that which is most

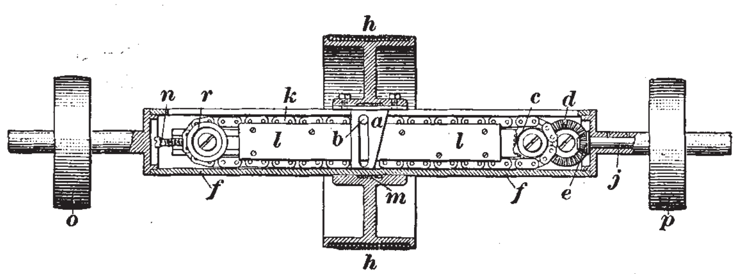



FIG. 18

angular in form. **Corundum**, which belongs to the same class of mineral as emery and is similar to it in appearance, is sometimes used, but is not so successful as emery, which is tougher and more durable.

The covering of emery rollers should not be attempted in the mill unless emery fillet is employed, as the work must be perfect and the roller true ; otherwise, the grinding will be imperfect. The emery should always be coarse, so as to allow the particles to project into the clothing and to grind the sides of the teeth as well as the top. To obtain this result more quickly and satisfactorily grooved fillet has been introduced, which is usually made with either eight or sixteen grooves to the inch. The fillet used in covering emery wheels is usually 1 inch wide and for covering emery rollers is $1\frac{1}{2}$ inches wide.

**62. Grinding Wheels.**—**Grinding wheels** are usually about 4 inches across the face and 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*, Fig. 18, is cut round the inside of its hub and a felt washer inserted ; and this, being saturated with oil, lubricates the shell as the grinding wheel slides backwards and forwards. The lubricated washer also prevents dust from accumulating on the tube or entering the boss of the emery wheel, and thus obviates any risk of stoppage of the emery wheel in its traverse. 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.

**63. Speed of Grinding Wheel.**—The speed at which grinders are driven varies considerably with different carding engineers, but Table VI gives the average speed of the grinding wheel and the number of times that it traverses across the machine per minute. The table includes different widths of machines.

TABLE VI

SPEED AND TRAVERSE OF GRINDING WHEEL

| Traverse of Wheel Inches | Revolutions Per Minute of Wheel | Number of Traverses Per Minute |
|---|---|---|
| 36 | 375 | 15 |
| 40 | 365 | 14 |
| 48 | 340 | 12 |
| 60 | 300 | 10 |
| 72 | 275 | 8 |

**64. Adjusting Device.** After a traverse grinder has been used for some time, the grinding wheel and the shell wear so that the grinding wheel becomes 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 bush with a chamber for the felt oiler is inserted in the tapered hole in the grinding wheel ; a collar is then screwed on each side of the hub of the wheel up to the bush. By loosening the collar at the small end of the bush and tightening the one at the large end, the bush is pressed into the hub of the wheel and, being split and tapered, is contracted round the shell until a proper fit is obtained.

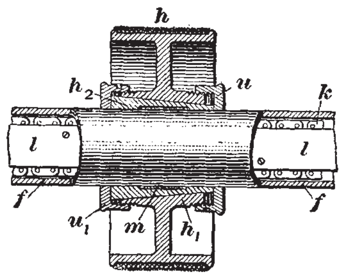


FIG. 19

This device is not shown in Fig. 18, being placed only on the latest models, but it is shown in Fig. 19, in which $h_1$ is the hub of the grinding wheel, which is bored tapered, while $h_2$ is the tapered bush that fits into $h_1$ and is held in position and adjusted by means of the threaded collars $u$, $u_1$. Tightening the grinding wheel, thus giving less play on the shell, is accomplished by loosening the collar $u$ and tightening $u_1$; loosening $u_1$ and tightening $u$ has the opposite effect.

**65. Reciprocating Screw.**—Many grinders, instead of using 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 grooves that are joined at each end. In the groove fits a fork, or traveller, 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 groove or thread to the other and reverses the traversing motion of the grinding wheel at each end.

**66. Differential-Motion Traverse Grinder.**—A differential-motion traverse grinder that is largely used is illustrated in Fig. 20, which shows all the parts in position. The driving pulley *a* gives a rotary motion to the steel tube *b* and also to the grinding wheel *c*. The traverse motion is obtained by means of the differential gearing shown encased at *d*. The differential motion causes the reciprocating screw shaft *e* to revolve at a speed slightly less than that of the tube, so as to give the requisite traverse to the grinding wheel, and in this way obtain a more satisfactory result.

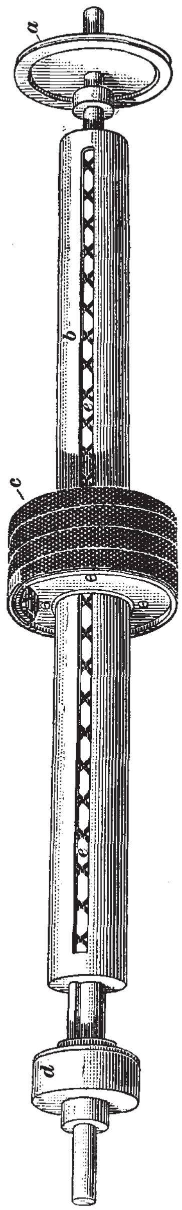
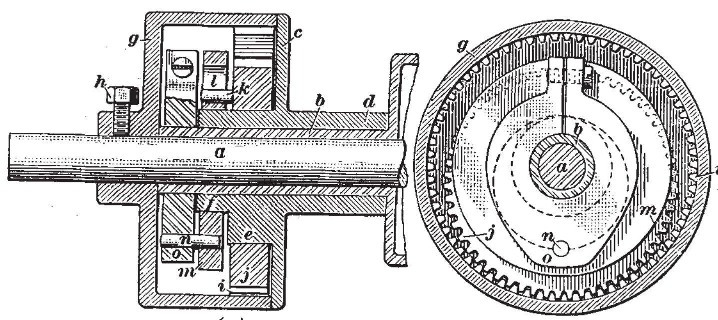


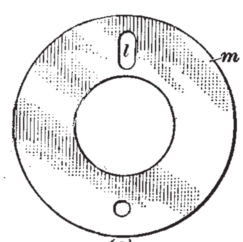

Fig. 20

**67. Construction of Traverse Grinder.**—A longitudinal section through the differential gearing *d*, Fig. 20, is shown in Fig. 21 (*a*) and a sectional elevation is shown in (*b*). The shaft *a* is the screw shaft, which is driven through the differential gearing by the sleeve *b*, the latter being a prolongation of the steel tube. A flanged collar *c* is slipped over the sleeve and carries at one end a projection *d* that fits into a bracket on the machine, thus preventing the collar from turning. The collar is formed with two bosses *e* and *f*, the former being eccentric to the shaft *a* and the latter concentric with it. A casing *g* is secured to the shaft by a setscrew *h*, so that the two must rotate together, and on the inner face of this casing gear-teeth are cut, as at *i*, thus forming an annular gear-wheel. The teeth of this annular wheel mesh with those of the wheel *j* that rotates on the boss *e*. The wheel *j* carries a pin *k* that fits in a radial slot *l* in the disc or plate *m*, a front elevation of which is given in Fig. 21 (*c*), and which turns on the boss *f*. A split collar or driver *o*, which is fitted on the sleeve and grips it tightly, carries a pin *n* that enters a corresponding hole in the plate *m*. As the sleeve *b* rotates, the split collar *o* turns, causing the plate *m* to turn at the same speed. The plate *m*, through the pin *k*, rotates the wheel *j*, which in turn transmits motion to the larger annular wheel or casing *g* and thus causes the screw shaft to turn. Since the wheel *j* has fewer teeth than the annular wheel, the latter will turn more slowly than the former; consequently, the shaft *a* will turn at a speed somewhat slower than that of the driving sleeve *b*. Changing the wheel *j* and the annular wheel alters the rate of traverse.

**68. Operation of Traverse Grinder.**—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. 17, 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 roller 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.




(a) (b)




(c)

Fig. 21

When grinding the main cylinder and the doffer at the same time, one method is to reverse the direction of rotation of the main cylinder in order to grind against the backs of the teeth. When the scribbler or carder is driven with an open belt, the direction of rotation of the main cylinder or cylinders may be reversed by crossing the belt, but if they are driven by a crossed 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 machines while grinding. 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.

**69. Driving Traverse Grinder.**—The grinder may be driven from pulleys fastened to the third stripper shaft. 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. If a grinder similar to that shown in Fig. 20 is used, only one pulley for driving will be required. The stripper may be driven from a belt directly from the flange on the main cylinder. Before placing the grinder in position, 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 evenly.

**70. Importance of Careful Grinding.**—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 point will be formed. It is better to set the grinder light at first, and after the grinding has been going on for an hour to set it down a little heavier. The grinding of the cylinder and doffer usually takes from 8 to 16 hours. The wire is tested at intervals to see whether 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 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. When the rollers are properly ground they have a deep blue-black appearance, while a partly ground roller is lighter in colour. Usually the workers and smaller rollers are being ground on the grinding frame while the main cylinders and doffers are being ground in position.

**71. Facing.**—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 roller covered with straight clothing set loosely in the foundation. This roller 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 running of the grinding roller against the points of the clothing 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 roller in this manner.

**72. Length of Traverse.**—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 grinding the clothing at the ends of the cylinders more than in the centre, 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.

**73. Traverse Grinding Frame.**—The workers, strippers, fancies, and lickers-in are not ground in their positions, as are the main cylinder and doffer, but are removed and taken to a machine called a **grinding frame.** This machine, shown in Fig. 22, 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 rollers at one time, one on each side of the grinding wheel, the rollers being placed in **V**-shaped notches *b* 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 rollers being ground to be adjusted to the same. The screws are provided with hand wheels *d* for easily adjusting the rollers and also with check-nuts for locking them when once the rollers have been set. Pulleys, secured by setscrews to the shafts of the rollers 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

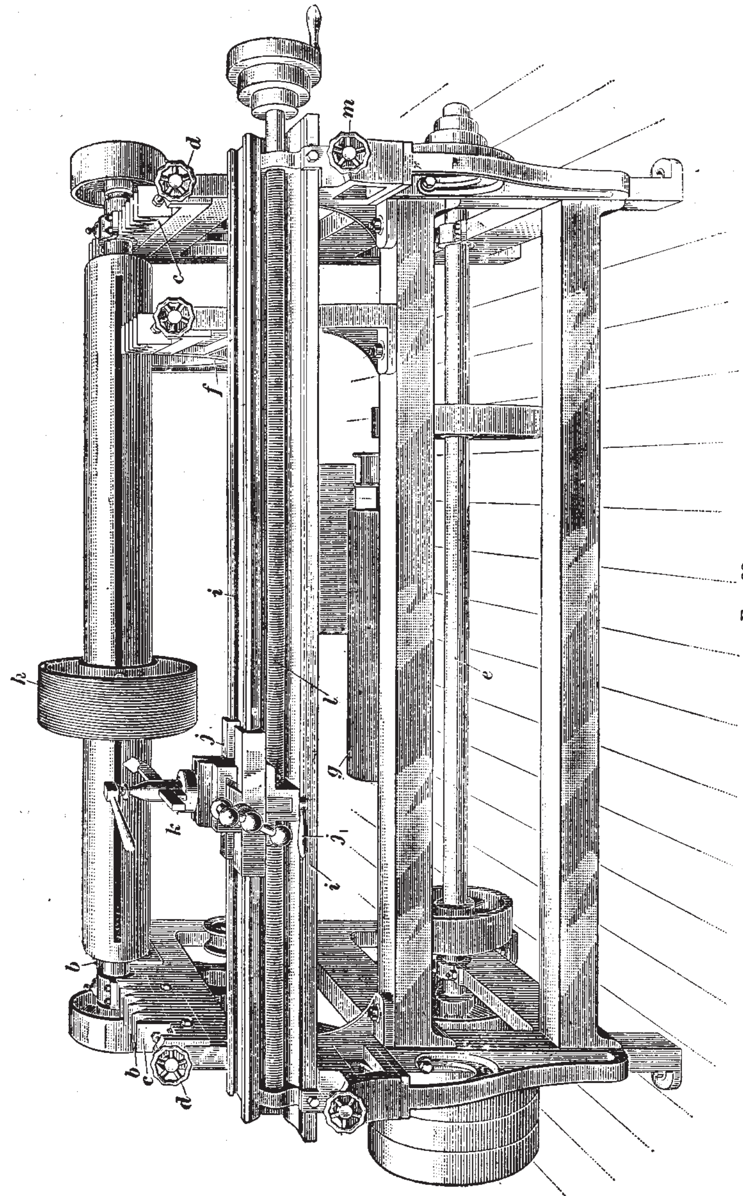



FIG. 22

belts before grinding, care should be taken before the rollers 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 roller.

**74. Grinding Shorter Rollers.**—It will be seen in Fig. 22 that an adjustable stand *f* also carries slides with **V**-shaped notches; this is for the purpose of grinding shorter rollers that do not have shafts long enough to rest in the bearings on each side of the machine. Inside the frame of the grinder there is a small emery-covered roller *g* for grinding hand cards; this is driven from the main or bottom shaft.

The grinding of the smaller rollers takes from 2 to 4 hours. Great care should be taken in 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 rollers. The workers should be ground more than any other of the smaller rollers, as they need sharp points for taking the wool from the main cylinder as well as for the actual carding.

**75. Grinding Fancy.**—The fancy, when new, should be ground very carefully, and afterwards no grinding will be necessary, as the friction caused by setting the fancy into the swift keeps it in good condition. Many carding engineers do not in any case grind the fancy to a keen point, claiming that as the fancy does not engage with the material, perfect smoothness is better than sharpness. The point produced on any roller 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 roller. After grinding, it is a good plan to allow the fancy to run into the cylinder for about $\frac{1}{2}$ hour, being set up hard at first and afterwards moved off to its normal position. This will take off any roughness left by the emery. When grinding the lickers-in, perfect smoothness is desired rather than extreme sharpness.

**76. Grinding Metallic Rollers.** — Occasionally the lickers-in, or feed-rollers, need grinding and sometimes the burr rollers of the burring machine are brought to the carding room to be ground. The grinding of these rollers, which are covered with Garnett wire, is a difficult work and should never be attempted until the roller is considerably worn, as at best they can only be improved and not rendered as good as new. Metallic burr rollers 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 rollers the grinding wheel should always revolve against the points of the teeth. This is the opposite way to that in which the rollers covered with card clothing revolve, but it is necessary in order to prevent the metallic wire from becoming hooked. The burr roller should be made to revolve very slowly, not more than 10 revolutions 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 roller. Sometimes a file is fixed in the turning post of the grinder and allowed to bear on the surface of the roller. The roller is then revolved toward the file at the rate of from 250 to 300 revolutions per minute. If burr rollers are worn very badly, they are placed in a lathe and turned down.

77. **Smoothing After Grinding.**—When grinding any metallic roller, great care should be taken not to heat it, which is very apt to be done and may affect the trueness of the roller. Small rollers, like feed-rollers, are very difficult to sharpen and more satisfactory results can be obtained by filing them by hand. Needle-pointed feed-roller fillet cannot be sharpened, but if it is made from tempered-steel wire it retains a good working point as long as the teeth remain firm.

After the roller has been 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 roller rough and the teeth more or less burred, or hooked. One way to smooth a metallic roller 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 roller smooth and in good condition.

### ROLLER GRINDING

**78. Roller-Grinding Frames.**—The grinding frame shown in Fig. 22 contains a narrow traversing grinding wheel, but Figs. 23 and 24 show grinding frames that are known as **roller-grinding frames.** A grinder of the latter type is generally used, as it performs the work in less than half the time that a traverse grinder takes. This will be understood from the fact that with the latter only 4 inches of a cylinder or other roller can be ground at one time. The traverse grinder is therefore used only where the best results must be obtained, as, for instance, in the case of ring doffers, for the grinding of these rollers is most particular and delicate work and better results can be obtained if the last cylinder is ground by a traverse grinder ; otherwise, unless the machines are only narrow, a roller grinder is used.

**79. Construction of Roller Frame.**—The roller-grinding frame shown in Fig. 23 is identical with the traverse-wheel grinding frame with the exception of the wheel, or roller, $h$ for grinding, which extends entirely across the frame, grinding the entire surface of the worker or other roller at once. Rollers can be ground in less time with a roller grinder, but are more liable to be ground in stripes or 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-roller shaft. This consists of a worm on the shaft, which gears with a worm-wheel, both being contained in the casing $h_1$. On the side of the worm-gear is a crankpin that is connected to the stationary bearing of the grinding-roller shaft by means of the rod $h_2$. When the grinding-roller shaft revolves, the worm-wheel is turned, and the crankpin, working against the arm attached to the stationary bearing, moves the whole casing, and also the grinding roller, by means of collars on the shaft. A roller grinder is also made for grinding cylinders and doffers.

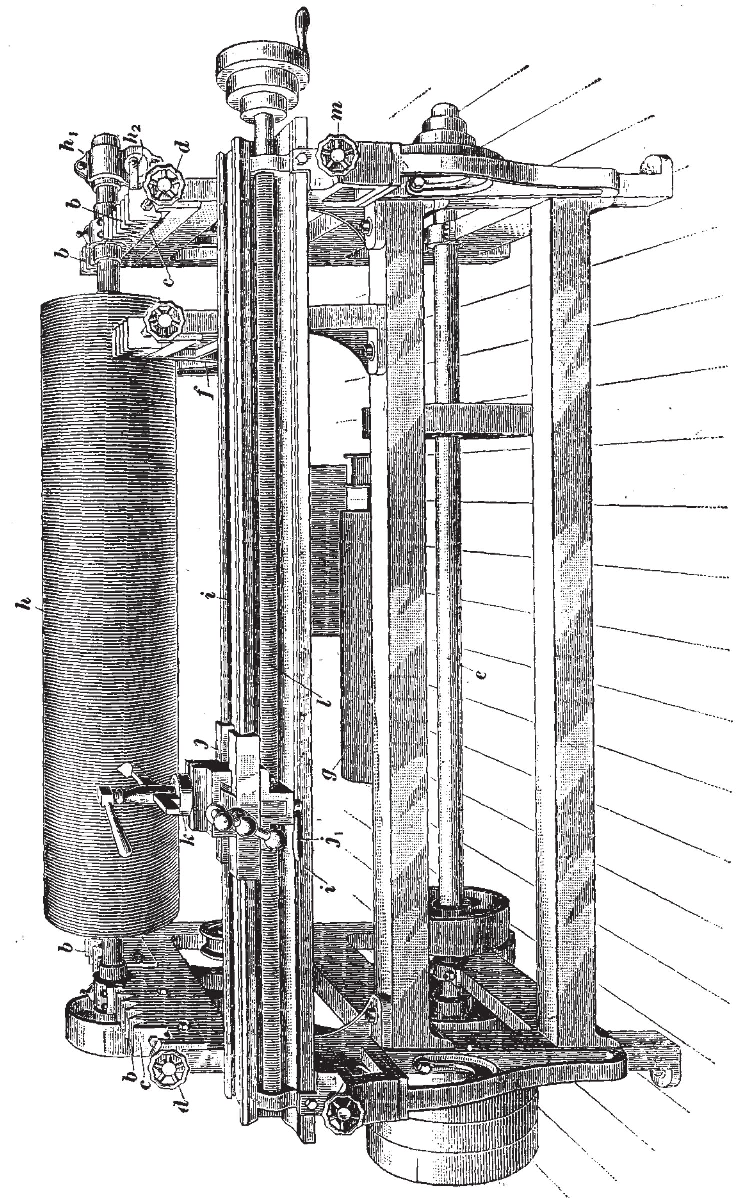



Fig. 23

**80. Grinding Frame Suitable for Large Rollers.**—Another type of grinding frame which is largely used is shown in Fig. 24. Two rollers may be ground at the same time on this machine, as the

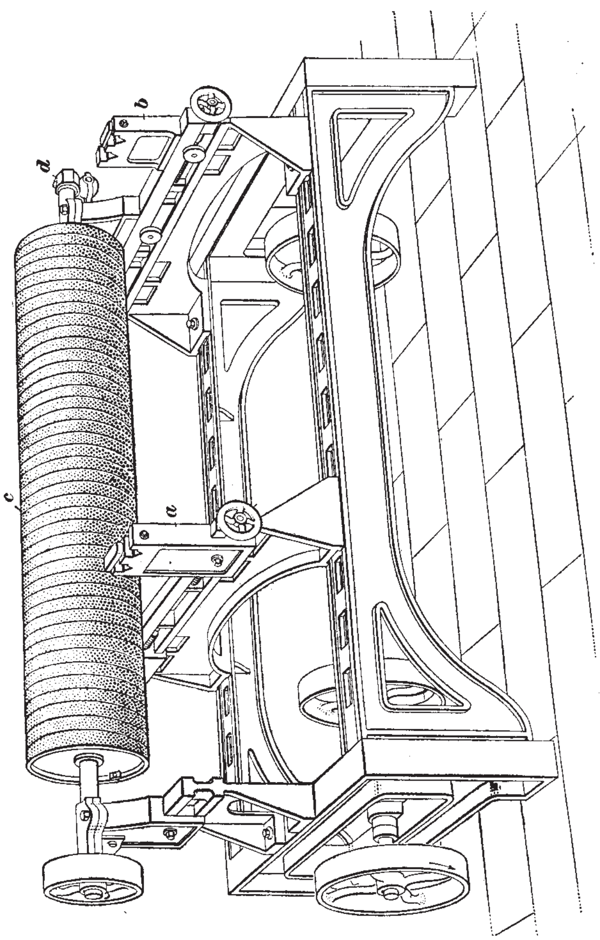



FIG. 24

bearings *a* and *b* that support the roller to be ground are duplicated on the other side of the grinding roller *c*. The bearings rest on the framework, as shown, and are capable of being adjusted so as to grind rollers of varying widths. Rollers of any diameter of from 3 to 30 inches may be ground on this machine. The diameter of the grinding roller varies from 3 to 12 inches, but is usually 8 or 12 inches. A traverse of about 2 inches is given to the grinding roller; therefore, the roller is made about 2 inches longer than the longest roller the machine is capable of grinding. This obviates any tendency to grind in stripes or grooves, as already explained. The traversing motion is shown at *d*, and is similar in principle to that described in connection with Fig. 23.

**81. Driving Roller Frame.**—The action of the grinder will be more clearly understood by referring to the diagram given in Fig. 25, which represents an end elevation of the principal working parts. The grinding roller receives its motion from the pulley *a* on the shaft, as shown, by means of the belt *b*, and revolves in the direction indicated by the arrow. At the other

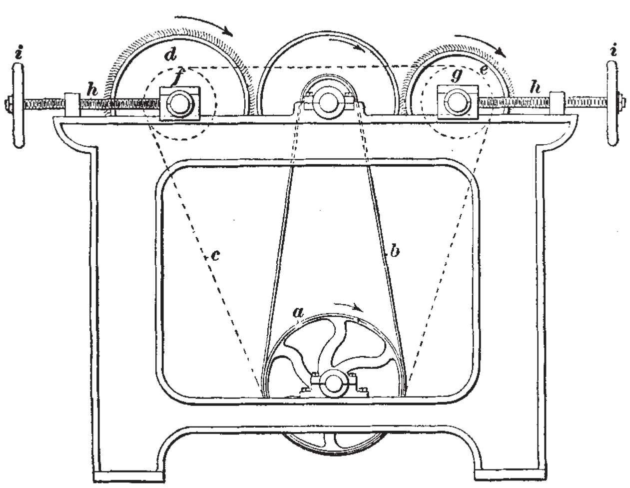



Fig. 25

end of the shaft is another pulley carrying a belt *c* that drives both the rollers *d* and *e* that are being ground, the belt *c* being passed partly round the lower pulley and over both pulleys *f* and *g*, which are placed on the ends of the shafts of the rollers. In many cases a separate belt is used for driving each roller, but whether one belt or two are used, it is absolutely necessary that the rollers being ground be driven in the directions indicated by the arrows, so that in each case grinding will occur on the backs of the teeth.

**82. Setting and Care of Roller Frame.**—The rollers are set to the grinding roller by means of adjusting screws *h*, Fig. 25, which are operated by hand wheels *i*. Care should be taken in setting the rollers to the grinding roller, because if the setting is too close at the commencement of grinding, the pressure is liable to loosen the wires in the foundation and thus render the clothing useless. After grinding has been completed, the grinding roller should not be left in the machine nor be allowed to rest on the floor, but should be stored away in a suitable rack, as it is important that it should always be in good condition. When the emery has been worn unevenly, the roller should be re-covered, so that good and even grinding will be obtained.

**83. Grinding Doffers and Cylinders.**—For grinding the doffers and cylinders, a grinding roller similar to that shown in Fig. 23 is used ; and when grinding has to be done the grinding roller is mounted in the bearings of an ordinary stripper or an angle stripper, according to the method adopted. One common method when grinding the cylinder is to put the grinding roller in the brackets of an ordinary stripper and drive it from the body pulley of the cylinder by means of a belt. To grind the doffer, the grinding roller may be put in the brackets of the angle stripper and driven from the cylinder by a belt, or the course described in Art. **69** may be adopted.

**84. Dicky Stripper.**—As there is no angle stripper to keep point on the last doffer of the scribbler or the intermediate, a special emery roller, or a roller covered with fillet clothing, known as a dicky stripper, is used. This roller revolves in the same direction as an ordinary stripper, but is clothed so that the smooth side or the backs of the teeth are constantly rubbing into the smooth side or backs of the teeth of the doffer, thus keeping the latter clean and sharp. If this were not done the point on the doffer would quickly become blunt.

## MANAGEMENT AND ADJUSTMENTS

### TRUING WOODEN CYLINDERS

**85. Points in Truing Rollers.** — Often when wooden rollers are used in a carding machine it will be found that they are not true when being set or when the roller is being ground. In this case the rollers should not be evened up by grinding the wire, 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 up the roller. This is done on a grinding frame, except in the case of the main cylinder, or large doffer, which is trued by fastening the turning lathe to the frame of the machine, the doffer being removed when truing up the cylinder. After the clothing has been taken off the roller that is to be trued, the roller is placed in the grinding frame. In the case of large rollers, as, for instance, a fancy or a ring doffer, it is sometimes necessary to remove the grinding wheel from the grinding frame in order to make room. In the ordinary course of work truing up is done before the new clothing is applied. The old clothing will have been worn true during operation, if the roller has gradually worked out of truth.

**86. Turning Lathe.**—It will be seen by referring to Figs. 22 and 23 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. The screw is turned either by hand by means of a handle or preferably driven by means of a belt and two stepped pulleys, one on the screw shaft and the other on the bottom shaft $e$ of the grinding frame, as seen at the right of the frame. A small handle $j_1$, under the slide, allows the slide 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.

**87. Adjusting Turning Lathe to Roller.**—The whole turning lathe may be adjusted to the roller that is being trued by means of hand wheels *m*, Figs. 22 and 23, 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 handle that operates the tool post. Care should be taken to have the rest perfectly parallel with the shaft of the roller 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 roller should be on a level with or slightly above the axis of the latter.

**88. Truing Main Cylinder.**—When truing the main cylinder 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 framing of the machine. 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 than to attempt too thick a shaving. Before putting the knife to the cylinder, the latter should be scraped by holding to 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 tacks protruding from the wood, where they will come in contact with and ruin the turning knife.

**89. Traverse of Slide.**—It is better to drive the slide that carries the knife with a belt 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 levelled also ; but otherwise it is a good plan to sight the shaft of the cylinder over the lathe rest.

**90. Smoothing Surface of Cylinder After Truing.**—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 rollers 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 up in the machine shop.

**91. Advantages of Accurate Truing of Rollers.**—Before commencing to cover iron rollers it is good practice to see that they are perfectly true, especially when re-covering has to be done, as wear and tear on the brackets and roller shafts are liable to cause the roller to become slightly untrue. It is also good practice to grind iron rollers so as to ensure a perfectly even surface for the card clothing, because when old clothing has been removed it will be found that the crowns have by their rubbing action made the surface uneven. By grinding the roller, and thus making it perfectly even, the new card clothing will bed better. All wooden plugs should be examined to make sure that they are firm.

## SETTING CARDING MACHINES

**92. Points in Setting Carding Machines.**—The setting of carding machines is the adjustment of one roller to another in order that each may have its proper action on the material as it passes through the machine. The various parts are set according to the work that is being carded and the condition of the material when it comes under their action. If the rollers are set too open, the wool will not be properly carded or opened out; if they are set too close, especially on the scribbler, where the wool is not so well opened as on the other machines of the set, the fibres may be broken or cut and the value of the spinning properties of the wool materially reduced. The setting of the scribbler should be more open than that of the intermediate and carder, and the first part of the scribbler should be more open than the last, for it receives the material in almost its natural condition and has to perform the first opening of the material. As it is constantly being opened, the carder may be set closer than the scribbler and intermediate.

**93. Setting Gauges.**—Formerly it was customary to set carding machines by the eye and ear alone, but owing to the fact that the light struck at varying angles on the card clothing, the settings were never really accurate. The setting is now accomplished by means of **gauges,** as shown in Fig. 26. These are flat strips of tempered steel about $1\frac{1}{4}$ to $1\frac{1}{2}$ inches wide and from 8 inches to 12 inches long, and resemble a 2-foot rule in appearance, except that instead of there being only two wings or sections, as in a 2-foot rule, there are usually five. These wings vary in thickness according to a given standard. Each blade, plate, or wing should be carefully ground and accurately finished, 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. 26 gauge is the same as the diameter of a No. 26 wire, which, according to Table I, is ·018 inch in both the standard gauge and the Birmingham gauge. A very useful set of gauges for a five-wing gauge might include Nos. 20, 24, 28, 32, and 36.

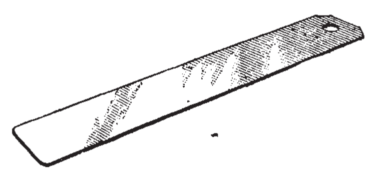


Fig. 26

**94. Damaged Gauges.**—Although the most exact settings are obtained by means of setting 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. 27 (*a*), they become shaped as shown in (*b*) and (*c*), and consequently touch at points *d*, *e*, and *f* in (*b*), and *g*, *h*, *j*, and *k* in (*c*).

While the thinner gauges, if bent in the shapes shown in (*b*) and (*c*), will straighten somewhat when introduced between the rollers of the machine 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 (*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 carding machine 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-rollers or burr rollers.

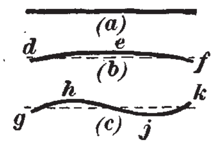


Fig. 27

**95. Points Where Adjustment of Rollers is Made.**—The points at which the rollers of the woollen-carding machine need to be adjusted, or set, are the following: Between the feed-rollers; between the licker-in and the feed-rollers; between the licker-in and the angle stripper; between the angle stripper and the main cylinder; between the main cylinder and the strippers; between the main cylinder and the workers; between the workers and the strippers; between the main cylinder and the 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 taking-off, or condenser, stripper to the doffers and the proximity of the rubbers must also be regulated.

**96. Factors Determining Setting of Carding Machines.**—The setting of the various parts must necessarily vary according to conditions. The length of the fibre is one important element; the longer the fibre, the more open must be the settings. Then, again, the condition of the wool as it comes to the scribbler must be considered; if it is matted, the setting must be more open on the first two or three workers of the first cylinder in order not to bend the clothing and cause undue breakage of fibre by trying to open out the material at once. With such material it is sometimes a good plan to set the workers progressively on the scribbler, but if the material is well opened and lofty they may be set close.

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

**97. Setting Workers and Strippers Progressively.**—The back, or delivery, end of the machine is always set finer, or closer, than the front, or feeding, end, in order to card the material thoroughly, fibre from fibre. After each carding, the material is more open and separated, and thus allows closer adjustments of the working parts without breaking the fibre of wool. Before setting the machine, care should be taken to have all belts in place, for if the machine 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.

**98. Process of Setting Rollers.**—Only one end of a gauge is ground accurately to the indicated thickness, so that in setting the different parts of the machine to each other the opposite end, which is the one with the hole in it, should be grasped and the gauge inserted between the rollers for a distance equal to barely one-half of its length. It should then be moved slowly backwards and forwards across the machine and the proximity of the rollers varied until a correct setting is obtained.

One side of the machine should be set first, regulating the distance between the rollers 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 rollers. Then the other side should be set in the same manner. After both sides are set, the side that was adjusted first should be gone over again, as the setting of the other side always disturbs the original setting, more or less. On very particular work some carding engineers go over each setting several times.

**99. Differences in Methods of Setting Carding Machines.**—The range of variation as regards setting is such that no two conditions are the same, and therefore no hard and fast rule can be laid down. Some carding engineers would set the workers to the first cylinder of the scribbler to a No. 28 to 32 gauge, and would use a No. 36 gauge in setting the workers to the last cylinder of the carder, with the ring doffers set to the same gauge. This, however, is an extreme case and is possible only when the machines are in excellent condition and the material very fine. Others working on a similar grade of wool may use Nos. 24, 30, and 32 gauges. Again, the machines are frequently set much more open, as, for instance, a No. 20 gauge on the first cylinder and a No. 28 gauge on the last cylinder of the scribbler, while the carder would be set to a No. 30 gauge.

**100. Condition of Material.**—Much, in carding, depends on the carding engineer, the previous preparation of the material, and the condition of the machines. A variation of a point or two in setting is of no material consequence, provided that the wool is well carded. The main point to be observed is the condition of the sliver as it leaves each machine. Take the sliver from the scribbler and pull it apart, holding it toward the light; it can readily be seen whether the carding machine is operating on the wool satisfactorily or whether the sliver is full of specks or neps that are not opened out. Should the sliver not be satisfactory, the workers and doffers must be set closer to the cylinder, or the point on these rollers must be improved.

**101. Judgment in Setting Carding Machine.**—The carding engineer must use judgment in setting, and take into consideration the material being worked and also the count of yarn to be spun. If the setting is too close, the wool is cut or the fibre broken; if too open, the material is not opened and is liable to be rolled into bunches. The settings should be between these extremes and yet be as open as possible to card the material properly; if set finer than necessary, the treatment of the material is more severe than is necessary.

Some carding engineers set progressively; that is, they begin with the first worker on the first cylinder or breast, which is set open; the setting then grows finer until the ring doffers are reached. Such an adjustment might begin with a No. 20 gauge with the first worker and end with a No. 34 between the last cylinder on the carder and the ring doffers. In some mills it is customary to set strippers one point finer to the main cylinder. Strippers are never set progressively as just explained, the progression being between the workers and the main cylinders and the main cylinders and the doffers, which are the *working points* of the machines.

**102. Effect of Quality of Material on Setting.**—As has already been mentioned, the chief consideration in setting is the quality of the material. Long wool needs less carding, and is, in fact, damaged by having the staple broken through too severe carding, although this depends to some extent on the amount of material passing through the machine. It is evident that when a large weight of material is being put through the machine it cannot be worked to the same extent as when a smaller weight is being handled. When carding long material the rollers must be set fairly well apart, especially at the breast or first cylinder, the setting being made gradually closer until, when the last cylinder of the carder is reached, the setting is closest, as the material is then partly carded and able to receive without

TABLE VII

SETTINGS OF WORKERS AND DOFFERS WITH MEDIUM WOOL

| Name of Roller | Number of Gauge Used in Setting to Cylinder | |
|---|---|---|
| | Workers | Doffer |
| SCRIBBLER: | | |
| First cylinder . | 20 | 24 |
| Second cylinder | 24 | 28 |
| Third cylinder . | 28 | 30 |
| CARDER: | | |
| First cylinder . | 30 | 30 |
| Second cylinder | 30 | 30 |

injury the final working necessary to obtain its thorough disintegration. Thus, long wools need the rollers more open at all working points, while in working some short material the setting can hardly be too close.

**103. Gauge Numbers for Setting Workers and Doffers.**—Good gauge numbers for setting the workers and doffers to the various cylinders, where a medium-stapled wool is to be used, are given in Table VII. In setting for long wools a No. 12 or No. 16 gauge might be used for setting the workers and the doffer to the first cylinder of the scribbler, while in setting similar rollers to the last cylinder of the carder a No. 26 or No. 28 gauge might be used. In carding very fine materials, providing that such material has been well opened previously and is quite free from hard bits, the workers and doffer might be set to the first cylinder or breast of the scribbler with a No. 24 or No. 26 gauge, similar rollers being set to the last cylinder of the carder with a No. 34 or No. 36 gauge.

**104. Setting Workers and Strippers.**—When setting workers and strippers or other rollers to a cylinder covered with sheet clothing, the cylinder should be moved so that the adjustment will take place at the centre of a sheet and not on the edge, because nearly all sheets are slightly higher in the centre, and if the worker is set on the edge there is some liability of contact with the highest part of the sheet. Sheets are apt to become higher in the centre 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 centre, especially if it is loose. The strippers are usually set about the same distance from the main cylinder as the workers.

**105. Setting of 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 carding machine is in operation there will be no contact between the two. It is important when setting the doffer to have the gearing 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.

The doffer is usually set closer to the cylinder, which it clears, than any other two rollers on the machine are set to each other. This is done so that the doffer will effectually clear the cylinder; but if they are not set close enough the material is taken round and round on the cylinder, which results in breaking of the fibres and filling of the cylinders with material. The consequence of this is what is known as **fly**, that is, fibres that fly or drop from the machine during the operation of carding.

**106. Setting of Fancy.**—More trouble is usually experienced with the fancy than with any other part of a woollen-carding machine. The fancy is the only roller of the machine 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 is judged by the sound produced by the fancy wire in passing through the cylinder clothing. After it has been set and the material is on the machine, it is often necessary to change its setting, for if not properly set for a given class of work the fancy will either throw the material out of the machine or else choke up, or lap; or it may pack the main cylinder. When the fancy is throwing the material, 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.

**107.** The material should not be thrown from the machine and only a small percentage of light material should be found underneath it. The points on the cylinder should be kept sharp and well forwards. The fettlings or dressings which result from cleaning the cylinder should be heavy with dirt and practically worthless, and the material, in going through the process of carding, should be deposited on the workers only in thin or small quantities. Should the fancy not be raising the material properly, the doffer will not keep the cylinder clean, and, consequently, the workers and cylinder will become choked and the carding of the material will be much less perfect. When a fancy is working right, the wool is lifted to the points of the cylinder clothing uniformly and thus can be taken readily by the doffer.

**108. Speed of Fancy.**—The surface velocity of the fancy should be only slightly in excess of the surface velocity of the cylinder. To find the relative surface velocities of the main cylinder and the 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 or 5 to 6, if the fancy is speeded right. In carding blends of shoddy, mungo, or other low material, a speed ratio of 4 to 5 will give good results; for carding medium-class materials a ratio of $4\frac{1}{2}$ to $5\frac{1}{2}$ is satisfactory; and for carding or working lofty stuff, that is, lofty materials, a ratio of 5 to 6 is suitable.

**109. Theories as to Setting and Speed of Fancy.**—In setting the fancy several theories are put into practice by carding engineers. Some set the teeth of the fancy a certain depth into the teeth of the cylinder according to experience, and change the speed to suit the work in hand by running the fancy faster for low stuff and slower for lofty material, the increased or decreased speed being obtained by adding or taking off leather laps on the fancy pulley; others will, on the contrary, run the fancy at the highest speed and set as deep into the cylinder as is practicable. Again, some carding engineers prefer to set the fancy into the cylinder slightly at the commencement and gradually deepen until a suitable working position is reached; others will set fairly deep in commencing and ease off after running a short time. Usual settings are from $\frac{1}{16}$ to $\frac{1}{8}$ inch, the deepest settings being required on heavy, low materials, such as blends of shoddy, mungo, and so on.

**110. Setting Fancy to Exact Depth.**—To set the fancy into the cylinder to an exact depth is a very difficult, if not an impossible, task. A method often practised is to mark the wires along a portion of the side of the cylinder with white chalk, the marking being done to a considerable depth. Then, by rotating the fancy, its teeth will brush off the chalk just so far down the wire as it is set into the cylinder. By this method it is also comparatively easy to set both sides of the fancy exactly alike. It is possible to set the fancy fairly accurately by setting to a gauge, and then, by ascertaining the pitch of the screws, the setting may be done to $\frac{1}{64}$ inch; for example, setting to a gauge of known thickness and supposing that the pitch of the screw is $\frac{1}{16}$ inch, then, by turning the regulating nut one complete revolution, the fancy will be set $\frac{1}{16}$ inch closer to the cylinder, and by turning the nut $\frac{1}{4}$ revolution more it will be set $\frac{1}{64}$ inch closer.

**111. Clothing on Fancy.**—The card clothing on the fancy must be fairly open in character, because a fancy that is too full of wire has a tendency to press the material into the cylinder rather than to raise it. The dimensions of the finest clothing used for a fancy will be about 75/7 or 80/8, and No. 32 or No. 34 wire. When an open fancy is used, it has a tendency to wear grooves in a cylinder covered with fine clothing, therefore, on some machines a slight traverse is given to the fancy.

**112. Setting of Condenser.**—The ring doffers are set close, but not too close, to the cylinder, care being taken that they do not touch each other at any point of their circumferences. A No. 32 or No. 34 gauge might be used. The condenser stripper is set into the doffer about $\frac{1}{16}$ inch, the points on both the doffer and the stripper being kept sharp and the points clear to that depth. The taking-off roller is set by a thin gauge between the stripper on one side and the top rubber on the other, and about $\frac{3}{16}$ to $\frac{1}{8}$ inch above the bottom rubber. The rubbers are set to about a No. 20 gauge, but the pressure on the press rollers causes the rubbers to touch lightly in the middle.

**113. Varying Amount of Rubbing.**—The amount of rubbing that is given to the material may be varied (*a*) by increasing the speed of the stroke, that is, the number of strokes per minute, (*b*) by increasing the length of the stroke, and (*c*) by increasing the pressure of the rubbers. Defective work is often made because the speed of the eccentrics is so slow that the ribbons of material cannot be rubbed into roving by the rub aprons as fast as they are delivered by the condenser stripper. The eccentrics may be run at a speed of 400 revolutions per minute, but care should be taken that the vibration is not so great as to cause unnecessary wear and tear of the mechanism and the rubbers, and consequently uneven roving.

**114. Length of Stroke of Rubbers.**—The length of the stroke of the rubbers should not be greater than the width of the rings on the ring doffer. The stroke is usually from $\frac{1}{2}$ to $\frac{3}{4}$ inch, and must not be greater than the distance between the separate ribbons of material as they are passing through the rubbers to the bobbin frame; otherwise the ribbons are liable to become entangled. Another factor that affects the length of the stroke is the length of the fibre in the material. For a short material which is to be spun to fine counts a good length of stroke might be allowed, while for a long fibrous material the stroke must be short and quick. The pressure on the rubbers should be slight, because, if it is too great, there is an excess of friction, which tends to shorten the life of the rubbers and to cause uneven rovings, since the rotation of the rubbers is liable to be unsteady. The relative surface speeds of the ring doffers, rubbers, and bobbin drums should be carefully arranged. To do good work when condensing short stuff, all their speeds should be about equal; but a considerable draft is possible when long wools are being condensed, as the draft helps to prevent the threads from tying, that is, becoming entangled.

## FETTLING CARDING MACHINES

**115. Necessity for Fettling.**—From time to time the card clothing becomes so choked and filled with short fibres, 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 for cleaning or dressing, or, as it is usually called, **fettling.** Some material contains much refuse matter and other dirt that quickly fills up the card clothing; other material, being comparatively clean, will allow the carding machines to run for a much longer time without fettling. Less fettling is required, therefore, if the material is prepared for carding in the best manner and as thoroughly cleaned of foreign matter as possible.

**116. Indications That Fettling is Required.** — Machines are fettled or dressed when in the opinion of the carder they require it. The time machines are allowed to run varies considerably, according to the class of material in work ; thus, for low, thick, dirty stuff, fettling may be required to be done every 8 or 10 hours, while for fine washed wool the machines may not require fettling oftener than once in 8 days. The following are indications that a carding machine requires fettling, other conditions being equal: (*a*) When the fancy begins to throw the material excessively when the cylinder is normally full ; (*b*) when the strippers become filled and, instead of stripping the material clean from the workers, commence to roll it ; (*c*) when the angle strippers roll the material to the sides, which, when it happens on the carder, results in thicker threads or rovings at the sides than in the centre ; and (*d*) when the workers and doffers become shiny because of the dirt and grease embedded in them.

**117. Time of Fettling Scribbler and Carder.**—The scribbler might be expected to require fettling oftener than the carder, but in practice this is not done, since the carder cannot be run successfully as dirty as the scribbler on account of the finer and more delicate nature of its work. The workers and strippers are allowed to run twice the length of time allowed for running the cylinders, so that half of the workers and strippers over one cylinder are dressed with the cylinder at one time, and the remainder the next time. In some mills the scribbler and the carder are fettled together, but this is not so satisfactory as fettling at different times, since, in the former case, the machine has to run for a considerable time before the rovings become of proper thickness, and, further, with all the machines running dirty at the same time the carding is insufficient and causes inferior work.

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

**118. Fettler Plates, Combs, and Board.**—When the machine is to be fettled the belts are thrown off and the fettling is performed by means of **fettler plates**, or, as they are more frequently termed, **fettler combs**. The ordinary type of fettler comb is shown in Fig. 28. It consists of a plate *a*, which is about 6 inches by 1 inch, made with teeth about $\frac{3}{16}$ inch long, as shown at *b* ; to this plate is fitted a handle *c*. Combs with different numbers of teeth per inch are used, one set with fourteen teeth per inch for rollers covered with coarse card clothing, such as may be used on the breast cylinder of a coarse set of machines, one with sixteen teeth for fettling scribblers and strippers, and one with eighteen teeth for the carder and fine clothing generally. When fettling the ring doffers a **fettling board** is often used. This consists of a flat board 6 by 4 inches, with a handle attached, and covered on one side with a piece of coarse card clothing. The board gives both safer and better results, as the wires get between those of the rings on the doffer more easily and are not so liable to damage them when the fettling board is being drawn through the teeth, as they offer less resistance than the teeth of the ordinary fettling comb.

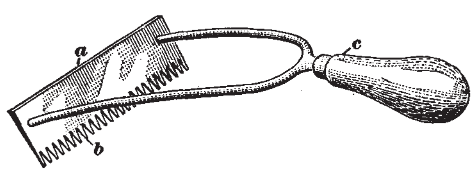


Fig. 28

**119. Preparing Machines for Fettling.**—In fettling a machine two men are employed, one on each side, this being the most advantageous way of accomplishing the work. The usual method of fettling is as follows : The belt is thrown off from the hopper feed, if the scribbler is to be cleaned, and the feed-rollers of the machine are disconnected by means of the small lever that throws the side shaft out of gear. The machine is then allowed to run 2 or 3 minutes in order that it may clean itself as much as possible. All belts and chains are taken off before fettling is commenced. Care must always be taken when removing any roller of the machine not to damage the clothing, which, if bent and bruised, will not properly perform its functions. Two pieces of piping, usually termed *lifting piping*, are used when it is necessary to lift any roller from the machine, and are practically indispensable if the roller is a heavy one. These pieces of piping are slipped over the ends of the shaft, and the roller can then be lifted out of the machine by two men without any danger of dropping it, as otherwise is liable to occur owing to the grease on its shaft.

**120. Fettling by Four Men.**—A good method of fettling is where four men work together on one machine. Two of them commence at the breast or first cylinder, one taking the right-hand side and the other the left-hand side of the machine. These men are usually termed *right-hand* and *left-hand fettlers*, respectively. They fettle the two strippers and two workers over the breast, then the first angle stripper, then the breast cylinder, and lastly the breast doffer. This done, they take the last cylinder and, if necessary, the last doffer, though the latter will probably not require fettling each time. The two other fettlers take the second cylinder and its full complement of rollers, consisting of four pairs of workers and strippers, together with the second angle stripper and the second doffer.

**121. Fettling Full-Sized Cylinder.**—In proceeding to fettle a full-sized cylinder and its full complement of rollers, the fettlers begin at the fourth worker by standing on the frame near the doffer. Then, standing on the fancy shaft with one foot, and one knee on a cushion, they proceed to fettle the third worker; and by following up in a similar manner all the workers are fettled without being lifted out of their bearings. The fettlers then turn round and begin at the angle stripper, and taking each stripper in order work back to the fourth stripper. The cylinder is then fettled, and to accomplish this in an easy and efficient manner the fourth worker and stripper are lifted out of their bearings and placed in the position shown at *a*, Fig. 29, by dotted lines. Lastly, the doffer is fettled.

**122. Process of Fettling Scribbler.**—It will be seen that in fettling a scribbler consisting of a breast cylinder over which are two workers and strippers, and two cylinders over which are four pairs of workers and strippers, one pair of fettlers begin with the breast and fettle the workers, the strippers, the first angle stripper, the breast cylinder, and the breast doffer, in the order given.

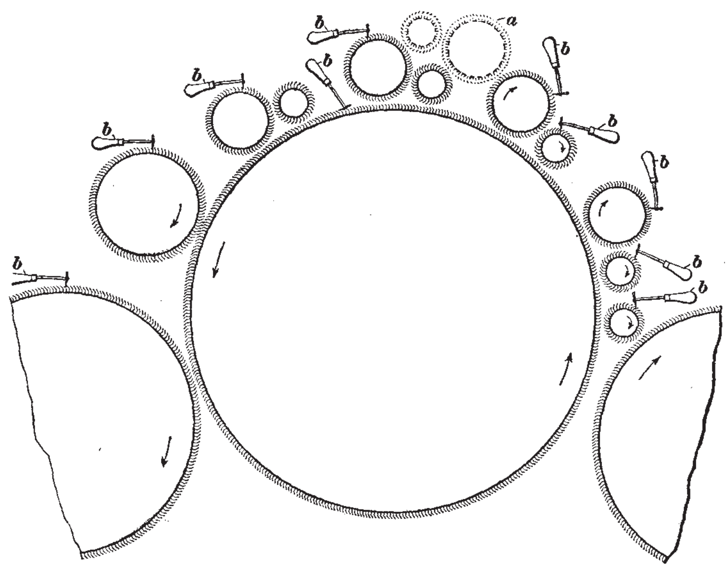



FIG. 29

The same two fettlers also take the last cylinder. The other fettlers take the second or middle cylinder, and begin with the workers, and then proceed, in the order given, with the angle stripper, the worker strippers, the cylinder, and the doffer. They then proceed to fettle the *tops* of the last cylinder, that is, the workers and strippers.

The fancy is usually touched only by the carding engineer, as it is considered that a certain amount of dirt on it helps it to work better. The licker-in and the feed-rollers will in many cases run for several weeks without cleaning, though the doffing comb should always be kept very free from dirt.

**123. Fettling of Carder.**—A carder with two cylinders may be fettled as follows: One pair of fettlers will take one cylinder, the first, for instance, and all the rollers over it, while the other pair of fettlers will take the second cylinder and all the rollers over it, the general procedure being the same as that explained with regard to the scribbler. The ring doffers on the last cylinder of the carder will run for months without fettling, as the condenser strippers, being set into the doffers about $\frac{1}{16}$ to $\frac{3}{32}$ inch, keep the doffers both clean and sharp. Four men will keep from eight to twelve sets of carding machines clean, varying of course according to the material, whether low or fine, and also according to its previous preparation.

**124. Points in Fettling.**—Fettling must never be done against the point of the tooth, but always from the knee toward the point of the tooth, that is, along the backs of the teeth. This is clearly shown in Fig. 29 by the position of the comb *b* in relation to the various rollers being fettled, the comb in each case being drawn toward the fettler. It will thus be seen that fettling all the workers first, in the manner previously described, is much the easiest and best method, as no change of position is necessary, for all the teeth of the workers point in one direction. Then, by turning back when commencing to fettle the strippers, these also can be fettled without changing the position, as their teeth, like those of the workers, point in one direction.

Some fettlers prefer to take out the workers, strippers, and fancies and fettle them in a rack which is used for this purpose; but as the rollers are large and heavy, especially on new machines, and the machines themselves are built high, there is less risk and labour entailed by allowing all the rollers to remain in the machine during the operation. Fettling should be well and carefully done, and the fettlers should not allow their feet to come in contact with the card clothing, on any of the rollers, with such force as to injure the clothing.

**125. Restarting Machine After Fettling.**—After the machine has been thoroughly cleaned and the various parts and the belts and chains replaced, it may be allowed to run empty for 2 or 3 minutes, in order to remove loose particles of refuse that may be resting on the surface of the clothing. After this it is a good plan to run over the settings, if there is time, 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 machine may then be put in operation and the wool allowed to enter by putting the feed-rollers in gear again, but it must be allowed to run for 4 or 5 minutes after this, so as to become filled with wool to its utmost capacity and so that the sliver will attain its original weight before the product is passed on to make roving. If this is not done the rovings made just after fettling will be thin and light and will not spin to the right counts of yarn. The roving is apt to be a little light for an hour or so after the fettling; this of course is not returned to the hopper feed, but is spun, although perhaps the draft in the subsequent spinning of the roving into yarn may have to be changed slightly to make the required counts of yarn.

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## MANAGEMENT OF CARDING ROOMS AND MACHINERY

**126. Principal Objects in Management.**—In the management of carding rooms many points must be watched, but the following results should always be attained: (*a*) The production of good work; (*b*) as large a production as is consistent with the quality of the work required; (*c*) economy in avoiding unnecessary waste and keeping down the expense of wages, power, supplies, etc.; and (*d*) the maintenance of the machinery in good condition.

**127. Twits.**—The production of good work 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, bunches and thick places are also likely to be found. If the roving is twitty, the yarn will also be full of thin places.

**128. Causes of Twits.**—Twitty roving causes much trouble in carding 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 liquor that is too hot the grease seems to be driven into the fibre, 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 carder cylinders grows slack and blisters through usage ; this is a cause of twits and is remedied only by taking the clothing from the cylinder, re-covering it, and afterwards grinding to a true surface. A poorly working licker-in on the carder is also apt to cause lumps and 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 fit only 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*. This fault is usually due to a too slow speed. All doffers should be speeded correctly, so as to transfer the correct amount of material. Any defect in the rings of the ring 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 carder.

**129.** If the condenser stripper, which strips the ribbons of carded wool from the rings, is driven too fast or is not set properly with regard to the rings, twitty roving is likely to be the result. Twits are also sometimes caused by too much draft between the rubbers of the condenser, and sometimes by poor or dirty rubbers ; also by setting them too close at the back, that is, where the ribbons enter as they are stripped from the condenser. In some cases the rovings are not rubbed solid enough and so are liable to be weak in places. Twits are often caused by a too high speed of the carding machines, especially of the ring doffers. If one fibre receives more oil than another, it 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.

**130. Prevention and Remedying of Twits.**—Great care should be taken to bring the material from the scribbler in good condition, as on the character of the carding done by the scribbler the resulting roving will largely depend. The side drawing from the scribbler should be examined frequently for neps and vegetable matter. The sliver should be round and full from the scribbler and intermediate and the rovings from the carder should be round and perfect, without having been rubbed too little. All little points that tend to reduce the quality of the work should be carefully attended to and the machines fettled 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 material as it passes through the machine.

**131. Large Production in Carding.**—Large production can be obtained by limiting as much as possible the time allowed for fettling, grinding, or setting the carding machines, and also by not allowing the rest of the set to be stopped any longer than is necessary while fettling or grinding one machine. The production may be increased by speeding up the whole machine or by increasing the speed of the doffer and the feed-rollers by changing the small gear-wheel that drives the large gear-wheel on the doffer shaft. Carding machines 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 machine and make it more difficult to clean, besides having a tendency to work into the bearings and round the shaft, collecting in lumps that are sometimes caught and carried into the machine, and rendering the roving uneven. Too much material should not be forced through the machine by speeding up the doffer, nor should the sliver be made too heavy. The quality of the work in woollen carding should rarely be sacrificed for production. Production in carding depends quite as much on the man who manages the machines as it does on the machines. Generally speaking, the efficiency of a well-managed plant should reach 90 per cent. ; in other words, if the calculated output of a set of machines is estimated to be 200 pounds per day, the actual production should at least reach 180 pounds per day.

**132. Economy in Working Carding Machines.**—Economy in working carding machines depends principally on the amount of waste made and the cost of labour. As a rule, one girl will attend to two sets of carding machines. Four men will fettle from eight to twelve sets of machines, and one carding engineer with an assistant will have charge of a like number. The labour cost of a carding room varies according to the standard of wages in the locality in which the mill is situated, 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 machines again. A good deal of the waste round the machine may be dusted, run through the willow, 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.

**133. Cleaning and Lubrication of Carding Machinery.**—Carding machinery requires to be cleaned and oiled frequently. Machines that are not in use should be run fairly frequently, as the wire may suffer from corrosion, even though it is tinned and thus protected. Corrosion is especially likely to occur during the winter months. Should the wire become rusty, the efficiency of the machine will be correspondingly reduced. The machines should be wiped down with a piece of waste each noon and night, and every week the carding machinery should be swept underneath and the carding room properly swept up. The carding machines should be carefully cleaned after each fettling, and all dirt and waste removed from the bearings. After grinding has been done, the machines should be cleaned and the wire brushed out with a strong bristle brush.

All fast-running parts, such as the stripper, main-cylinder, tumbler, and licker-in bearings should be oiled twice a day, and the fancy bearings 3 times 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 oil cups on the main-cylinder and fancy bearings should be packed with tallow, which will 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 oil cups and soaked with heavy oil. The doffer-comb driving mechanism is run in oil and should be examined once in 2 weeks to see whether there is sufficient oil in the reservoir, or casing.

**134. Care of Belts.**—It is important that the belts on carding machines should be examined once a week, especially the belt that works the strippers. Broken or worn laces should be replaced, and weak places made good, so that no time may be lost in repairing when work should be proceeding. Joints should be spliced and sewn or laced, so as to give a solid leather surface that is always in contact with the pulley. Belts should be cleaned every time the machines are fettled, and the best time for doing this is when the machine is being emptied, immediately prior to fettling. When the belts become dry they should be oiled with castor oil. When any of the parts of the machine are disturbed they should be carefully gone over again, for there may be some variation in the setting. It is necessary that the driving should be uniform if the best results are to be obtained. All belts and other moving parts working outside the end framing should be adequately fenced ; otherwise, workmen are liable to be seriously injured, in which case the employer would have to pay compensation and the machine might be so far damaged as to require extensive repairs, which would not only be expensive but also cause loss of time.

## ELECTRICITY IN THE CARDING ROOM

**135. Cause and Effect of Electricity in Carding.**—Any animal fibre, especially wool or silk, is liable to become charged with electricity arising from friction combined with a dry state of the fibre and of the atmosphere. Should the material become too dry, this trouble might develop, and the place where it would be most apparent in woollen carding would be at the condenser, where the action of the rubbers tends to charge the rovings with static, or frictional, electricity. This might cause the rovings to cling to the rubbers and to the iron parts of the carding machine and bobbin frame, thus becoming broken and winding round the rubbers. When a roving breaks and is not immediately replaced, a blank space is left in the spool, making it imperfect.

**136. Remedy for Electricity in Carding.**—A remedy that may be used with good results, should trouble with frictional electricity occur, 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 material moist and silky to the touch, 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 material.

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## WEIGHT OF ROVING

**137. Influence of Draft on Weight of Roving.**—In order that a woollen yarn may have a definite weight or count, that is, a certain number of yards per pound, it is necessary that the roving, or carding, from the condenser shall be of a given uniform weight. It is, therefore, one of the duties of the carding engineer to make the rovings of such weight that they may be spun into the required count of yarn with a reasonable draft in the spinning. The draft that can be given on the *mule*, which is the name given to the machine that is most largely used in converting the roving as it leaves the condenser into yarn, depends on the quality of the material used and the count of the yarn being spun. If the material is of good quality and is not spun too fine, a half draft in the mule is reasonable; that is, if the carriage, which is the part of the mule that supports the spindles on which the yarn is wound, has a draw of 72 inches, then 36 inches of roving will be let out before the delivery rollers of the mule stop. If a low grade of material is being spun, it may be necessary to let out 40 inches or more of roving before stopping the delivery rollers. If the mules are running on half draft, that is, letting out 36 inches of roving and drafting or drawing it into 72 inches of yarn, the roving brought from the condenser must be just twice the weight of the required yarn.

**138. Obtaining Correct Weight of Roving From Scribbler.**—It is not customary actually to calculate the weight of the roving from the amount of material fed to the machine, as the weight of material fed is an unknown quantity; for though the automatic feed supplies the wool to the machine uniformly by weight, this weight is not usually known or taken into account. The point is to bring from the scribbler a sliver that will allow a suitable gear-wheel on the scribbler to give the required weight of the roving.

**139. Finding Required Count or Weight of Roving.**—The count or weight of the roving, as has been previously explained, depends on the count of the yarn to be spun and the draft of the roving in spinning. The latter depends on the character of the material, and also on how near to the limit of its capabilities it is being spun; low stuff will stand less draft than sound wool with good spinning properties. The count of the roving as it leaves the condenser and the amount of draft that is given to it in the spinning process are considerably influenced by the type of condenser used; for instance, a tape condenser will bring off a finer roving than it is possible for a ring doffer to produce, and therefore such a roving will require a proportionately less draft to enable it to spin to the required count.

**140.** The weight of the roving necessary to spin a given yarn is to the amount of roving let out by the delivery rollers of the mule as the count of the yarn spun is to the draw of the carriage; therefore, the following rule is necessary to find the count of roving that should be made on the condenser for a given count of yarn, the draft in the mule in spinning being known:

**Rule.**—*Multiply the length of the roving, in inches, delivered by the rollers on the mule by the count of the yarn to be spun, and divide the product by the length of the draw of the carriage, in inches; the result will be the size of the roving.*

EXAMPLE.—Find the weight or count to which the roving must be condensed in order to give a 20s Yorkshire skein yarn when the carriage has a draw of 72 inches and the delivery rollers deliver 36 inches.

SOLUTION.—Applying the rule,

$$\frac{36 \times 20}{72} = \text{10s skeins (Yorkshire). Ans.}$$

NOTE.—A certain amount of take-up due to twisting takes place in spinning; therefore, in the above example, the yarn may be drawn to 21s Yorkshire skein and twisted back to 20s, in which case the roving would require condensing to $10\frac{1}{2}$s Yorkshire skein.

**141. Changing Weight of Roving.**—The carding engineer, having calculated the required weight of the roving, must take steps to produce the right weight and to have all the rovings uniform. It must be remembered that changing the change wheel on the side shaft of the carder does not change the weight of the roving when the carder is fed continuously from the scribbler. This gear-wheel simply changes the character of the feeding of the Scotch feed. If the slivers are crowded on the feed-sheet and do not lie smoothly, a larger gear-wheel on the side shaft of the carder will drive the feed-sheet 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 change wheel on the side shaft of the scribbler; a larger wheel produces a heavier sliver, as it speeds up the feed-rollers of the scribbler and also increases the speed of the feed-lattice, which extends from the hopper feed to the scribbler and is driven from the feed-rollers.

**142. Measuring or Reeling Roving.**—To find the weight or count of the roving that is being condensed, it is necessary to measure or reel a certain length and find the weight, or from a certain weight to find the length. 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, round which a number of rovings are carefully wound until the length desired is obtained; or, the required number of rovings are taken and laid on the yard stick and broken off. Thus, if 20 yards of roving is desired, by taking twenty rovings and laying them on the yard stick and measuring them exactly, a more accurate length is obtained than by winding or reeling a smaller number round the yard stick.

**143.** Sometimes, instead of using a stick for measuring, marks exactly 1 or ½ yard apart are made on a post or on the wall. 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 ensures the weighing of an even and uniform length each time, as the tension is always the same. It is somewhat difficult in winding the rovings round 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.

**144. Method of Testing Roving.**—The usual method of obtaining the count of the roving is as follows: Suppose that a 20s Yorkshire skein is to be spun; then, according to the material being carded, the rovings would be made between 11s and 15s Yorkshire skein. In finding the weight, 1 or 2 yards must be run from the full width of a condenser bobbin, laid over the yard stick, carefully measured, and the number of rovings counted. These should be placed on one side of a small pair of scales and a dram weight placed on the other side, and it will then be seen whether the roving is too heavy or too light.

**145. Necessity for Keeping Condenser Bobbins Separate.**—The condenser bobbins, on which are wound the rovings that come from the top and bottom doffers, respectively, are, for very particular work, spun separately, either on different mules or on separate sides of the same mule, it being sometimes possible to have different drafts on different sides of a woollen mule, thus allowing the same size of yarn to be spun even if there is some variation in the thickness of the roving. The necessity for keeping the top and bottom condenser bobbins 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 carder and takes a slightly longer quality, while the bottom doffer takes what is left on the cylinder.

**146. Prevention of Uneven Production.**—To overcome the difficulty of uneven production, one method is to make all the rings on the top doffer $\frac{1}{8}$ or $\frac{3}{16}$ inch narrower than the rings on the bottom doffer, so as to neutralize the fact that the rings on the top doffer receive the material from a full cylinder, and this immediately after the fancy has raised it to the tips of the teeth of the cylinder. In many cases one worker over the last cylinder is given a traversing motion, so as to distribute the material and prevent any accumulation on the cylinder. But even when this precaution is taken and the speed of the top doffer is changed, there is a tendency for the rovings from the top doffer to be both heavier and of a better quality than those from the bottom doffer.

**147. Weighing of Rovings From Top and Bottom Doffers.** Separate weighings must be made from the condenser bobbins on which are wound the rovings from the top and bottom doffers, respectively, and if there is a great 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. With single ring doffers, or doffers for a tape condenser, there is not this difficulty of uneven weight of the rovings, since all the material is taken off the cylinder at the same time and is condensed into rovings under exactly the same conditions and at the same time.

## SPECIAL EFFECTS IN CARDING

### METHODS AND MECHANISM

**148. Knicker Yarns.**—Novelty or fancy yarns may be produced in the operation of carding. The most common of these are **knickerbocker, or knicker, yarns,** the appearance of a sample of which is shown in Fig. 30. This class of fancy yarn is a single

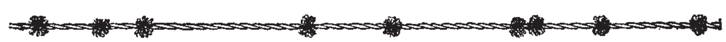

Fig. 30

yarn intertwined with relatively bulky pieces of the same material, which, however, are not so large as unduly to weaken the yarn or to prevent it from being used for weaving purposes. The extra

Fig. 31

pieces are spoken of variously as *neps, specks, motes, nubs,* or *knickers.* Sometimes this yarn is called **flake yarn,** but it is not a true flake yarn, as the knickers are not evenly spaced and are additions to the ground thread. Flake yarns, as shown in Fig. 31,

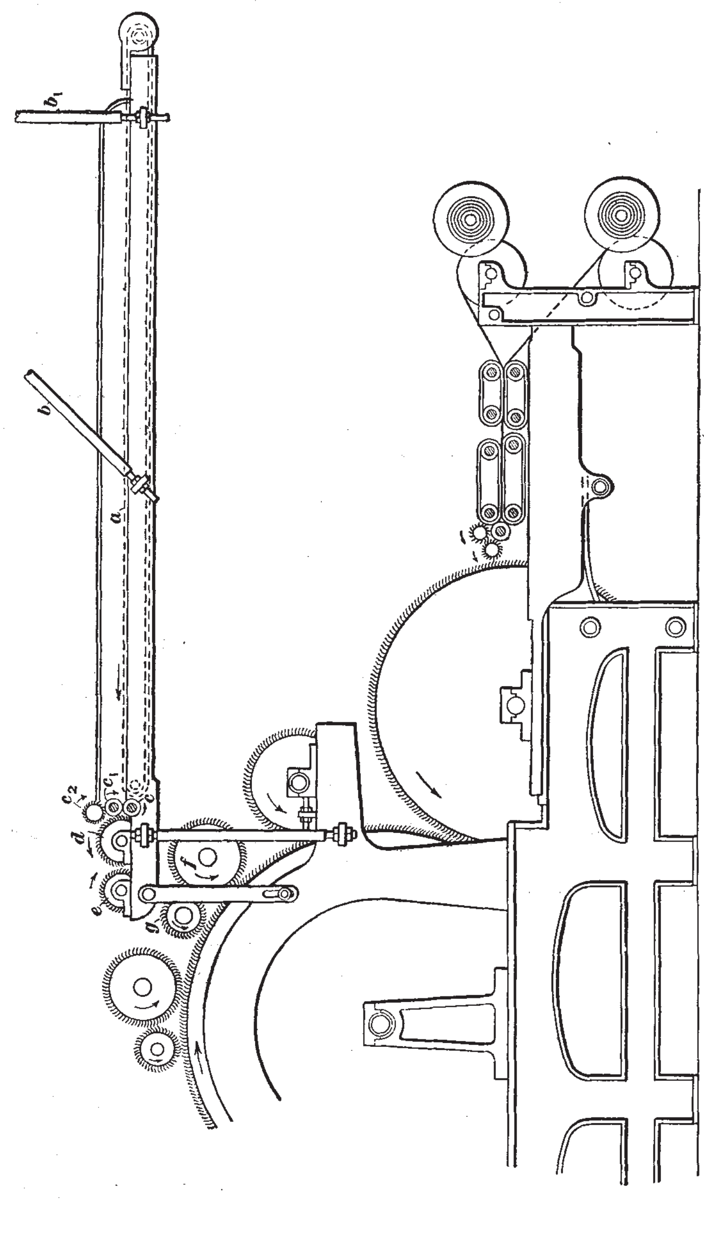


Fig. 32

are uniformly uneven single yarns, in which thick and thin places alternate regularly, the larger portions gradually tapering off to a thin thread, which enlarges again to a thick place. The knickers in a knicker yarn can be picked from the thread and still leave a single yarn; they differ from the true flake yarns also in the fact that the knickers are composed of balls of fibres crossed in all directions, prepared in the manner previously described.

Knicker yarns, which are used in the hosiery and fancy-woollen suiting trades, may be made of materials in their natural state, that is, the yarn undyed and the ground thread and the knicker of the same material; also, they are sometimes made with the knicker of one colour and the ground thread of another. The best grades of knicker yarns are so constructed as to show knickers at close intervals on as fine a ground thread as it is possible to produce.

**149. Mechanism Used in Producing Knicker Yarns.**—The mechanism employed in the production of knicker yarns is shown in Fig. 32 and consists of a long travelling lattice $a$ supported above the condenser by means of stays $b$, $b_1$ which are attached to the roof or the floor above. The knickers, that is, the small tufts of hard material, which have been previously prepared, are spread out on the lattice and are fed to the feed-rollers $c$ and $c_1$, the feed-roller $c_2$ acting only as a stripper or clearer. The feed-rollers feed the knickers to the licker-in $d$, which is stripped by means of the stripper $e$ which forces or beats the knickers between the last worker $f$ and the stripper $g$, over the last cylinder of the carder. All the rollers, with the exception of the bottom and middle feed-rollers, which are simply fluted, are usually clothed with Garnett wire, or with diamond-point fillet. It is important that the knickers should be fed into the carder as late as possible, consistent with satisfactory amalgamation with the ground material, that is, the material which ultimately has to form the principal portion or body of the roving and thread. If the knickers are fed into the carder too early they will be opened out just so much as they are acted on by the main cylinders, workers, and doffers, and thus the required knicker effect will be seriously impaired.

**150. Fancy-Mixture Yarns.**—A method of making fancy-mixture yarns which calls for special mention is that in which balls of different colours of material are fed to the carder by means of a ball-and-bank, or ball-and-creel, feed. By this means innumerable varieties of mixture yarns can be produced; for instance, balls of different colours may be passed side by side, through separate eyes of the guide rail, which is given a traverse of about the width of one guide eye. As the traverse takes place, if two colours are contiguous, the colours gradually take each other's place; that is, if blue and green balls are placed side by side, as the guide rail gradually moves alternately to the right and to the left, the two slivers exchange positions as regards the point at which they are fed on the feed-lattice of the carder, and, consequently, the material goes through the condenser in patches of colour, which results in a varicoloured roving being wound on the condenser bobbin. To produce the best results by this method, the ball feed must be used in feeding the carder, as the Scotch feed would largely neutralize the effect desired, the reason for this being that the sliver with a Scotch feed is fed across the width of the feed-lattice, being carried from left to right. Should a ball feed have been used in feeding an intermediate, and the colours added at that stage, the employment of a Scotch feed in feeding the carder would practically neutralize the desired effect.

# WOOLLEN SPINNING

(PART 1)

## CAM-SHAFT MULE

### CONSTRUCTION AND ACTION

#### INTRODUCTION

**1. Spinning in General.**—The material, after having been carded and converted into roving of a suitable size or count, is ready to be spun into yarn of the required count. 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*.

**2. Evolution of Spinning.**—The spinning of yarn from fibres 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 spun the yarn automatically, but the winding had to be done by the operative. Following this, Roberts made the mule self-acting and introduced the quadrant for winding the yarn on the bobbins. From these, the present *woollen mule* has been evolved.

**3. Advantages of Good Roving.**—Before wool can be spun into yarn, it must be carded and converted into rovings, which, being wound on condenser bobbins, are placed on the mule ; the roving is then unwound from the bobbins, drafted, twisted, and wound as 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 count of yarn may be spun without an excessive attenuation, or drafting, of the roving during the spinning.

**4. Amount of Draft.**—Generally speaking, the longer the fibre, or the better the grade of the material, the greater is the draft that can be given in the spinning ; short-fibred material requires more roving to be delivered by the delivery rollers of the mule for every stretch of yarn. Low material 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 material will spin much better and stand more draft than poorer material.

**5. Quality of Roving.**—There are, generally speaking, three kinds of roving spun into woollen yarn : (*a*) Roving made from inferior material or from material that is barely capable of spinning to the desired count; (*b*) roving that has been broken, rolled, or otherwise affected by poor carding; (*c*) 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 material 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.

**6.** The second class of roving is generally caused by carelessness or lack of skill. It is ordinarily expected that the roving, if made of good material, may during the spinning process 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 easily be drawn out to this length, or possibly more, but poor, uneven roving, or that made from low material, cannot.

The uneven places in roving of this class are a great hindrance in producing even yarn and necessitate 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.

**7.** 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 thick ones 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 rollers 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.

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

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## PRINCIPAL PARTS AND THEIR FUNCTIONS

**9. Headstock and Carriage.**—The machine used in woollen spinning 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 woollen thread; namely, the **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 rollers for delivering the roving; and the movable **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.

**10.** 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. The same letters of reference are used in all the illustrations of the woollen 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.

**11. Delivery of Roving.**—Referring to Fig. 1, which shows a section through the carriage and a portion of the headstock,

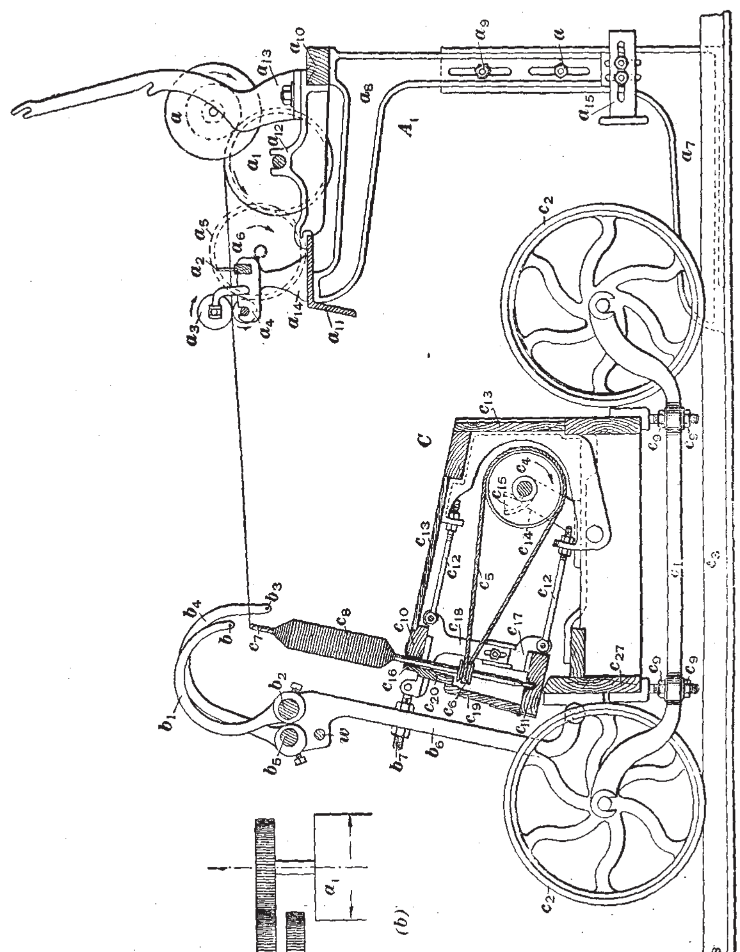


Fig. 1

$a$ is the condenser bobbin on which the roving to be spun is wound. The bobbin rests on a rotating drum $a_1$, which turns the bobbin and unwinds the roving, allowing it to be passed through the stationary guide, or raddle, $a_2$ to the delivery rollers $a_3$, $a_4$. Thence the roving passes directly to the spindle $c_7$, situated in the carriage $C$, and is wound into the form of a cop $c_8$ or on a bobbin; that is, after the roving has been drafted and twisted into yarn.

The bottom delivery roller $a_4$ is driven from the headstock, while the top roller $a_3$ is made into short sections, each of which is sufficiently long to rest on two threads, or rovings, and heavy enough to hold them, as required, by means of the bottom roller. Each of the short sections, usually termed a *top roller*, may be removed in order to replace rovings that break between the delivery rollers and the condenser bobbin.

**12. Spindles.**—In Fig. 1 only one spindle is shown; it must be remembered, however, that each mule often contains as many as 300 or 400, and sometimes as many as 500.

The spindle $c_7$ is carried in two bearings: a bottom, or footstep, 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, wharl*, or *wharve*, that has an endless cotton spindle band $c_5$ passed round it. This spindle band also passes round a tin cylinder $c_4$, called the *tin roller*, which supplies the motive power for turning the spindles by means of the spindle bands $c_5$. The drum runs the full length of the carriage, each spindle having a separate band that passes round its wharl and round the tin roller. The spindle is not vertical, but is inclined toward the delivery rollers. The spindles and tin roller are borne in the 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, or slips, $c_3$, so that if power is applied to the carriage it can readily be moved to or from the delivery rollers.

**13. Fallers.**—The yarn passes under a long horizontal wire $b$ fixed in the *sickle* $b_1$, Fig. 1, which oscillates with the faller shaft $b_2$; this wire is known as the *faller wire*, or, more definitely, the *winding faller*. Its object is to guide the yarn 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 wire is known as the *counter*, *tension*, or *under faller*, and is for the purpose of keeping tension on the yarn during the winding in order to prevent snarls and soft-wound bobbins.

**14. Drafting Roving.**—The method by which this mechanism, shown in Fig. 1, produces yarn is as follows: The carriage is brought close to the delivery rollers, so that the points of the spindles are within a short distance of the point of contact between the delivery rollers where the yarn is delivered. As the delivery rollers combined with the drum $a_1$ begin to deliver the roving, the carriage simultaneously commences to recede from the rollers at practically the same speed as that at which the roving is delivered, and the spindles begin to rotate. When the carriage with the spindles has travelled about half the length of its full traverse, the distance varying according to the draft of the roving, the delivery rollers and the bobbin drums stop, but the carriage continues to recede at a gradually decreasing speed until the points of the spindles are about 72 inches from the delivery rollers. By this means the roving is drafted, or drawn out, to twice its original length or thereabouts.

**15. Inserting Twist.**—As these operations are taking place the twist is being put into the yarn by the rotating spindles; this is made possible by the fact that at each turn of the spindle the yarn will slip over the end of the spindle, due to the inclination of the latter as shown more clearly in Fig. 2. If the spindle were vertical and the point of delivery at the rollers $a_3$, $a_4$ were level with any point on the bobbin or cop $c_8$, the yarn would tend to be wound on the spindle 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 spindle; thus, when the spindle rotates, the yarn rises on the cop or bobbin and spindle 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.

**16.** The tendency of the yarn to rise in the manner illustrated in Fig. 2 continues until the top of the spindle is reached, when the yarn slips over the end, 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. That the yarn receives one turn of twist for each loop that slips over the end of the spindle may not be evident at once. But if it be supposed that the revolving spindle is placed so as to be in line with the stretched yarn, it is clear that each turn of the spindle gives one turn of twist to the yarn. If now the spindle is gradually moved into the position shown in Fig. 2, it is evident that the conditions are not changed, so long as the loops of yarn are allowed to slip off over the top of the spindle.

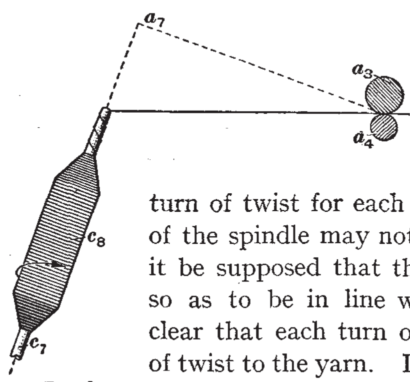


FIG. 2

It is the combined drafting and twisting action of the woollen mule that gives to the woollen thread its distinctive woollen 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 rollers, 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 *roller drawn*. Woollen 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 rollers.

**17.** When the carriage reaches the end of its travel, that is, when the spindles are at their greatest distance from the rollers, it is stopped and is held while more twist is given to 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 out, but would break instead, since the twist prevents the individual fibres from being drawn past each other as is necessary in order that the roving may be drafted. This extra twist is put in by means of an accelerated motion, known as a *double speed motion.*

**18. Backing Off.**—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 and the yarn already spun and wound on the bobbin are unwound, thus unwinding the yarn that is coiled too high on the spindle, bobbin, or cop; it is then rewound along with the stretch of spun yarn.

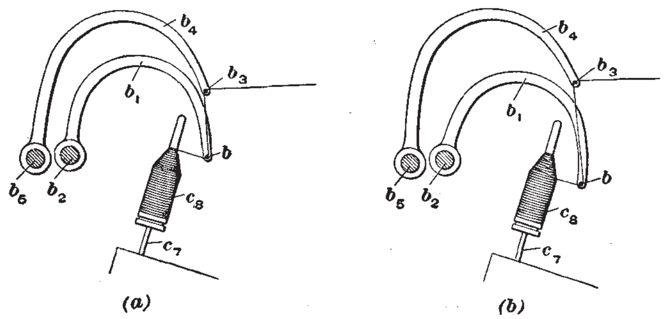



Fig. 3

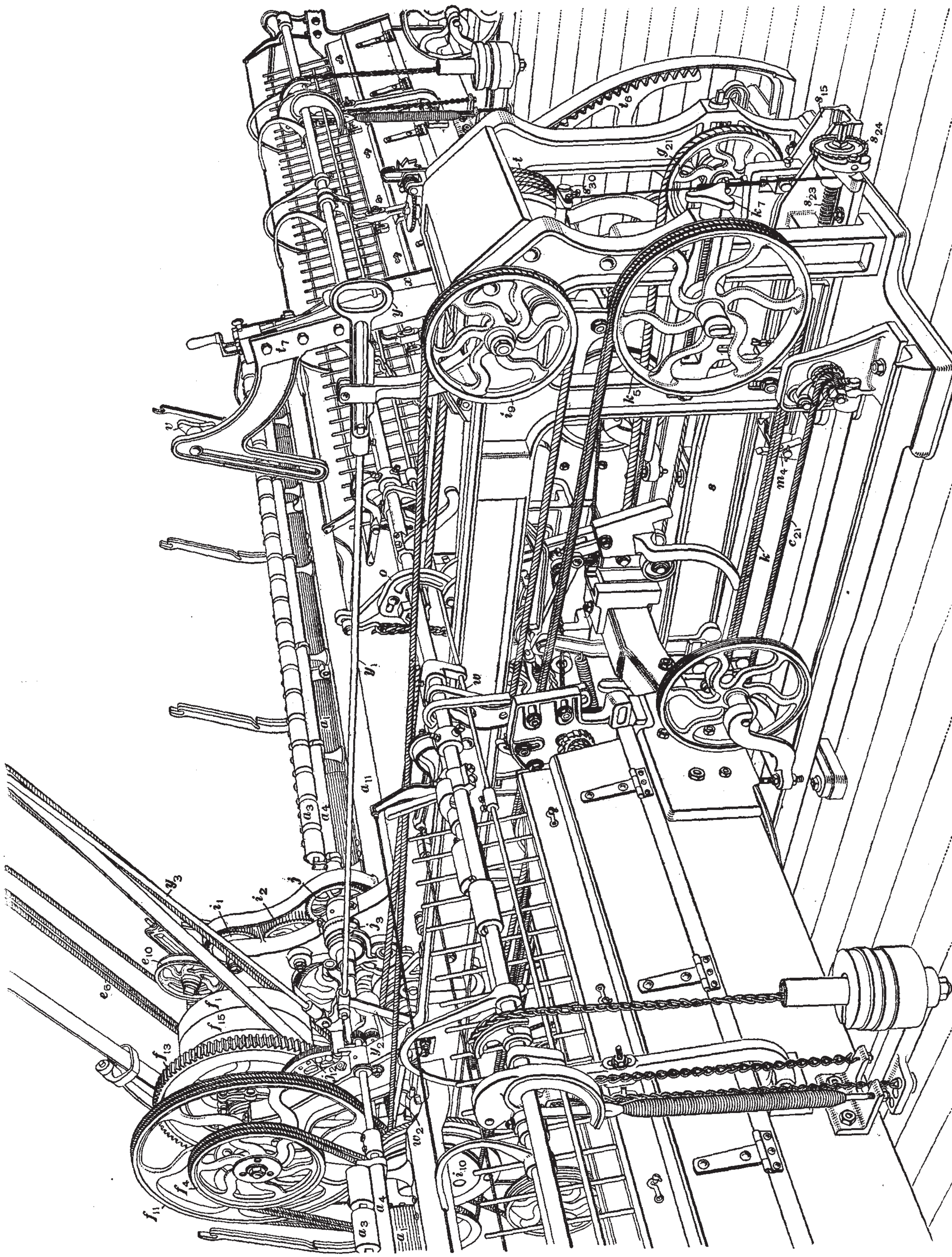
This operation is technically known as *backing off;* as it takes place, the winding faller $b$, Fig. 1, descends and assumes a position for guiding the yarn on to the bobbin, while the counter faller $b_3$ ascends so as to produce the requisite tension of the stretch of yarn for winding it on to the bobbin and to prevent the formation of snarls. 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 is shown in Fig. 3 (*a*). By a **stretch** of yarn is meant a length equal to the distance through which the carriage travelled in its outward journey.

**19. Drawing In and Winding.** — Immediately after the backing off is completed, the *drawing in* of the carriage is commenced and the spindles are revolved in the usual direction so as to wind the yarn on to the bobbin as the yarn 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, termed *binding coils*, and then in a series of finely pitched ascending coils which is the winding proper. Thus, each stretch of yarn is wound on the bobbin in two layers, the coarsely pitched layer giving the bobbin strength, firmness, and solidity, and the finely pitched layer serving to place on the bobbin the remainder of the yarn contained in one stretch or draw. The complete outward and inward run of the carriage is technically called a *draw*. This motion of the winding faller is regulated by what is known as the *builder*, or *shaper, 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, as in Fig. 1, and the parts are again adjusted to begin the work of drafting and twisting.

**20. Classification of Operations.**—The brief description given of the principal parts enables the movements of the woollen mule to be classified as follows : (*a*) delivery of roving, (*b*) drafting and twisting, (*c*) backing off, (*d*) winding, (*e*) re-engagement. 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, such as Figs. 4, 5, and 6, which show the positions of many of these parts and their relation to the mule as a whole. Fig. 4 is a perspective view showing all the parts in position as seen from the front, with the carriage some distance from the delivery rollers. Fig. 5 is a perspective view of the right-hand side of the headstock as seen from the back



§ 86

Fig. 4

*Rotated 90° degrees to fit on page.*

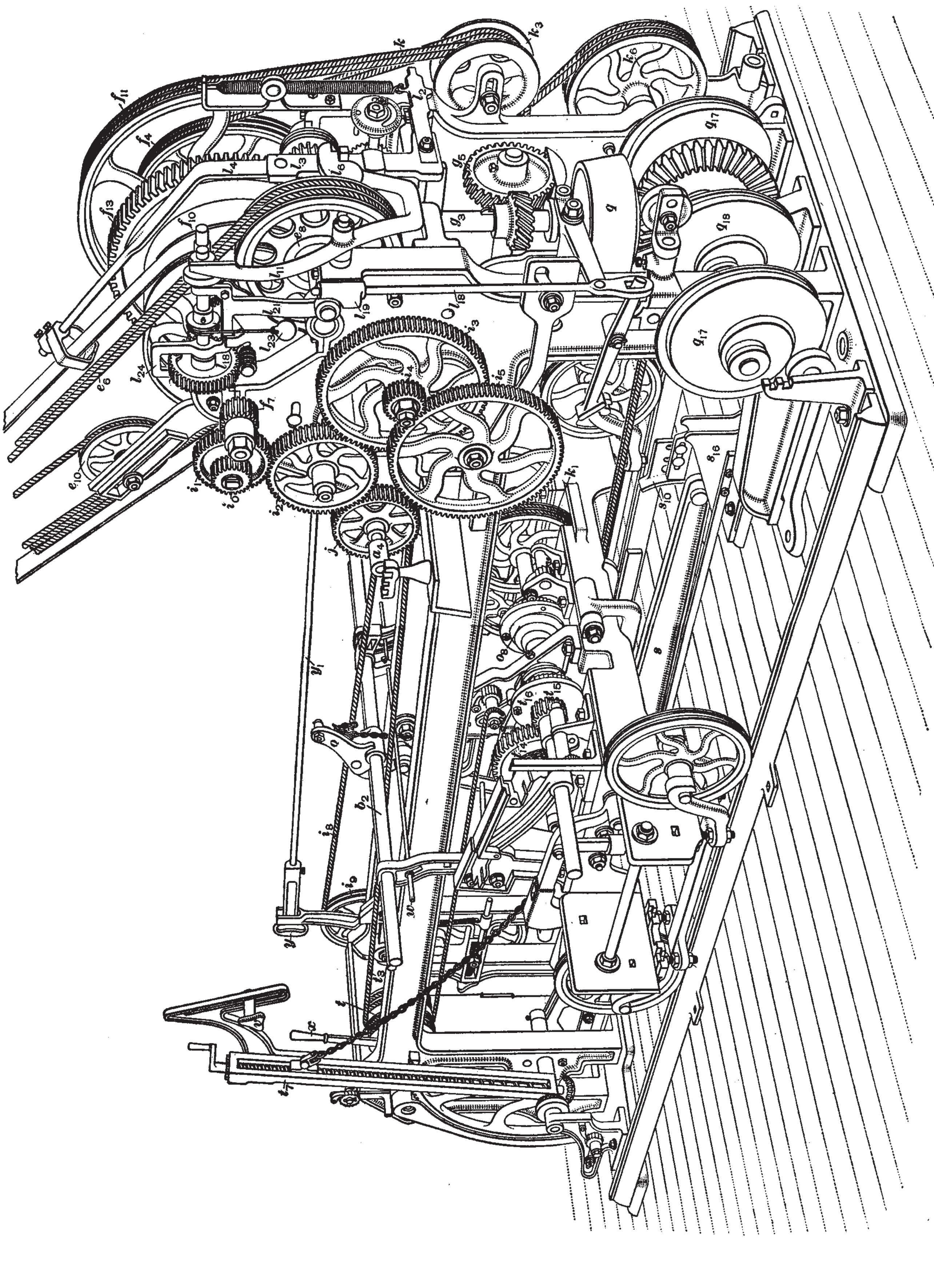


Fig. 5

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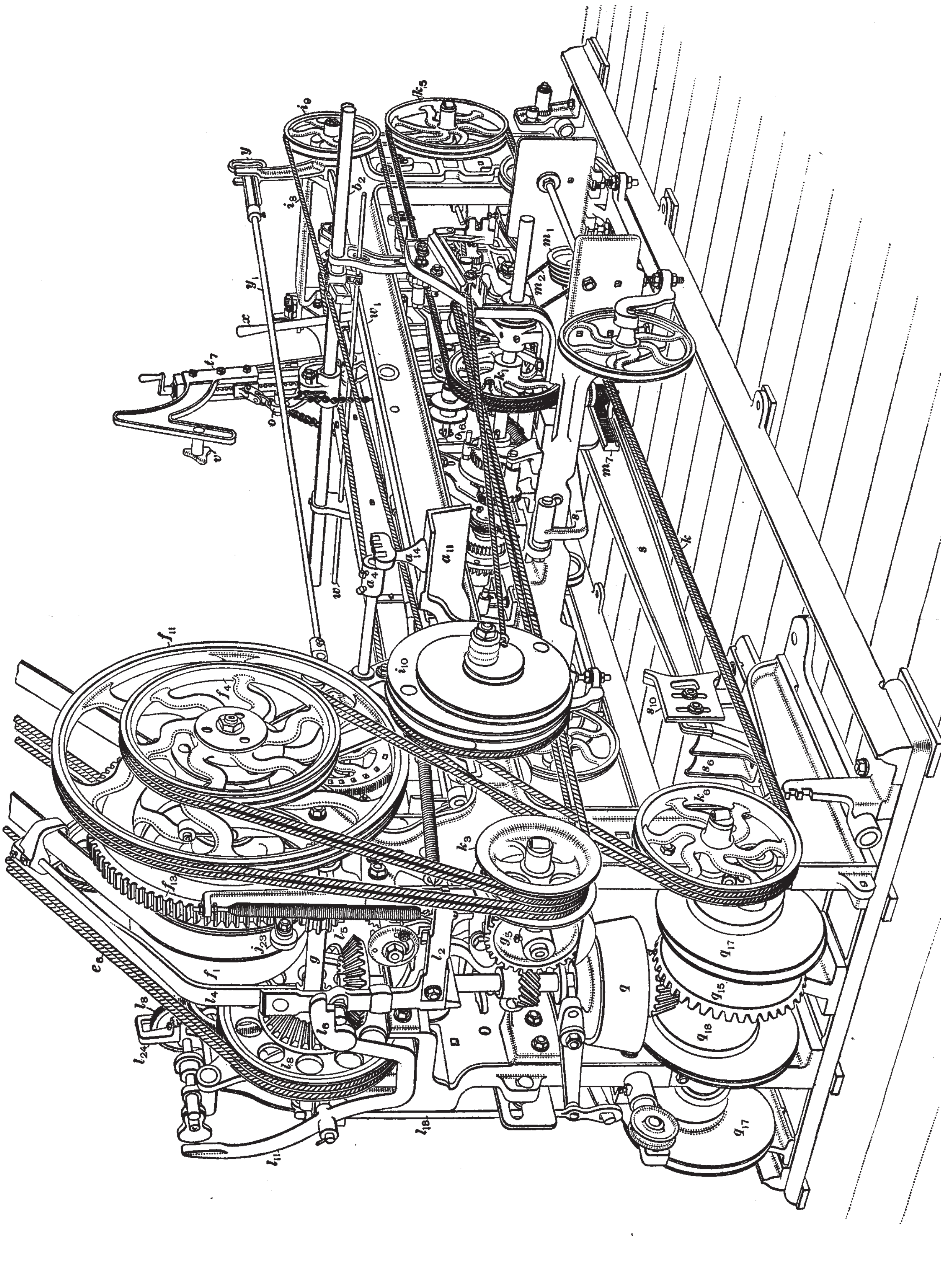

FIG. 6

*Rotated 90° degrees to fit on page.*

with the carriage and delivery mechanism removed. Fig. 6 is a perspective view of the left-hand side of the headstock as seen from the back with the carriage and delivery mechanism removed. The ropes for drawing in the carriage have been omitted from these views, to avoid confusion. Some portion of every motion is visible in at least one of these illustrations.

**21. Headstock.**—The **headstock** consists of a stationary iron framework supporting the mechanisms that perform the majority of the various motions necessary in the operation of the mule. It is not situated opposite the centre of the carriage, but a little to one side, which causes the carriage to be divided in two sections, of unequal lengths. Only a portion of the carriage is shown on each side of the headstock, which extends from the front to the back of the mule, as shown in Fig. 4 ; but it must be understood that the carriage extends for a considerable distance in either direction, in some cases as much as 40 feet. The headstock contains the *rim shaft*, or main driving shaft of the machine ; the *cam-shaft*, which controls the period of action of the various motions ; the friction couplings for backing off and drawing in ; a portion of the spindle driving mechanism ; a part of the roller driving mechanism, etc.

**22. Arranging Pair of Mules.**—The one-sided position of the headstock is clearly seen from Fig. 7, which is a plan view of two mules placed front to front. The headstock is placed in this unsymmetrical position so as to save floor space. Strictly speaking, the headstock is in two parts, the elevated part $A$ at the back carrying the driving pulleys, rim shaft, etc., and which is termed the *headstock* proper ; and the part $A_2$ at the front, termed the *tail-piece*. The mules are placed together in pairs, with the carriage of one facing the carriage of the other, as shown in Fig. 7, and so that the headstock of one mule does not come opposite to the headstock of the other, but a little to one side. If the headstocks were placed in a central position and a sufficient space were left between the two tail-pieces, there would be a waste of space between the carriages. This is avoided by arranging the headstocks a little to one side of each other, thus producing what are known as a *long side* and a *short side* to each mule. The long side of one mule faces the short side of the other mule, as shown in Fig. 7.

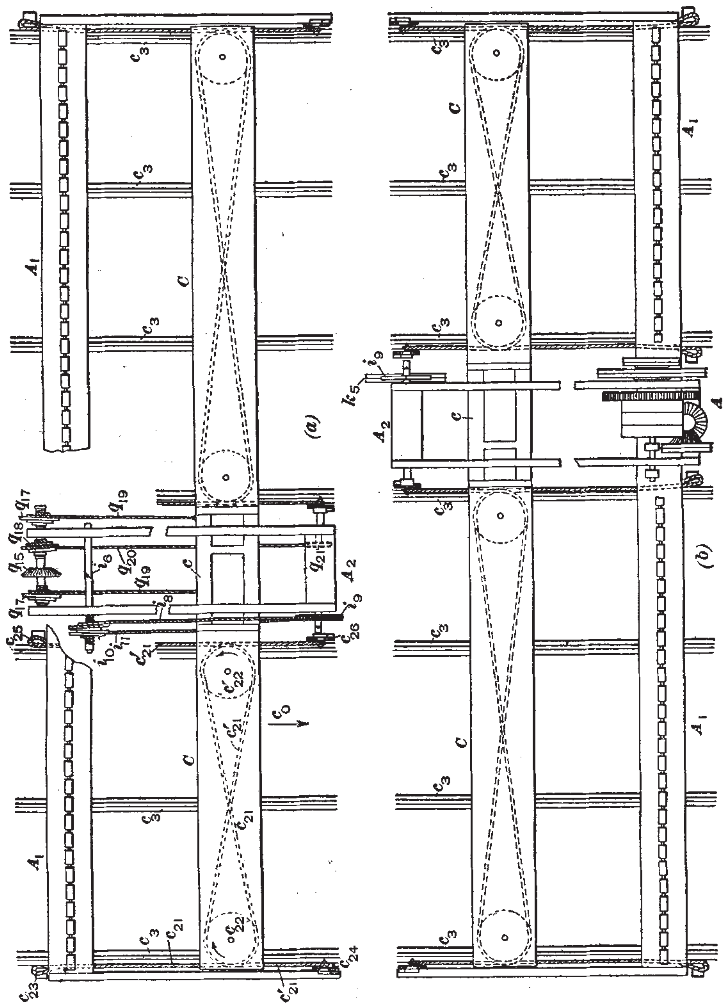

FIG. 7

**23.** In the process of spinning the principal duty of the operatives is that of piecing broken threads, and this can be done only when the carriage is about a yard distant from the *roller beam.*

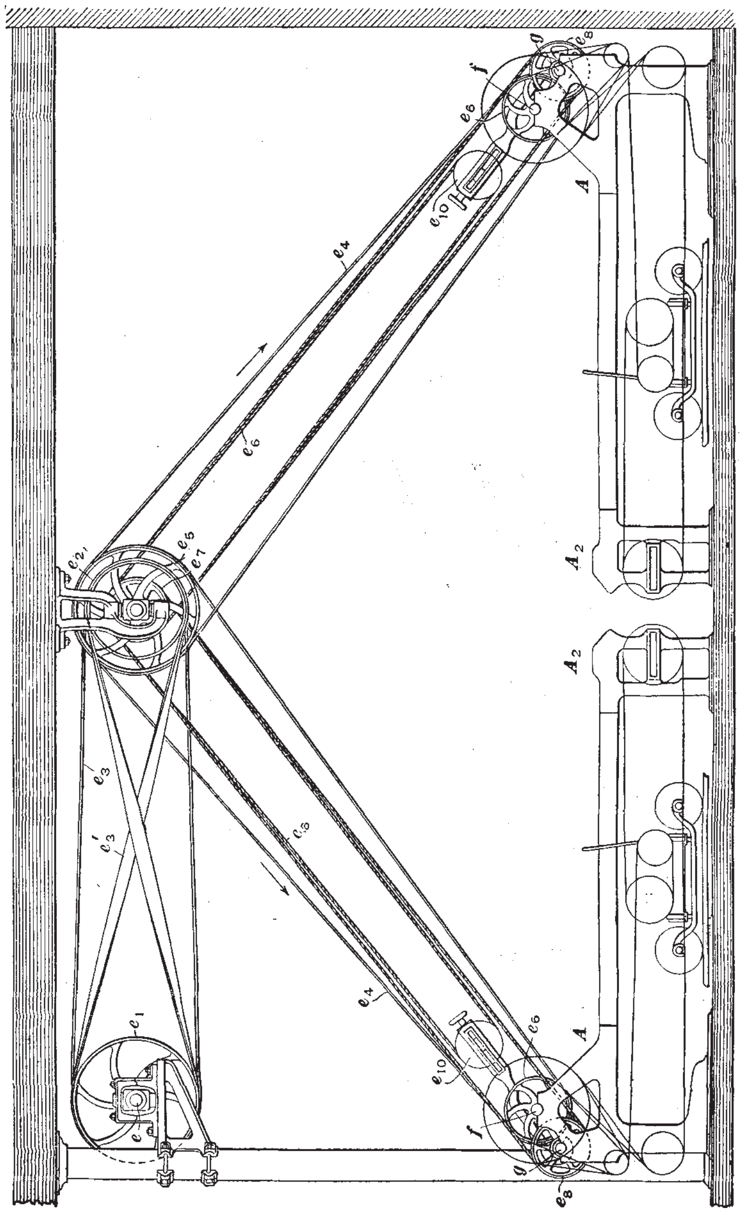


Fig. 8

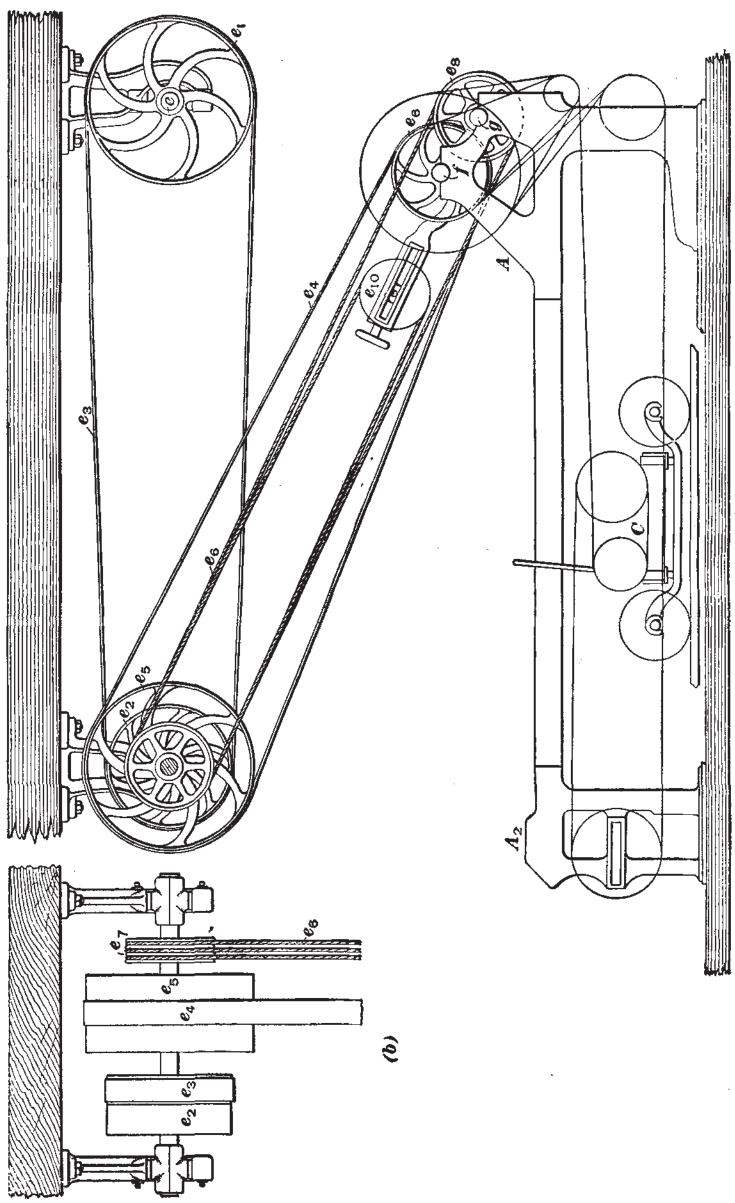


Fig. 9

The **roller beam** is the stationary frame, or creel, $A_1$, Fig. 7, that extends to the right and the left from the headstock and supports the bobbin drums and delivery rollers. In view (*a*) a portion of the roller beam is removed, also the upper part of the headstock, so as to show the scrolls and their connections with the carriage and the tail-piece. By arranging the mules, as in Fig. 7, the three operatives, that usually attend to two mules, may conveniently perform their various duties, since one mule can be arranged to be twisting while the carriage of the other is coming out ; the operatives can thus attend alternately to each mule to piece broken threads. By arranging the headstocks on opposite sides of the carriage centre line the operatives can readily pass from side to side of each mule.

**24. Driving, Rim, and Back Shafts.**—Figs. 8 and 9 are diagrammatic side elevations of the belt drive for a pair of mules, while Fig. 10 is a plan view of a portion of the drive. The **rim shaft** $f$, shown in these views, is the main driving shaft of the machine, as it is through this shaft that the power for operating nearly all the parts is transmitted. It is usually driven from the main shaft $e$ of the room through a countershaft, so that when required the belts and ropes driving the mule can be stopped. The main shaft carries pulley $e_1$ which drives pulleys $e_2$ on the countershafts by means of belts $e_3$. The countershaft for one of each pair of mules is driven from the line shaft by a crossed belt $e'_3$, as shown in Figs. 8 and 10. The driving of the countershafts is arranged in this manner in order that the mules composing one pair may be driven in opposite directions. When the belts $e_3$ are on the fast pulleys at $e_2$, the belts $e_4$, which are driven from pulleys $e_5$ on the countershafts, drive the pulleys on the rim shafts $f$. Pulleys $e_7$ on the countershafts drive by means of ropes $e_6$ the 12-inch rope pulleys $e_8$ fixed on the *back shaft* $g$, which is situated at the back of the headstock. The ropes are tightened by a screw and carrier wheel, shown at $e_{10}$, by which arrangement the rope is also allowed to cross back to the third groove from the first in the rope pulleys $e_7$.

**25.** As the pulley $e_5$ by means of the belt $e_4$, Figs. 9 (*a*) and 10, drives the rim-shaft pulleys on $f$, which are three in number, the

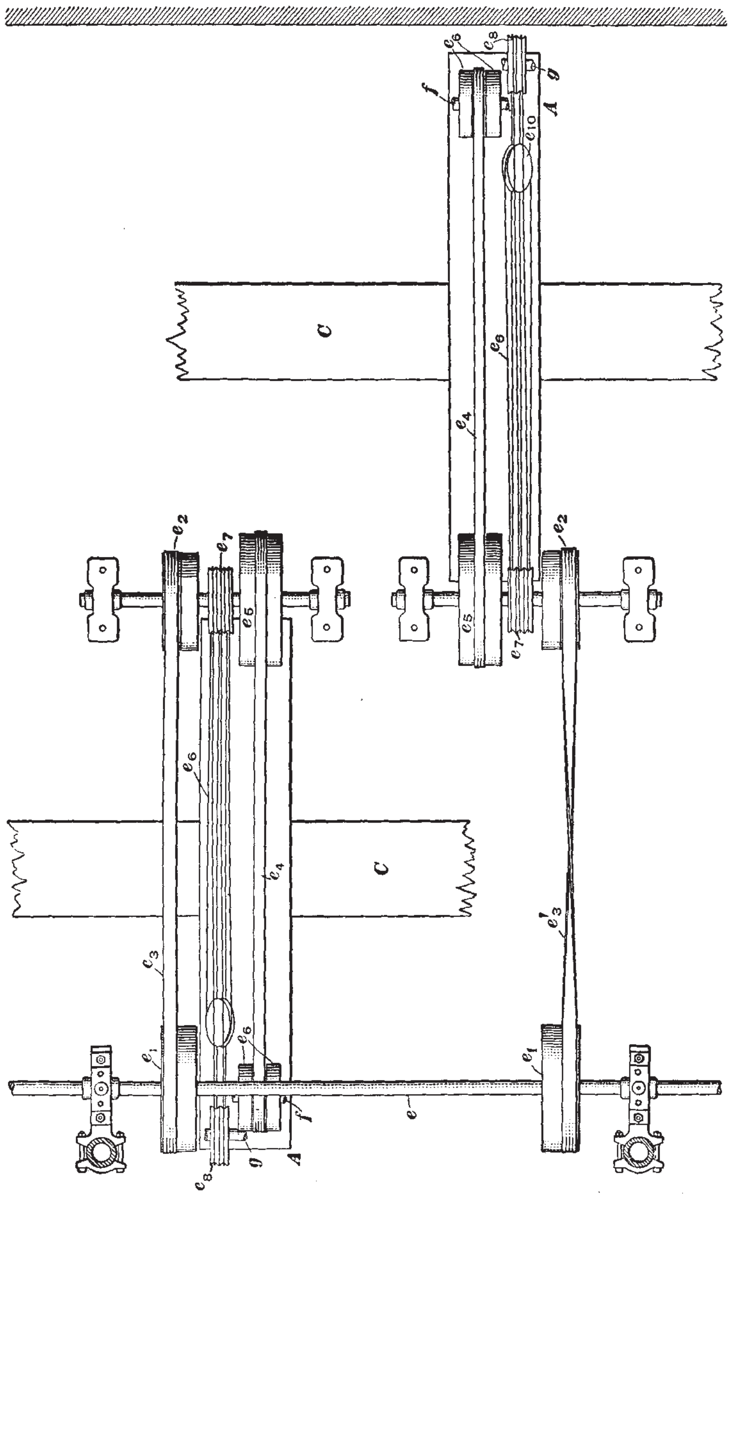

Fig. 10

pulley $e_5$ must be wide enough to allow the belt to operate any one of them. The rim shaft $f$, and a section of some of the pulleys and other parts carried by it, are shown in Fig. 11. The 2-inch rim shaft $f$ has keyed to it a pulley $f_1$, so that when the belt $e_4$ is on this pulley the rim shaft must revolve; the belt is on this pulley only while the carriage is on the outward run, as it is drawing the roving. Near one end of the rim shaft is keyed a disc $f_2$, which carries three studs $f_3$, only one of which is shown. These studs fit into suitable holes in the boss of the *spinning-rim pulley* $f_4$, generally termed *spinning rim*, a nut $f_5$ securing its

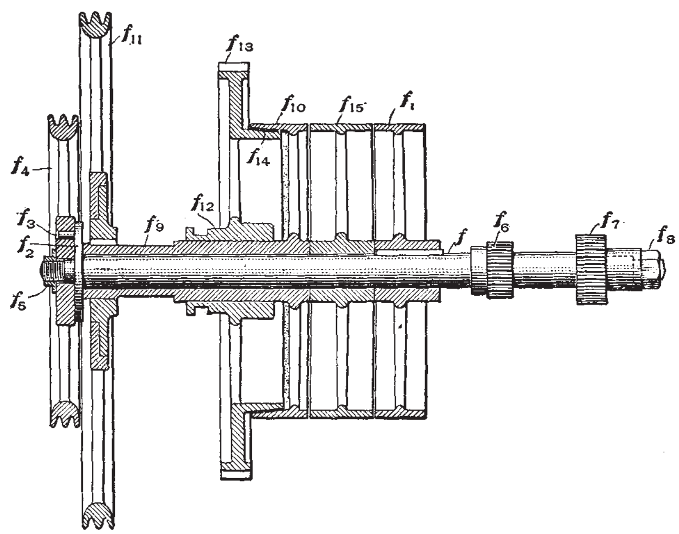


Fig. 11

position. The wheel $f_6$ gives motion to the twist-regulating mechanism; the gear-wheel $f_7$, fixed on the end of the rim shaft by a nut $f_8$, drives the mechanism by which the carriage is drawn out. On one end of the loose sleeve $f_9$ is fixed a pulley $f_{10}$, and on the other end a large double-grooved rim pulley $f_{11}$, termed the *twist*, or *double-speed, rim*. The double-speed rim is driven through pulley $f_{10}$, when the carriage is out. On sleeve $f_9$ is a loose sleeve $f_{12}$, which carries the large *backing-off wheel* $f_{13}$ and *backing-off friction cone* $f_{14}$. When the operation of twisting is completed and the belt moved on to the loose pulley $f_{15}$, the sleeve $f_{12}$, and thus the backing-off wheel and the leather-covered friction cone, are moved along sleeve $f_9$ until the backing-off friction drives by friction the pulley $f_{10}$.

**26.** The position of the rim shaft, as shown in Figs. 7 to 10, is parallel to the carriage, but in older types it is at right angles to it. It is then necessary to use bevel gear-wheels to drive those shafts that require to be parallel to the carriage. This type is known as the *cross-drive* and was formerly largely used; it has the advantage that any number of mules, placed in a row one behind the other, can be driven from one line shaft. At the present time most woollen mules are made with the rim shaft placed parallel to the carriage; this is known as the *parallel drive*, and is most suitable in ordinary mill work where the line shafting runs lengthwise, as up to four pairs of mules can be driven direct from it. This latter type is generally considered the simpler and most satisfactory, and is the one that will here be described.

**27. Roller Beam.**—The roller beam $A_1$, Fig. 7, carries the bobbin drums and delivery rollers and is supported by a number of stands divided into two parts $a_7$, $a_8$, Fig. 1, that can be adjusted in their relative positions by bolts $a_9$. A beam $a_{10}$ and angle bar $a_{11}$ extend from the headstock to each end of the mule; between these are placed at intervals cross-stays $a_{12}$, which carry the bobbin stands $a_{13}$, against which rest the studs of the condenser bobbins. Small notches are provided in the stands $a_{13}$ in which the studs of the full or empty bobbins may rest. Supporting the $1\frac{1}{2}$-inch bottom delivery roller and raddle are castings $a_{14}$, which are placed at intervals of from 10 to 14 inches along the angle bar $a_{11}$. Each section of the $2\frac{1}{2}$-inch top rollers rests on and controls two threads; the top rollers are made larger in diameter than the bottom roller to obtain a sufficiently heavy roller, so that it may grip the roving securely. The loops in the raddle $a_2$, Fig. 1, are alternately broad and narrow, so that the threads pass under each top roller in pairs. In connection with the roller beam, mention must be made of the *back stops*, one of which is shown at $a_{15}$. The **back stops** are for the purpose of preventing the carriage overrunning itself when coming toward the roller beam and doing damage to the spindles or other parts.

**28. Carriage.**—The **carriage** $C$ is that portion of the mule which travels backwards and forwards during the operations of spinning and winding. Its object is to keep the yarn under tension, so as to prevent the ends from becoming slack, also to impart a certain amount of draft to the yarn and to carry the parts required for performing these operations. It carries the tin roller for imparting motion to the spindles, and the fallers for guiding the yarn on to the spindles.

**29. Carriage Square and Slips.**—The **carriage square** is that portion of the carriage that lies directly within the headstock, as at $c$, Fig. 7; it serves to carry that portion of the mechanism that drives the spindles during the various periods in the action of the mule, also the faller-locking devices, etc., and to connect the two sections of the body of the carriage which are on either side of the headstock; for that purpose it is provided with the necessary cross-pieces so as to be perfectly rigid. The plan view of the carriage with carriage square, shown in Fig. 7, is without the various mechanical devices for operating the parts mentioned. The rails, or slips, $c_3$, Figs. 1 and 7, on which the carriage runs are laid about 10 to 15 feet apart, and at each side of the headstock the slip is bolted to the foundation plates so as to obtain the maximum firmness. The arrangement of the slips for the long and short sides of the carriage is shown in Fig. 7.

**30. Adjustments of Carriage.**—The carriage may be adjusted vertically by the nuts $c_9$, Fig. 1, and the thick rails $c_{10}$ and $c_{11}$ horizontally by the nuts on stayrods $c_{12}$; by this means the spindles can be set with their tops in one straight line and also given the correct inclination or *bevel*. Means for obtaining the correct angle of the spindles is necessary, since, if they are set too nearly vertical, the yarn is not so easily released by the spindle and has a tendency to break. If, on the contrary, the spindles are inclined too much, a portion of the yarn is pulled from the bobbin or cop, and as a result the thread is made longer and thicker, as it receives less twist per inch of length. The thin boards $c_{13}$ serve simply as covering boards. The tin roller $c_4$ is made in sections 8 to 10 feet long from heavy sheet tin, each section being connected by a short shaft, which rests in bearings $c_{14}$, made adjustable in a horizontal direction so as to give the cylinder a correct alinement throughout its length. The bearings are supported by cross-stays and provided with an oil cup $c_{15}$; in many cases a tube passes through the board $c_{13}$ by means of which each bearing may be lubricated from the outside.

**31. Dimensions of Spindles.**—The spindle $c_7$, Fig. 1, is made in various sizes, but the distance between the footstep at the bottom and the bolster $c_{16}$ is generally about 7 inches. The length of the spindle above the bolster rail depends on the class of work for which the mule is built; for weft bobbins the length is usually about 9 inches, while for long-warp cops it is usually about 11 to 12 inches. The full length of the spindle in each case is about 17 and 20 inches, respectively. Each spindle is pointed at its lower end, where it fits into the brass footstep to reduce friction during rotation. The portion of the spindle that is situated between the wharl and the bolster is the largest in diameter, generally about $\frac{5}{16}$ to $\frac{3}{8}$ inch, while the point is about $\frac{3}{16}$ to $\frac{1}{4}$ inch in diameter. The spindle is tapered gradually from a point just above the bolster, so as to facilitate the removal of the cops and to reduce the resistance to the yarn slipping over the point during twisting. The distance between the footstep and the bolster can be adjusted by the slotted ends of the supporting parts $c_{17}$ and $c_{18}$. The front board $c_{19}$ is hinged at its lower side to allow it to open outwards and thus give access to the spindle bands whenever their renewal becomes necessary. The top board $c_{20}$ is arranged to fit over the wharls to prevent them from accidentally jumping out of the footsteps.

**32. Pitch of Spindles.**—The **gauge**, or **pitch**, of the spindles is the distance between the centres of adjoining spindles. It varies according to the class of work for which the mule is intended. For coarse counts and large cops the pitch of the spindles might be as much as $3\frac{1}{2}$ inches; the usual pitch is $2\frac{1}{2}$ inches, which for weft yarn is reduced to $2\frac{1}{4}$ or even 2 inches. The number of spindles is variable and depends on the class of yarns to be spun, the pitch of the spindles, the size of the room, and the arrangement of the mules, etc. About the greatest number of spindles to one mule is 500, and the smallest about 150; but it is generally found that a mule with 400 spindles of $2\frac{1}{8}$ to 3 inches pitch is as long as can be satisfactorily operated. The total length of a mule with 400 spindles of $2\frac{1}{2}$-inch pitch is about 88 feet. The length of a mule increases, approximately, in direct proportion with the pitch and number of spindles.

**33. Squaring Bands.**—The **squaring bands** serve the purpose of keeping the carriage in proper alinement with the roller beam, so that the spindles will be equidistant from the delivery rollers; they also serve to prevent the carriage from being strained, and, as a consequence, alternately curving toward or away from the roller beam. If the carriage assumes a curved form the spindles will not be equidistant from the rollers. When this curvature is suddenly changed, as when the carriage changes its direction of motion, the stretch will not be the same along the whole length of the carriage, and the yarn will be strained and may break. By reason of its great length it is not practicable to construct the carriage so that it will be perfectly rigid; consequently, since the ropes that move the carriage forwards and backwards are fastened at the centre, there is a tendency for the carriage to warp so that the line of spindles will not be parallel to the delivery rollers. This tendency, which exists when the carriage is being drawn in, as well as when it is being drawn out, is overcome to a certain extent by the faller shafts $b_2$ and $b_5$, Fig. 1, and by inserting cross-stays of wood, and iron rods; but the most effective means is by the use of squaring bands.

**34.** Squaring bands consist of strong ropes $c_{21}$, Fig. 7, which pass round double-grooved pulleys $c_{22}$ that are supported in a horizontal position underneath the carriage, one pulley being required at each end of the carriage and on each side of the headstock. Four bands are required for each mule, two for each section of the carriage, the arrangement of the bands in each being similar. The end of one rope is fixed to a stud attached to the roller-beam stand at $c_{23}$, and is passed round the front of pulley $c_{22}$, then diagonally across the carriage and to the back of pulley $c'_{22}$; from this point the rope passes to the front to the ratchet wheel and pawl $c_{26}$, where it can be tightened, as required. The end of the other rope $c'_{21}$ is fixed to a stud $c_{25}$ attached to the roller-beam stand and is passed round the front of the pulleys $c'_{22}$, then diagonally to and round the back of pulley $c_{22}$ to the ratchet $c_{24}$ at the front, by which it may be tightened as required.

**35.** The principle on which the ropes and pulleys, Fig. 7, operate to preserve the correct alinement of the carriage may be understood from the following explanation. Assuming that the carriage shown in the upper part of the illustration is being pulled in the direction of the arrow $c_0$, then the stationary ropes $c_{21}$ and $c'_{21}$ will compel the pulleys $c_{22}$, $c'_{22}$ to revolve in the directions indicated. Should the outer end of the carriage with its pulley $c_{22}$ have a tendency to lag behind, it would mean that this end, momentarily, would move slower, hence the pulley $c_{22}$ would revolve more slowly. But, by reason of the pulley $c_{22}$ being connected to pulley $c'_{22}$ by the ropes $c_{21}$, $c'_{21}$, any difference in speed will not be possible. Therefore, whenever the pulley $c_{22}$ tends to lag behind, it will be positively driven by the pulley $c'_{22}$ and will thus assist in pulling the carriage forwards by means of the rope $c'_{21}$.

**36. Faller Stands.**—The **faller stands** are the supports for the faller shafts and sickles, and must be adjustable. The stands themselves, one of which is shown at $b_6$, Fig. 1, is hinged at its lower end by a stud to a bracket fixed to the bottom board $c_{27}$. The stand is held to the carriage and adjusted into a position, nearer or farther from the spindles, by a bolt $b_7$ with suitable adjusting nuts. The faller shafts $b_2$ and $b_5$ extend from end to end of the carriage and carry the sickles which support the wires for winding and guiding the yarn; these sickles may be fastened in any desired positions on the shafts by setscrews. The faller stands also support the stop-rod $w$ by which the mule can be stopped or started from any point.

**37. Stretch.**—The **stretch**, **draw**, or **run**, is equal to the traverse of the carriage, and may be from 72 to 90 inches. Of late, the tendency has been toward increasing the stretch; for where 66 and 72 inches was formerly common, 72 to 84 inches is now the general practice. While time is saved by having a longer stretch, excessively long stretches may not be entirely advantageous, since the twist necessary for good spinning cannot be equalized as easily over a length of 90 inches as over a length of 66 to 72 inches.

**38. Driving Cam-Shaft.**—Fig. 12, which is a rear elevation of the headstock, shows the position and means for driving the

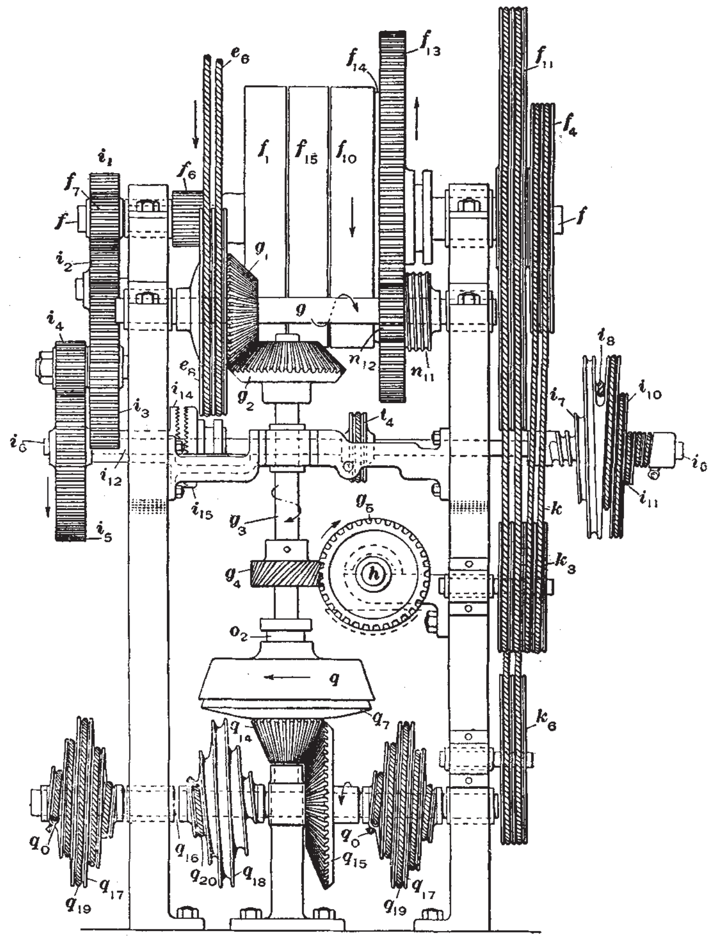


Fig. 12

**cam-shaft** *h*, which controls directly or indirectly the commencement and duration of the various motions, and also prevents conflicting motions from being set in operation at the same time. The cam-shaft is about 24 to 30 inches long and is supported within and near one side of the headstock by suitable brackets. This shaft is driven from the back shaft $g$, which receives its motion by ropes $e_6$ from the countershaft, the ropes driving pulley $e_8$, on the back shaft, as shown in Figs. 8, 9 and 10. The bevel wheel $g_1$ which is fixed to the back shaft $g$, Fig. 12, drives a similar bevel wheel $g_2$, fixed to the upright shaft $g_3$. To this shaft is fastened a *spiral gear-wheel* $g_4$, also termed a *skew bevel wheel*, that drives another spiral gear-wheel $g_5$, fixed on the rear end of the cam-shaft, the relative sizes of the two spiral gear-wheels being as 2 to 3. It follows from the mode of driving it, that the cam-shaft is revolving continuously.

**39. Details of Cam-Shaft.**—Fig. 13 (*a*) is a perspective view of the side frame of the headstock showing the cam-shaft in position; in views (*b*) and (*c*) the latter is shown in a side elevation and in section, respectively. On the cam-shaft is placed the cam-shell $h_1$, which carries the cams; this shell is made to revolve one-half of a revolution each time the carriage reaches the end of its inward or outward journey. The shell $h_3$ of a friction coupling is fixed to the front end of the cam-shaft; the cone $h_3$, which is leather-covered, is connected by means of the sleeve $h$ to a disc $h_4$, which carries two projections $h_5$ and $h_6$ placed diametrically opposite each other, but at different distances from the centre; a small incline leads from the surface of the disc toward the end of each projection, as shown.

**40. Cam-Lever.**—Along the inside of the headstock there is placed a lever $h_7$, Fig. 13 (*a*), called the **cam-lever**, which is pivoted on the bolt $h_{16}$. The lever extends nearly from the end of the tail-piece to the centre of the headstock, at which end it is provided with a bracket $h_8$ that carries a fixed pin $h_9$, as shown in Fig. 13 (*b*). The extent of the angular movement of the lever is determined by the width of the recess $h_0$ in the bracket $h_{17}$. Motion is imparted to the lever by the faller shafts $b_2$, $b_5$. When the carriage goes outward the faller shaft $b_5$ makes contact with the inclined end of the casting $h_{18}$, fastened to the outer end of the cam-lever, and depresses it, thus causing the other end, to which is bolted a similar casting $h_{19}$, to rise. The

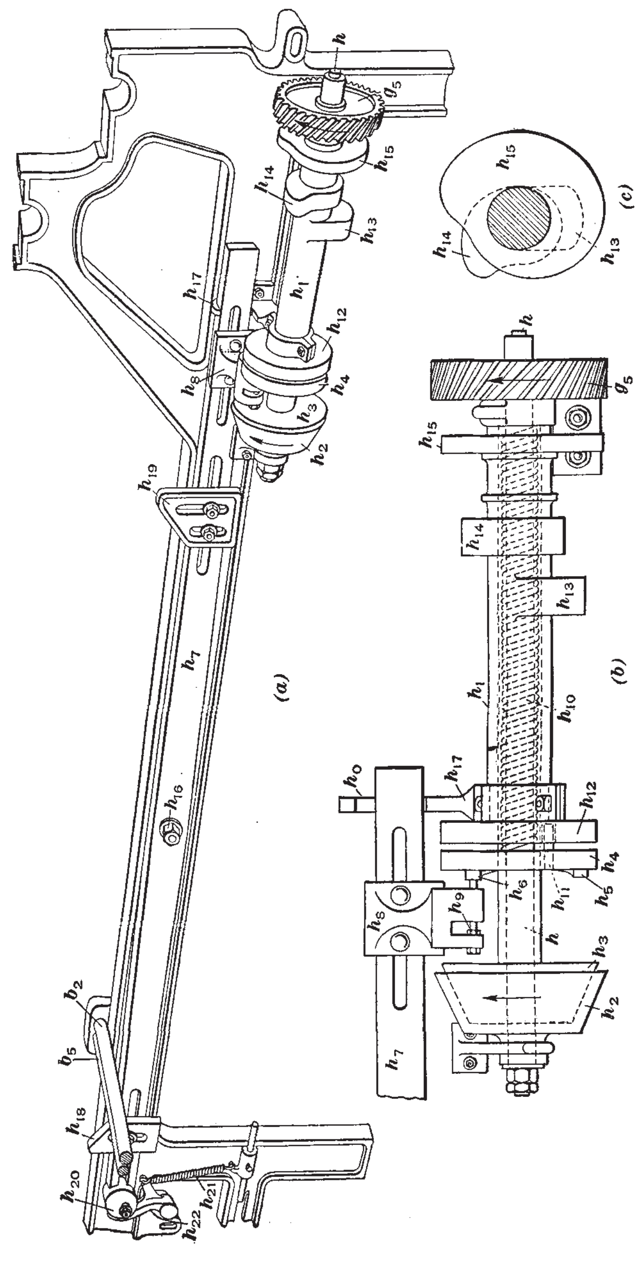
(a)
(b)
(c)
h
g5
h1
h2
h3
h4
h5
h6
h7
h8
h9
h10
h11
h12
h13
h14
h15
h16
h17
h18
h19
h20
h21
h22
h0
b2
b5

FIG. 13

outer end of the cam-lever carries a small weight $h_{20}$ having a pin resting in one of two notches in the lever $h_{22}$ which is constantly forced against the pin by the spring $h_{21}$ for the purpose of holding securely the cam-lever in either one of the positions into which it may have been forced by the faller shafts. When the carriage returns to the roller beam, the raised casting $h_{19}$ will be depressed and the parts returned to their original positions.

**41. Operation of Cam-Shaft Friction Cone.**—When the pin $h_9$, Fig. 13 (*b*), is moved down with the end of lever $h_7$, it will be in a position to meet the projection $h_6$, which is nearest the centre of the disc $h_4$; but when the pin is moved into its upper position, it will be in the path of the stud $h_5$. The disc $h_4$ is continually forced to the left by means of the long, coiled spring $h_{10}$, so as to compel the two parts $h_2$, $h_3$ of the friction cone to make contact and cause the sleeve $h_1$ to revolve, the motion of the disc $h_4$ being transmitted to $h_{12}$ by means of a stud $h_{11}$ which is fastened to $h_4$ and projects through a hole in $h_{12}$. Whenever the friction cone operates, the disc $h_4$ will revolve until the inclined part of $h_6$ comes against the pin $h_9$. Since the latter is fixed, the disc $h_4$ will be forced to the right against the pressure of the spring $h_{10}$, and, as the friction cone is forced out of action, the disc $h_4$ will cease to revolve, and likewise disc $h_{12}$ with its shell $h_1$ and cams $h_{13}$, $h_{14}$, and $h_{15}$. When the carriage finishes its outward journey and the faller shaft $b_5$ forces the incline $h_{18}$ downwards, the cam-lever lifts the pin $h_9$, hence the stud $h_6$ with the disc $h_4$ will be free to move to the left, permitting the friction cone to operate for another half of a revolution, that is, until the projection $h_5$ again forces the friction cone out of action. The two half-revolutions of the sleeve $h_1$ are made once for every draw of the mule.

## DETAILS OF OPERATION

### DRAWING-OUT MOTION

**42. Driving Delivery and Drawing-Out Motion.** — Motion is given to the bottom delivery roller and the carriage from change pinion $f_7$, Figs. 12 and 14, on the rim shaft through carrier wheels

$i_1$, $i_2$, to the wheel $j$ on the shaft of the bottom delivery roller $a_4$. A small pinion on this roller, at each end of the mule, drives through a double carrier wheel $a_5$, $a_6$, Fig. 1, the bobbin drum $a_1$.

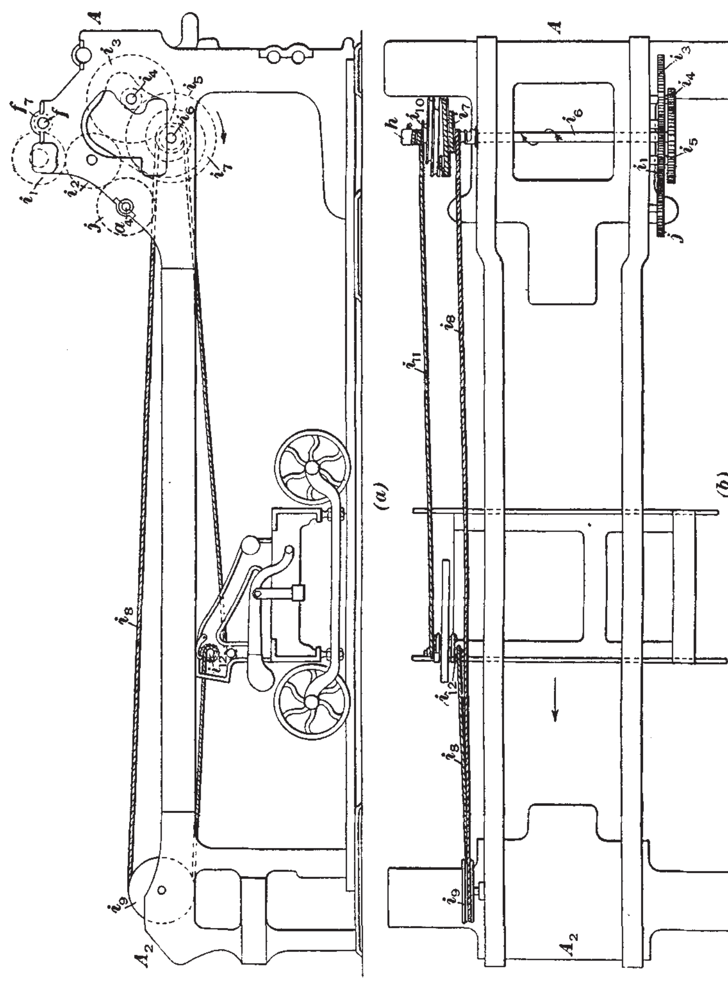

FIG. 14

A double carrier wheel is used so that one of them may be made to act as a change wheel. A change wheel is necessary since some materials are required to be unwound from the condenser bobbin at a different speed to others ; for instance, lofty materials will be unwound at a slower rate from the condenser bobbins than heavy materials, consequently a wheel with one or two teeth more will be used at $a_6$, when a change from lofty to heavy materials is made. In practice, the sizes of wheels at $a_6$ would range from 56 to 60 teeth, and these sizes will cover the whole range of qualities. The wheels $a_4$, $a_5$, and $a_6$ cannot be seen in Figs. 4, 5, and 6, as they are situated at the extreme end of the roller beam.

**43. Drawing Out of Carriage.**—The carriage is drawn out simultaneously with the delivery of roving, the carriage receding from the roller beam so that drafting and twisting of the roving may be carried on. The drawing out of the carriage is performed by means of the scroll shaft $i_6$, Figs. 7, 12, and 14, which receives its motion from the rim shaft $f$ through the pinion $f_7$ and carrier wheels $i_1$, $i_2$, $i_3$, and $i_4$, the latter driving the wheel $i_5$ on the scroll shaft. As this shaft revolves at a uniform speed, the variations in speed required for the operation of the carriage must be obtained by means of the *scroll* $i_7$.

**44. Scrolls.**—The motion of the carriage is not uniform throughout the stretch. When leaving the roller beam it moves very fast in the first part of its travel in order to keep pace with the delivery of roving by the delivery rollers. When the delivery of roving stops, the speed of the carriage is immediately reduced and the combined drafting and twisting of the roving commences. This variation in speed of the carriage is necessary, since, if it commenced the draw by moving slowly, there would be so much twist put into the roving at the start, before the drafting was completed, that it would be impossible afterwards to draw the yarn to the required count. Had the speed of the carriage been uniform throughout, motion could have been transmitted to it by means of a cylindrical rope drum; but as the requirements are that the speed shall be variable in a manner to suit various materials and products, peculiarly shaped pulleys, known as **scrolls**, are used. These are provided with spiral grooves that run along varying diameters of the scroll, the diameter being in accordance with the speed required at certain points of the stretch.

**45.** Scrolls may be used for one or two ropes. A scroll of the first kind is shown at $q_{17}$, Fig. 12 ; it has a ring at $q_0$ to which one end of the rope is attached. The rope is wound round the scroll in the continuous, spiral groove provided for it, and the free end at the right is connected to the part to which motion is transmitted. It is seen that the groove at the left is near the centre of the shaft, but that this distance increases toward the middle of the scroll, from which point it gradually approaches the shaft again. This indicates that when the scroll begins to pull the rope, the speed of the latter will gradually increase and then decrease again at the same rate.

It is evident that if the connection between the scroll and the carriage is by means of one flexible rope, it is not possible to control the motion of the carriage at all times. For instance, after the carriage has attained its maximum speed the rope would not be able to check the motion or to stop it. For this purpose it is necessary to have a supplementary scroll, as $q_{18}$, termed a **check-scroll,** on which the rope is wound in a direction opposite to that in which it is wound on the scroll $q_{17}$ ; the scrolls are otherwise entirely similar. By using a check-scroll in combination with another scroll, one scroll will wind up one rope while the check-scroll will unwind another rope at the same speed ; consequently, if both ropes are taut, the carriage will at all times be under complete control.

**46.** An example of a scroll operating two ropes is shown at $i_7$, Figs. 12 and 14. In Fig. 15 the scroll is shown on a larger scale, views (*a*) and (*b*) being end and side elevations, respectively. The left- and right-hand parts of the scroll are entirely symmetrical, except that they are displaced relatively to each other to the extent of one-half revolution. In this case one half of the scroll acts as a check-scroll to the other half, one of the ropes being wound on the scroll while the other unwinds, the points where they make and leave contact being at the same distance from the axis of the shaft. Referring to Fig. 15, the end of one rope is attached to the ring *6′* and the end of the other rope is inserted in a hole near the point *1*, a knot being tied in it on the inside of the scroll. In Fig. 15 (*a*) the two series of convolutions are shown partly in dotted lines and, in order to distinguish them, similarly placed points in the right-hand scroll are indicated in view (*b*) by the numbers *1, 2, 3, 4, 5,* and those in the left-hand scroll by the numbers *1′, 2′, 3′, 4′, 5′*. Referring to the left-hand one, it is seen that from *0′* to *1′* the groove is nearly straight and that at *1′* the active part of the scroll begins, increas-

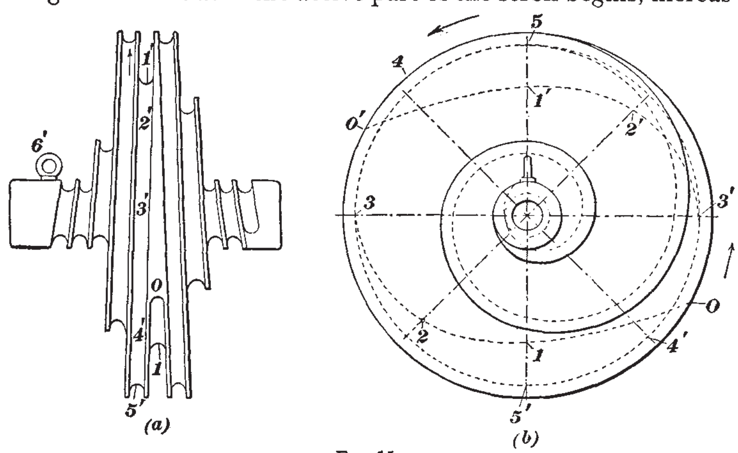


FIG. 15

ing in diameter at *2′*, and at *3′* attaining its maximum diameter, which is maintained during three-quarters of the circumference coinciding with point *5* vertically above the shaft centre. From this point the diameter of the scroll gradually decreases to the diameter of the small part at the extreme left. The relative positions of similar points in the right-hand half of the scroll are similar in every respect.

**47. Action of Scroll.**—The carriage is connected to the scroll $i_7$ by means of the rope $i_8$, Figs. 7, 12, and 14, which is fastened to the scroll, and after passing round the rope pulley $i_9$, at the tail-piece of the headstock, is attached to a ratchet and pawl $i_{12}$ by means of which the rope may be tightened. As the scroll $i_7$ is made to revolve in the direction indicated in Fig. 14 (*b*), for the purpose of drawing out the carriage, the rope $i_8$ will be wound up on the scroll. The largest diameter of the latter being about 12 inches, and this portion being reached after the first quarter-revolution of the scroll, it follows that when the scroll has made

$1\frac{1}{4}$ revolutions the carriage has moved away from the roller beam a distance of over 3 feet. The convolutions of the scroll then begin to decrease in diameter, so that the length of rope wound on for each revolution of the scroll becomes less and less until the part with the smallest diameter is reached, termed the *nose*, which may be less than 3 inches. While the carriage is being drawn by the latter part, it will move about 9 inches for each revolution of the scroll, or at a speed of about one-quarter of its maximum speed. As the rope $i_8$ is being wound on the scroll $i_7$ another rope $i_{11}$, fastened to the carriage, as shown in Fig. 7, is unwound from the scroll $i_{10}$, which serves as a check-scroll. From the fact that these ropes at any moment enter into contact or leave contact with the scrolls at points diametrically opposite each other, it follows that both ropes are under tension and, therefore, the carriage constantly is under control as to its speed and direction of motion.

**48. Driving of Scrolls.**—As the rim shaft *f*, Fig. 12, is constantly revolving in one of two directions, means must be provided for disconnecting the scrolls $i_7$, $i_{10}$ from the rim shaft, when the

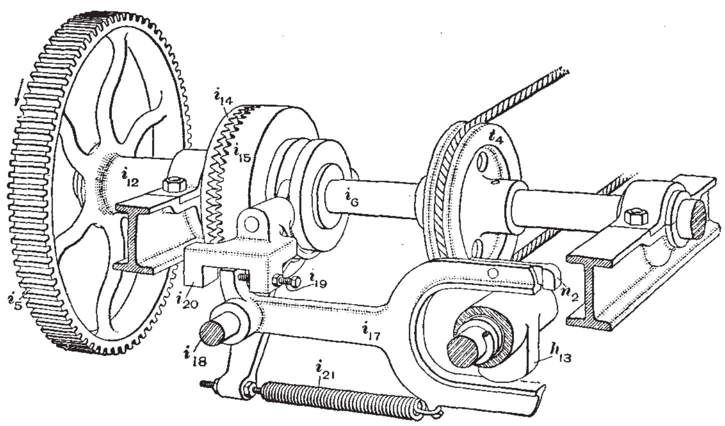


Fig. 16

carriage finishes its run toward the tail-piece. This is accomplished by means of the toothed clutch $i_{14}$, $i_{15}$, Fig. 16, in the following manner: The wheel $i_5$, which is driven from the rim shaft, Fig. 12, by means of intermediate wheels, revolves loosely on the scroll shaft $i_6$. The boss $i_{12}$ of wheel $i_5$ extends through the frame of the machine and carries at its inner end one half $i_{14}$ of a toothed clutch. The other half $i_{15}$ is keyed to the scroll shaft $i_6$ in such a manner that it may move longitudinally for a certain distance along the shaft. Thus, when the part $i_{15}$ by suitable means is pushed in gear with the part $i_{14}$ the latter will compel the scroll shaft $i_6$ to revolve; this shaft will stop when the clutch halves are separated.

**49. Stopping Scrolls.**—When the carriage reaches the end of its outward journey the cam $h_{13}$, Figs. 13 and 16, moves into the position shown from one diametrically opposite, and in doing so bears against the lower part of the fork-shaped lever $i_{17}$, fulcrumed on the rod $i_{18}$. The short arm seen above this rod will then move to the right and bear against the end of the adjustable bolt $i_{19}$ in the bracket $i_{20}$ and move the latter to the right. As this bracket supports a fork that rests in a groove formed in one end of the clutch part $i_{15}$, the latter will also move to the right and thus open the clutch and cause the scroll shaft $i_6$ to stop its rotation. The bracket $i_{20}$ is attached to a lever that turns loosely on the rod $i_{18}$ and at its lower end is acted on by a spring $i_{21}$ that tends to move the part $i_{15}$ so as to engage with $i_{14}$. At the end of the inward run of the carriage the cam $h_{13}$ makes again one half of a revolution and thus lifts the fork $i_{17}$; the end of the lever that is in contact with the bolt $i_{19}$ moves then to the left and thus allows spring $i_{21}$ to move the part $i_{15}$ into mesh with the part $i_{14}$. By giving the clutch teeth the peculiarly rounded form and by arranging the clutch to be put in action by means of a spring, provision is made for an automatic disengagement of the clutch in case of accident to the machinery.

## SLUBBING MOTION

**50. Construction of Slubbing Motion.**—The motion for regulating the amount of roving delivered by the delivery rollers for each stretch is termed the **slubbing motion.** It is necessary to be able to stop the delivery rollers at any point during the outward run of the carriage, that is, when a certain length of roving has been delivered. This is done by means of a toothed clutch on the bottom delivery-roller shaft, so arranged that when the carriage reaches the end of its inward run the two parts of the clutch will engage and cause the roving to be delivered as the carriage begins its outward journey. When from 40 to 60 inches of roving has

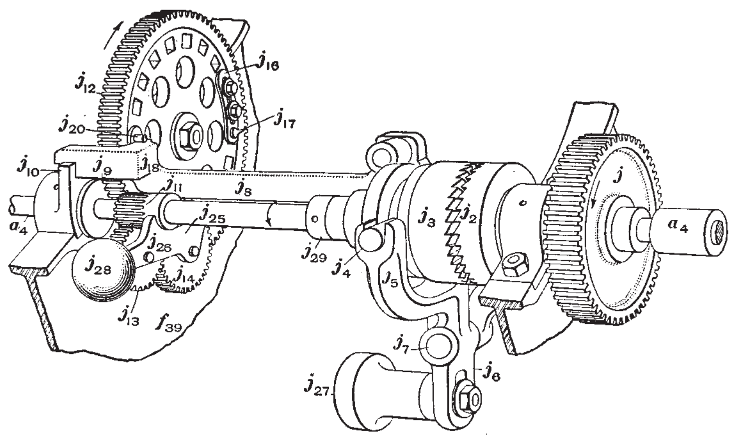


FIG. 17

been delivered the clutch is disengaged at any predetermined point. The parts relating to this motion are shown in perspective in Fig. 17, as they appear when viewed from the front; a rear elevation with a longitudinal section are given in Fig. 18 (*a*) and (*b*). Fig. 19 is an end elevation of the slubbing wheel and the parts that work in conjunction with it.

**51.** The gear-wheel $j$, Figs. 17 and 18, which is driven through carrier wheels from the rim shaft, as shown in Fig. 14, has a short sleeve $j_1$ that revolves loosely on the shaft of the bottom delivery roller $a_4$. The sleeve passes through the frame and connects with one half $j_2$ of a clutch. The loose half $j_3$ is controlled by the fork $j_5$ by means of pins which fit in a corresponding groove; the fork $j_5$ forms part of a lever $j_6$ pivoted on the stud $j_7$. This stud is carried by a bracket that extends from the frame, as shown in Fig. 18. To an extension of one of the fork arms is hinged a long arm $j_8$, which extends across the headstock and at its end is formed into an angular piece $j_9$, Fig. 17. One side of this piece has a recess that fits over the projection $j_{10}$ on the frame, when the clutch is in action, thus preventing the arm $j_8$ from moving in a longitudinal direction toward the left and opening the clutch. It is noted from Fig. 18 (*b*) that the loose half of the clutch $j_2$ is not fastened to the shaft $j_8$ by means of a key, as this means would

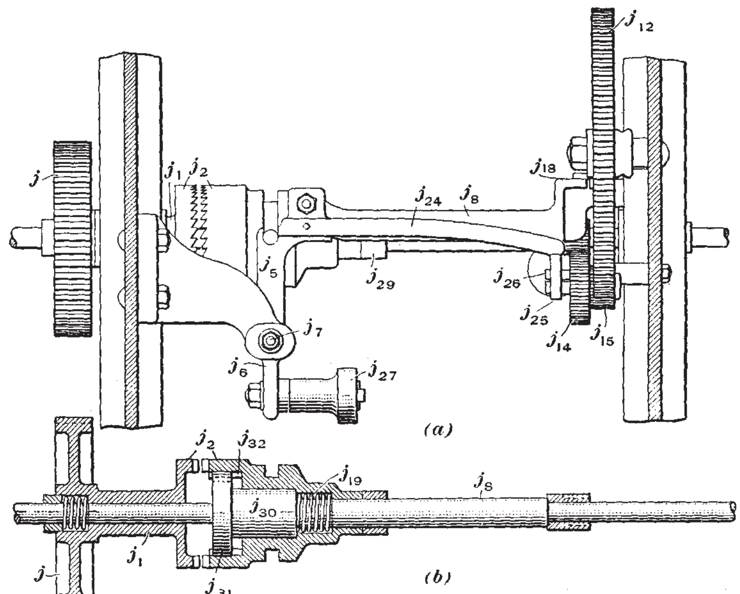


FIG. 18

not be sufficiently strong. In its place there is a boss $j_{30}$ with a collar $j_{31}$ keyed permanently to the shaft; the collar is provided with two slots, arranged diametrically opposite each other, into which fit two projections on the inside of the clutch. Thus the movable portion of the clutch may slide longitudinally over the boss $j_{30}$, but is compelled to revolve with the latter.

**52. Disengaging Slubbing Motion.**—On the shaft of the bottom delivery roller $a_4$, Fig. 19, is fixed a spur gear-wheel $j_{11}$, which gives motion to the *slubbing*, or *length, wheel* $j_{12}$ by means of carriers $j_{13}$, $j_{14}$, and $j_{15}$, the latter wheel driving the slubbing wheel slowly when the clutch is engaged. Along the rim of the slubbing wheel are a number of square holes by means of which a small plate $j_{16}$ can be bolted in any required position. This plate is at one end provided with a pin $j_{17}$, which, as the slubbing wheel revolves, eventually comes under a projection $j_{18}$ on the end $j_9$

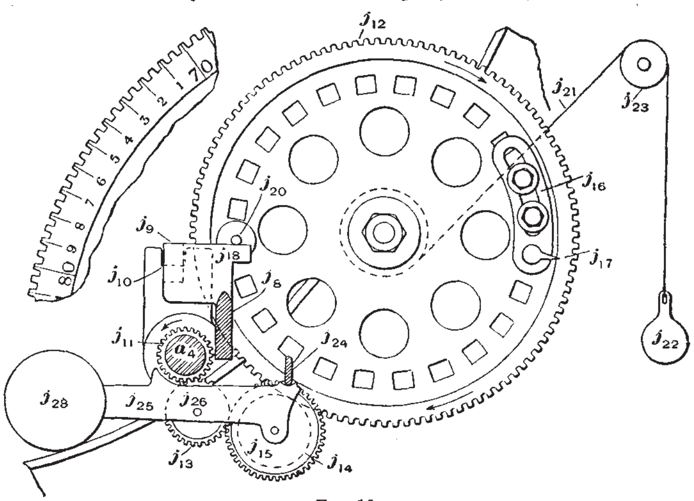

FIG. 19

of the arm $j_8$, and gradually lifts it above the projection $j_{10}$. The arm $j_8$ is then free to respond to the action of the spring $j_{19}$, Fig. 18 (*b*), inside the loose half of the clutch, with the result that the latter will be disengaged and thus stop the revolution of the delivery rollers and the delivery of the roving.

**53. Regulation of Slubbing Motion.**—The length of the roving delivered for each stretch is regulated by the position of the pin $j_{17}$ on the slubbing wheel $j_{12}$, Fig. 17. The greater the distance, measured in the direction of rotation, between the pin and the projection $j_{18}$, when the wheel $j_{12}$ begins to revolve, the greater will be the length of roving delivered. To facilitate the accurate reading and setting of the plate $j_{16}$ with pin $j_{17}$ the slubbing wheel is numbered in the manner shown in Fig. 19 ; the size of the wheel and the number of teeth are such that when the circumference of the wheel moves through a distance of 1 tooth, $\frac{1}{2}$ inch of roving will be delivered by the rollers ; thus, when the pointer is set opposite number *80*, the rollers will deliver 40 inches of roving.

**54. Initial Position of Slubbing Wheel.**—It is necessary that at the beginning of each draw the slubbing wheel shall occupy its initial position. For this reason there is a pin $j_{20}$, Fig. 19, fixed to the slubbing wheel in such a position that when the wheel is in its initial position the pin rests on the end $j_{18}$ of the arm $j_8$. The slubbing wheel is returned to this position after each revolution by means of a weight $j_{22}$ suspended from one end of a band $j_{21}$ of which the other end is attached to the boss of the wheel $j_{12}$. The band is passed over a guide pulley $j_{23}$ which keeps the weight from interfering with the mechanism of the headstock. The slubbing wheel is released by means of the arm $j_{24}$ which is rigidly connected to the fork $j_5$. When the end $j_9$ of arm $j_8$ is lifted and moves to the right in Fig. 18, the fork $j_5$ with arm $j_{24}$ will turn on the pin $j_7$ and the right-hand end of $j_{24}$ will move downwards, pushing down the end of the lever $j_{25}$ with wheel $j_{15}$. The latter being free will revolve by the action of weight $j_{22}$ until the pin $j_{20}$ comes in contact with $j_9$; then the wheel is in its initial position.

**55. Re-engaging Slubbing Motion.** — When the carriage reaches the roller beam after each stretch, the clutch must be put into gear preparatory to delivering the roving for the next stretch. This is done by means of an incline suitably fixed to the carriage square, which, as the carriage approaches the back stops, comes in contact with the under side of a roller $j_{27}$, Figs. 17 and 18, which revolves on a stud bolted to lever $j_6$. As the bowl $j_{27}$ is lifted up the forked part $j_5$ of lever $j_6$, Fig. 17, is moved about $\frac{1}{2}$ inch to the right, thus setting the clutch $j_2$, $j_3$ in action. Simultaneously, the shoulder on the end $j_9$ of the arm $j_8$ drops down on one side of $j_{10}$ and prevents the clutch from disengaging until the proper time. The arm $j_{24}$, Fig. 18, is at the same time lifted from lever $j_{25}$, which allows the weight $j_{28}$ to force the gear wheel $j_{15}$ into gear with the slubbing wheel. The collar $j_{29}$ prevents the clutch part $j_3$ from moving too far from the part $j_2$.

## DRIVING OF SPINDLES

**56. Passage of Rim Band.**—The spindles are driven from the rim shaft during spinning and backing off, but from a different source during winding; the rim-shaft method of driving is shown in Figs. 6, 12, and 20. The rim shaft $f$ carries the small rim $f_4$ and the double-speed rim $f_{11}$; both are double-grooved sheave pulleys. The driving is done by means of a rope $k$, termed the *rim band*, which drives the tin-roller pulley $k_1$, fixed to the tin-roller shaft. Commencing at the point $k_2$ the rim band passes down from the rim $f_{11}$, round the four-grooved guide pulley $k_3$, forwards round the two-grooved guide pulley $k_4$, supported from the carriage square, thence round the tin-roller pulley $k_1$. From this pulley the band passes to the front of the headstock round the guide and tension pulley $k_5$, thence backwards and round the guide pulley $k_6$ and upwards to the small rim $f_4$. Continuing from this point the passage of the band may easily be followed from the illustrations.

It is seen from Fig. 12 that the grooves on the pulley $k_3$ are of the same diameter, while the same pulley, shown in Fig. 20, appears to be conical, as the grooves are of different diameters. It is necessary to represent the pulley in this manner in order that the various turns of the band may be shown separately. The other pulleys are shown in a similar manner.

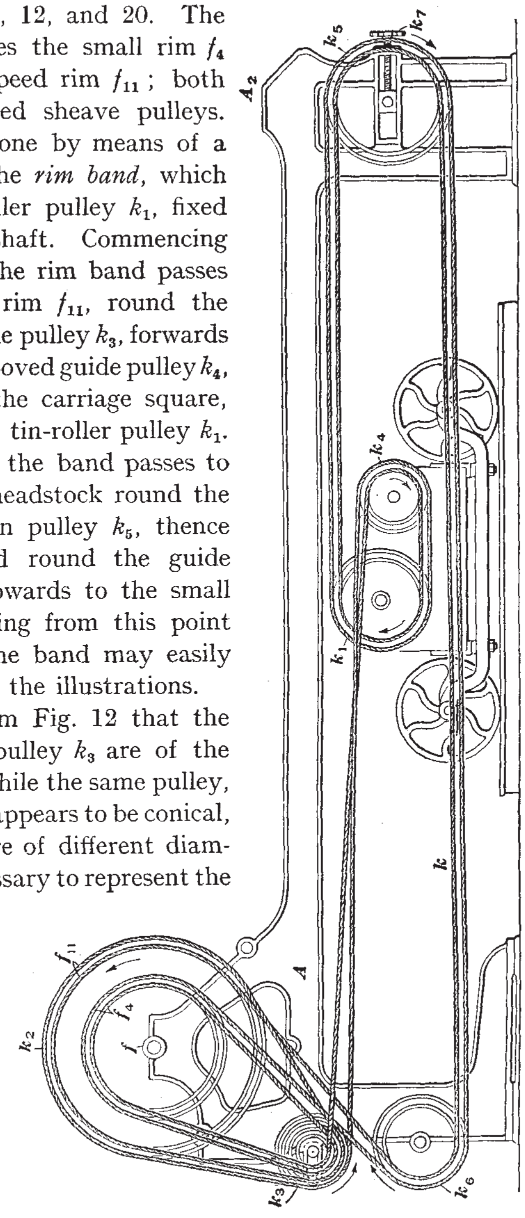


Fig. 20

**57. Tensioning Rim Bands.**—The guide pulley $k_5$ in the tail-piece, Fig. 20, may be adjusted in a horizontal direction by means of the hand wheel $k_7$ attached to a screw operating the bearing of the pulley. By moving the latter to the right the tension in the band $k$ will be increased. Since the rim band is continuous and running through the machine twice over different grooves on the same pulley, it must necessarily be crossed at some place in order that it may return to its starting point. If the band were not crossed it would necessitate the use of two parallel bands with two splices, whereas, with a crossed band, only one splice is necessary. In Fig. 20 the rim band is seen to cross at a point below the pulley $f_4$. When the rim shaft is being driven by the belt on pulley $f_1$, Figs. 11 and 12, the small rim $f_4$, Fig. 20, is driving the rope and turning the spindles while the large rim $f_{11}$ is acting as a carrier. As the carriage reaches the end of the stretch the belt is moved to pulley $f_{10}$, and the spindles are driven from the large rim, the rim $f_4$ acting as a carrier. Since this pulley is fastened to the shaft $f$, the latter will also revolve.

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## TWIST MOTION

**58. Driving Large Rim.**—As soon as the drafting of the roving is completed the requisite amount of twist is inserted as quickly as possible, which is done by setting in operation what is termed the *double-speed motion.* For this purpose the belt must be moved from pulley $f_1$ on the rim shaft to pulley $f_{10}$, Figs. 11 and 12. The large rim $f_{11}$ is connected through the sleeve $f_9$ with the pulley $f_{10}$, and as the diameter of the rim pulley $f_{11}$ is greater than that of the pulley $f_4$, which drives the spindles while the roving is being drawn, it follows that the speed of the spindles during twisting is also greater. The parts relating to this motion are shown in Figs. 20 and 21, which are perspective views representing a portion of the headstock, viewed from the right- and left-hand sides, respectively. Fig. 22 is a diagrammatic view of the lower part of Fig. 21.

**59. Moving Belt for Driving Large Rim Pulley.**—The means by which the belt is moved from pulley $f_1$ to pulley $f_{10}$ is shown in Figs. 13, 21, 22, and 23. A three-armed lever $l_1$, $l_2$, $l_3$ is pivoted on the stud $l$, Figs. 21 and 23, a belt fork $l_4$ being attached

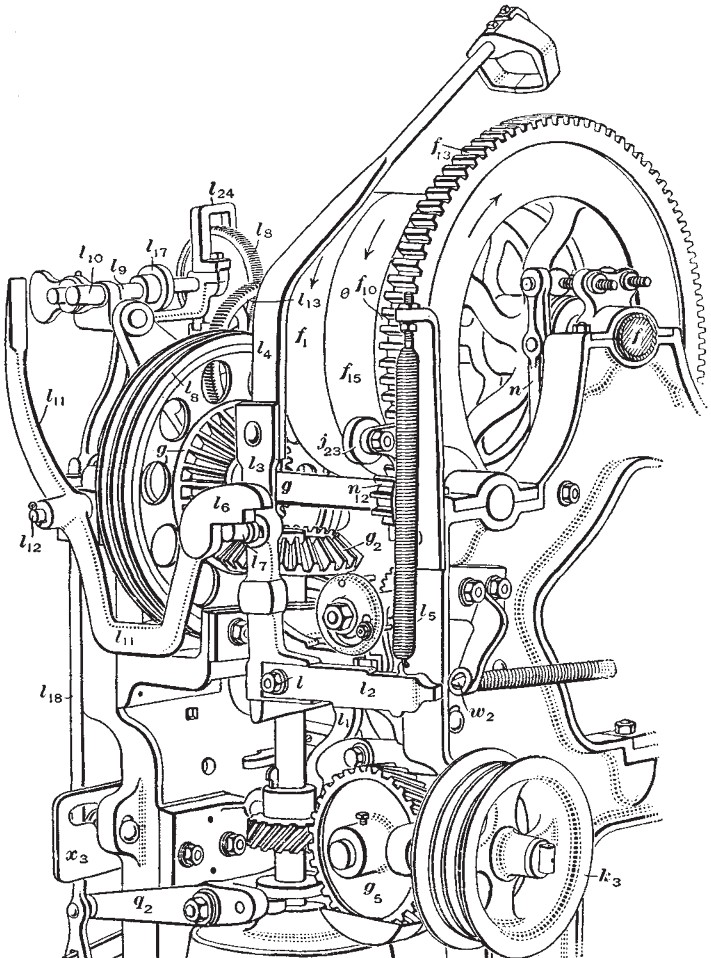

FIG. 21

to the arm $l_3$. When the belt from the countershaft is running on the loose pulley $f_{15}$, the end of the rod $w_2$ is holding down the arm $l_2$, preventing it from rising. When $w_2$ is withdrawn in the manner explained farther on, the spring $l_5$, attached at one end to the arm $l_2$, will tend to move the latter upwards and will cause the roller at the lower end of arm $l_1$ to bear against the smallest diameter of the cam $h_{14}$, as seen in Fig. 23. While the arm $l_1$ is in this position the belt lever $l_4$ is guiding the belt to pulley $f_1$ on which it remains during the outward run of the carriage. When the carriage reaches the end of its outward run the cam-shaft shell $h_1$ is allowed to make a half-revolution which will cause the cam $h_{14}$, Fig. 23, to move the arm $l_1$ to the left against the tension of the spring $l_5$, thus causing the belt to move to pulley $f_{10}$ which operates the double-speed rim.

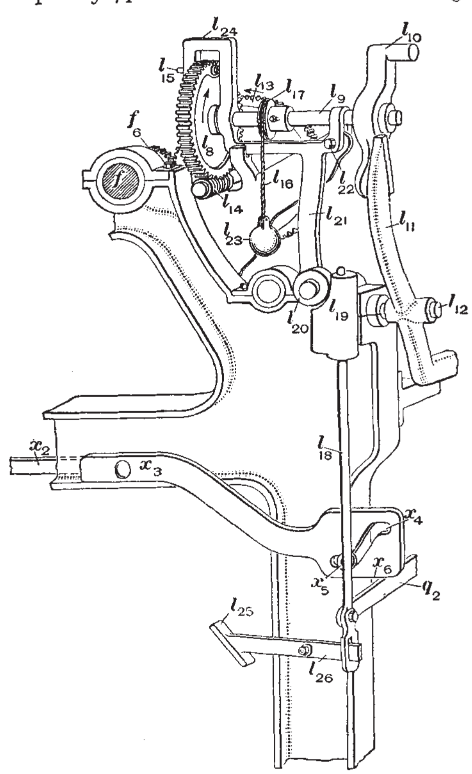

FIG. 22

**60.** After the cam-shaft shell $h_1$, Fig. 13, has made its half-revolution and the nose of the cam $h_{14}$ has passed the roller on lever $l_1$, the cam will occupy the position shown in Figs. 13 (*a*) and (*c*), and the lever $l_1$ will be out of contact with the cam $h_{14}$. The lever is held in this position by means of the catch $l_6$, Fig. 21, termed a *twist catch*, which forms one end of the lever $l_{11}$ pivoted on the stud $l_{12}$. As soon as the belt fork $l_4$ has moved the belt to the pulley $f_{10}$ the shoulder on the twist catch $l_6$ falls to the left of the pin $l_7$ on lever $l_3$ and prevents the latter from returning to the right until it is released by what is termed the *twist motion*.

**61. Moving Belt to Loose Pulley.**—A spur wheel $l_8$ termed the *twist wheel*, is fixed to a short shaft $l_9$, Figs. 21 and 22, which at its other end is provided with an arm having a projecting pin $l_{10}$. As the twist wheel turns, the pin $l_{10}$ will eventually make contact with the upper end of the lever $l_{11}$, and force it to the left. This motion will cause the strap catch $l_6$ to release the pin $l_7$ on lever $l_3$, and the spring $l_5$ will therefore be able to pull the arm $l_2$ upwards until the arm $l_1$ makes contact with the cam $h_{14}$. The extent of this motion will be sufficient to allow the belt fork $l_4$ to move the belt from pulley $f_{10}$ to the loose pulley $f_{15}$, hence the spindles will cease revolving.

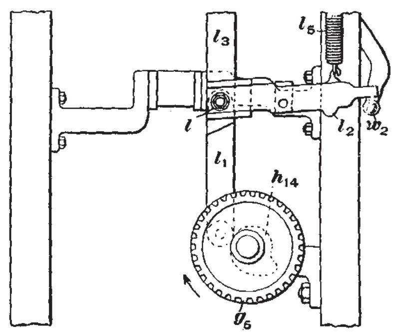

Fig. 23

**62. Adjusting Position of Twist Motion.**—It is necessary that the twist wheel, like the slubbing wheel, shall always revolve through a predetermined portion of a revolution. The return of the twist wheel to its initial position after each inward run of the carriage is accomplished by means of the drawing-in motion. The wheel $f_6$, Figs. 12 and 22, gears with the wheel $l_{13}$, Figs. 21 and 22, which is fixed to a short shaft, that at one end has a worm $l_{14}$ gearing with the twist wheel $l_8$. As the latter is turned in the direction of the arrow a band $l_{16}$ is wound on the grooved pulley $l_{17}$, lifting the weight $l_{23}$. After the belt is moved to the loose pulley $f_{15}$, the twist wheel stops and remains stationary for the present. When, now, the carriage is to be drawn in by means of the scrolls $q_{17}$, Fig. 12, the friction clutch $q$, $q_7$ must be thrown into gear. For this purpose the short arm of the lever $q_2$ moves down, by means to be described farther on, and forces the shell $q$ into gear with the cone $q_7$, while the long arm of the lever swings upwards and lifts the rod $l_{18}$ with the incline $l_{19}$, Fig. 22. Against the latter rests the roller $l_{20}$ of the arm $l_{21}$, pivoted on the stud $l_{22}$. On raising the incline $l_{19}$ the arm $l_{21}$ will swing to the left, in Fig. 22, and lift the arm $l_{24}$ with the twist wheel $l_8$. The latter will then be moved out of gear with the worm $l_{14}$, and the weight $l_{23}$ will be free to revolve the wheel $l_8$ until the pin $l_{15}$ makes contact with the end of the arm $l_{24}$. When the carriage reaches the roller beam the rod $l_{18}$ is lowered by a roller, fixed on the carriage, coming in contact with and raising the end $l_{25}$ of lever $l_{26}$, thus causing the opposite end with rod $l_{18}$ to be lowered. This will lower the incline and allow the wheel $l_8$ to move into gear with the worm $l_{14}$. It will also cause the lever $q_2$ to throw the friction clutch $q$, $q_7$, Fig. 12, out of gear.

### JACKING-UP MOTION

**63. Purpose of Jacking Up.**—The **jacking-up motion** is in operation while the accelerated speed is putting the twist into the yarn. As a result of the twisting action, the yarn contracts 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 inwards slightly, in order to accommodate the twist and ease the tension between the spindles and the delivery rollers that results from the insertion of the twist.

**64. Amount of Jacking Up Required.**—The amount of twist actually put into the yarn depends on the purpose for which the yarn is intended. Usually, warp yarns are hard twisted and weft yarns soft twisted. The speed and amount of jacking up must be adjustable, since thick yarns, that is, yarns of low counts, take up much more, and at a quicker rate than fine yarns. Generally, 3 to 4 inches is sufficient for jacking up, but the motion is usually arranged so that as much as 8 inches may be allowed. When spinning soft twisted weft yarns, jacking up is, as a rule, dispensed with ; the motion is therefore arranged so that it can readily be put out of action.

**65. Construction and Operation of Jacking-Up Motion.**—The necessary jacking up of the carriage is performed by the motion shown in Figs. 24, 25, 26, and 27. This motion is situated in the

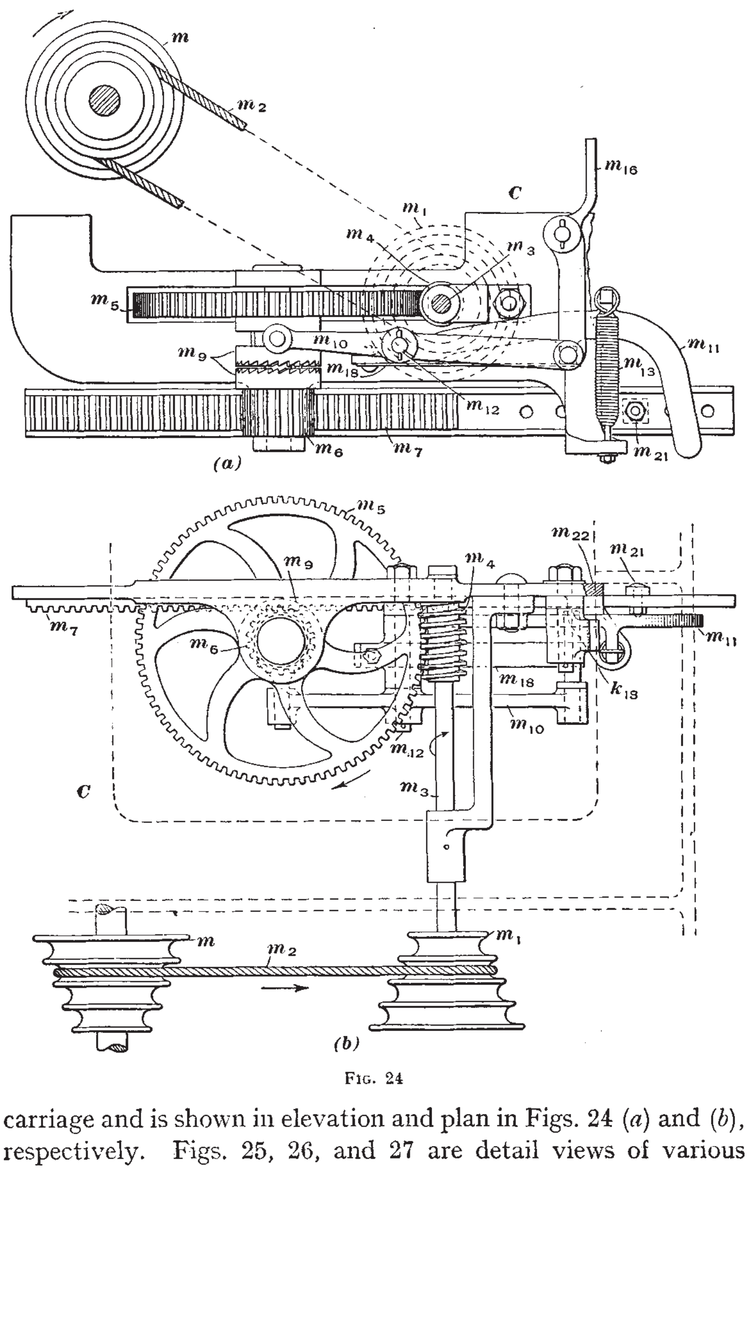


Fig. 24

carriage and is shown in elevation and plan in Figs. 24 (*a*) and (*b*), respectively. Figs. 25, 26, and 27 are detail views of various parts. A pulley $m$ on the tin-roller shaft in the carriage square, drives by a band $m_2$ a similar pulley $m_1$, mounted on a short shaft $m_3$ on which is a worm $m_4$, gearing with a worm-wheel $m_5$.

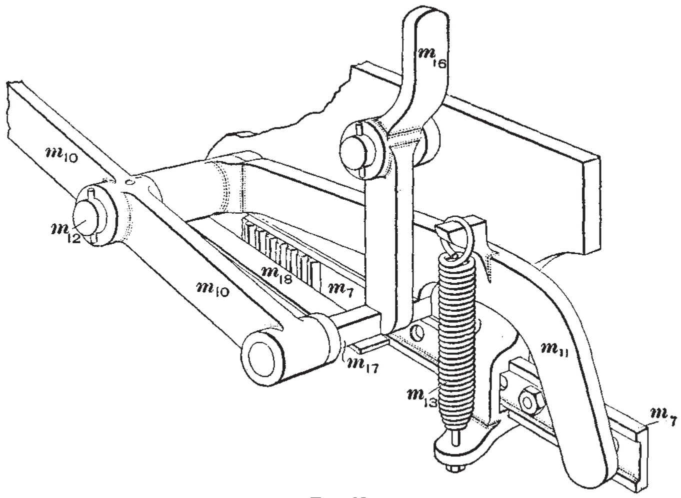


FIG. 25

Revolving loosely on the lower end of the shaft on which wheel $m_5$ is mounted is a pinion $m_6$ which gears with a rack $m_7$, supported

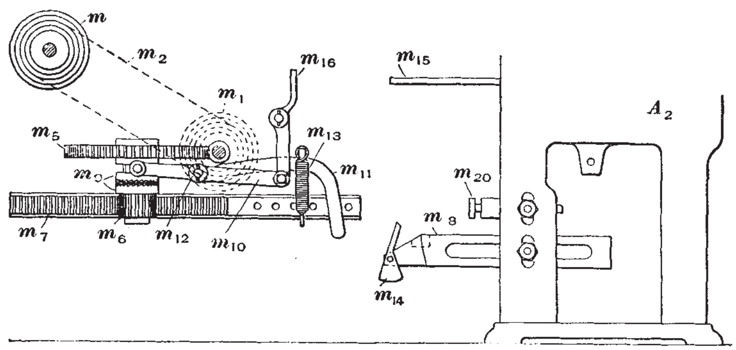


FIG. 26

by the carriage. The amount of jacking up performed depends on the position of the bracket $m_8$, Figs. 26 and 27, which by means of a slot $m_{23}$ and a bolt may be adjusted relative to the tail-piece $A_2$ in the required position. The worm-wheel $m_5$ may be connected to the pinion $m_6$ by means of a small clutch $m_9$; the position of the upper half of the clutch is governed by the fork lever $m_{10}$ in the usual manner. The clutch is engaged only during the jacking-up process, and when this is completed the upper part of the clutch is moved out of contact with the lower one.

**66.** The clutch $m_9$, Fig. 24, is moved into and out of action by a lever $m_{11}$, termed the **leg**, which is pivoted on the stud $m_{12}$ and is held down by a spiral spring $m_{13}$ attached at its lower end to the framing. The slotted bracket $m_8$, Figs. 26 and 27, is fixed at a certain distance forwards of the tail-piece $A_2$ according to the amount of jacking up required; thus, to cause the carriage to jack up 4 inches, the bracket must be set forwards a distance of 4 inches from its extreme rear position. When the leg $m_{11}$, Fig. 26, approaches the inclined part of the bracket $m_8$ it meets the tilting piece $m_{14}$ which it moves into the position shown in dotted lines in Fig. 27. The leg then slides along the piece $m_{14}$ to the horizontal part of the bracket $m_8$, while the carriage travels the additional distance of 4 inches, as required in this case. As soon as the leg leaves the tilting piece $m_{14}$ the latter returns to its normal position by reason of the weighted lower end.

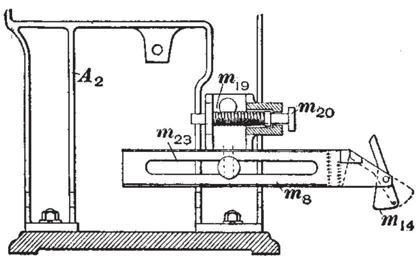

FIG. 27

**67.** When the carriage arrives at a point where only a length of $\frac{1}{2}$ inch remains for it to travel, a projecting rod $m_{15}$, Fig. 26, engages the top of the lever $m_{16}$ and pushes it back. As seen from Fig. 25, the lower end of this lever has a square notch which rests on the bar $m_{17}$ attached to one end of the lever $m_{10}$. When the lower end of the lever $m_{16}$ is pushed off from the bar $m_{17}$, the latter, with the right-hand end of the lever $m_{10}$, is allowed to rise, while the other end, by reason of the combined weight of the wheel $m_5$ and the upper clutch-half, together with the action of the flat spring $m_{18}$, will descend and set clutch $m_9$ in action. It should be noted that the wheel $m_5$ and the upper clutch-half are combined into one and that the former is allowed a certain amount of vertical motion by reason of the rectangular opening in the frame. The wheel $m_5$, as seen from Fig. 24 (*b*), is constantly revolving in the direction of the arrow; it will, therefore, by means of the pinion $m_6$, move the loosely mounted rack $m_7$ toward the right and against the head of a buffer $m_{20}$, which will be pushed back, thereby compressing the spring $m_{19}$. After the head of the buffer makes contact with the end of its bearing, the rack $m_7$ becomes stationary and the pinion $m_6$ will roll along the rack $m_7$ and move the carriage toward the roller beam.

**68.** If jacking up is to be done only for a length of 4 inches, the leg $m_{11}$, Fig. 26, will drop off the end of the bracket $m_8$ after moving that distance, the tilting piece $m_{14}$ moving out of the way. The spring $m_{13}$ is then free to depress the leg and therefore also the bar $m_{17}$ on the end of lever $m_{10}$, by the means shown in Fig. 25, thereby raising the opposite end, and disengaging the clutch and so stopping the jacking up. The spiral spring $m_{19}$, Fig. 27, is then free to push the buffer $m_{20}$ outwards together with the rack $m_7$ for a distance of about $\frac{1}{4}$ inch, the rack $m_7$ moving backwards until a square stop $m_{21}$ comes against the carriage framing at $m_{22}$, Fig. 24 (*b*), and fixes the initial position of the rack for the next jacking up. The position of this stop decides the amount of **dwell**, that is, the period during which the carriage shall stand before jacking up takes place, since the nearer the stop is fixed to the end of the rack, the farther it will be sent by the spring and buffer. The dwell will, consequently, be of a longer duration, as more time will be required for the rack to meet the tail-piece. To change the speed of jacking up, the band $m_2$ can be changed from groove to groove on the pulleys $m, m_1$. The motion may be completely put out of action by removing the band $m_2$ or the rack $m_7$; or the bracket $m_8$ may be moved to the extreme inward position. The slot $m_{23}$ is to provide means for adjustment.

### BACKING-OFF MOTION

**69. Purpose of Backing Off.**—When the yarn has received the required amount of twist the actual spinning of the yarn is completed, and it becomes necessary to wind the spun yarn on cops or bobbins before another stretch can be spun. Previous to the winding process it is necessary to revolve the spindles in a reverse direction a number of times, so as to unwind the yarn that is wound spirally on the blade of the spindle above the cop. In the case of bobbins it is necessary to unwind the yarn that is wound on the bobbin and spindle above that previously wound in the process of building the bobbins. This operation, called **backing off,** must be performed before the stretch can be wound in the form of layers of yarn on the cop or bobbin. When twisting is completed, the belt $e_4$, Fig. 10, is moved to the loose pulley $f_{15}$, Figs. 11 and 12, where it remains until the end of the inward run of the carriage. During this interval the back shaft $g$, which is driven by the ropes $e_6$ in the manner shown in Fig. 12, comes into operation by various clutches and completes the draw by backing off and winding on the yarn.

**70. Purpose of Relieving Motion.**—If the rim shaft, rim band, and spindles were suddenly reversed while the latter were revolving at a speed of from 2,000 to 4,000 revolutions per minute, the several parts would be severely strained. An intermediate motion, termed a **relieving,** or **easing, motion,** is therefore introduced, which, after the belt $e_4$, Fig. 10, has been moved on the loose pulley $f_{15}$, Fig. 11, holds the friction cone $f_{14}$ of the backing-off wheel $f_{13}$ out of contact with pulley $f_{10}$ during an interval of time sufficiently long to allow the spindles to slow down or even stop. After the relieving motion has been in action a sufficient length of time the backing-off process is begun which may be said to consist of the following three separate motions performed simultaneously: (*a*) The reversal of the direction of rotation of the spindles; (*b*) the lowering of the winding faller to the level of the nose of the cop or bobbin; (*c*) the lifting of the counter faller to take up the slack yarn.

**71. Operation of Relieving Motion.**—Figs. 28 and 29 are side and rear elevations, respectively, of the mechanism that constitutes the relieving motion. Fig. 30 is a perspective view of the motion as it appears from the rear of the headstock. The backing-off lever $n$, Fig. 30, is pivoted at its upper end on a stud $n_1$ fixed to a couple of bolts that extend from the framing of the headstock. During the drawing out of the carriage the lip $n_2$ attached to the fork $i_{17}$, Fig. 16, is moved upwards and will, by

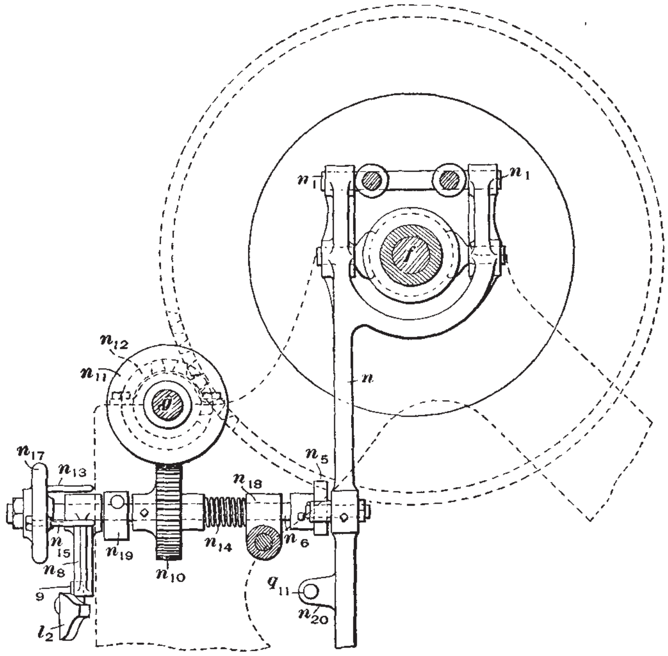


FIG. 28

reason of the cam-like end of the lever $n$, move the latter to the right. The spring $n_3$, attached with one end to the lug $n_4$ and with the other end to the upper end of the drawing-up lever, which is shown clearly in Fig. 38, tends to pull the backing-off lever $n$ to the left and thus to cause an engagement between the friction cone $f_{14}$ and the pulley $f_{10}$, Fig. 11. When, subsequently, the fork $i_{17}$, Fig. 15, descends, as the drawing-out motion is thrown out of action, the lever $n$ will still retain its right-hand position by means of the cam $n_5$ which at this time occupies the position shown in Fig. 30, where it is seen bearing against a roller $n_7$. The cam $n_5$ is fixed to a shaft $n_6$ which is caused to revolve when the belt is moved to the loose pulley $f_{15}$ by the means subsequently described. The length of time required to turn the cam $n_5$ before it releases the lever $n$ is sufficient to allow the spindles to slow down to such an extent that the friction cone $f_{14}$ may be set in action by the lever $n$ without any danger of injury to the machinery.

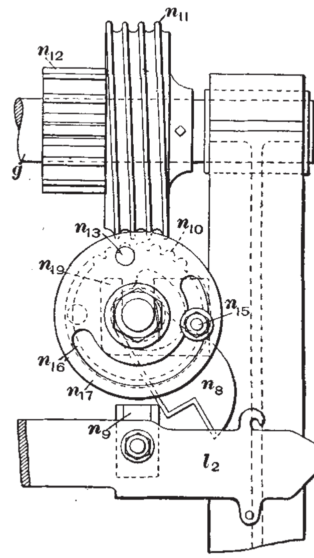

FIG. 29

**72.** In Figs. 28 and 29 the parts of the relieving motion are shown in the positions they will occupy while the belt is on the loose pulley $f_{15}$; the lever arms $l_2$ and $l_4$, Fig. 21, will therefore occupy their middle positions. In order that the function of the relieving motion may be fully understood, it is necessary to remember that the process immediately preceding the relieving action is that of twisting. While this process is performed the belt is on the pulley $f_{10}$, Fig. 30, and the lever arm $l_2$ will therefore be in its lowest position, as shown in Fig. 21. It is then possible for the catch $n_8$, Fig. 30, which swings loosely round the shaft $n_6$, to fall into a vertical position, so that its recess will fit over the casting $n_9$. In Fig. 29 the catch $n_8$ is seen to rest against the corner of $n_9$, the lever arm $l_2$ being in its middle position preventing the arm $n_8$ from engaging the casting $n_9$. When the operation of twisting ceases the belt is shifted to pulley $f_{15}$, and the lever arm $l_2$ will occupy its middle position. While moving into this position it will lift the shaft $n_6$ by means of the catch $n_8$ so as to bring the worm-wheel $n_{10}$ into mesh with the worm $n_{11}$, fixed to the revolving back shaft $g$, thus causing the shaft $n_6$ with its cam $n_5$ to revolve. When eventually the roller $n_7$ makes contact with the lowest portion of the cam $n_5$, the arm $n$ will be in a position to bring the friction clutch $f_{10}$, $f_{14}$

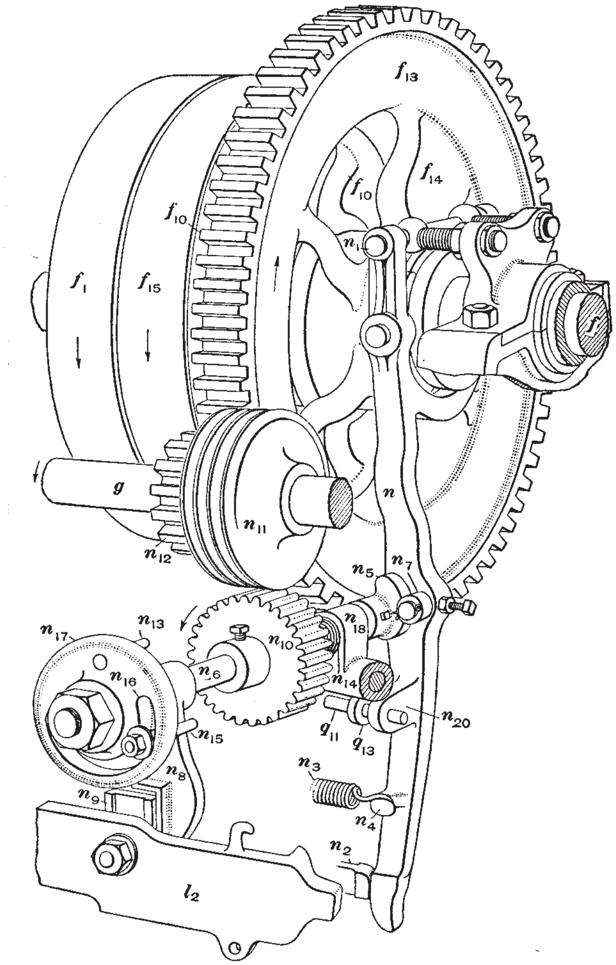


Fig. 30

into operation. The shaft $g$ will then, through pinion $n_{12}$, drive the wheel $f_{13}$, pulley $f_{10}$, and rim pulley $f_{11}$, Fig. 11. As the latter pulley is now revolving in a direction the reverse of that in which it revolves during twisting, the yarn will be unwound from the spindles. In order that the shaft $n_6$ may be able to swing in a vertical direction, its bearing $n_{18}$ is pivoted on a stud that is fastened to the frame of the headstock. When the shaft occupies its lower position it rests in a slot in the bearing $n_{19}$, Figs. 28 and 29.

**73.** The shaft $n_6$, Fig. 30, continues to revolve in the direction of the arrow until the pin $n_{13}$ in the adjusting disc $n_{17}$ comes in contact with the catch $n_8$ and forces it away from the casting $n_9$, thus allowing the shaft to drop into the bearing $n_{19}$, the worm-wheel $n_{10}$ consequently moving out of gear with the worm $n_{11}$. A spiral spring $n_{14}$, the ends of which are attached to the boss of the wheel $n_{10}$ and the bearing $n_{18}$, respectively, is wound up while the shaft $n_6$ is being revolved. When the wheel $n_{10}$ moves out of gear with the worm $n_{11}$ the spring, after backing-off is completed, returns the shaft to its initial position, which is the one shown in Fig. 29. The period of relief may be adjusted, as to duration, by changing the position of the pin $n_{15}$ in the slot $n_{16}$ of the adjusting disc $n_{17}$. If the pin is placed in the lower part of the slot the cam $n_5$ will turn through a smaller part of a revolution to bring its lowest portion in contact with the roll $n_7$, and the lever $n$ will therefore bring the cone $f_{14}$ in operation at an earlier stage than when the pin $n_{15}$ is placed at the upper end of the slot $n_{16}$.

**74. Mechanism for Lowering Winding Faller.**—Fig. 31 is a side elevation of the mechanism that gives motion to the winding faller, and Fig. 32 an enlarged side view of one of the parts, which is also shown in perspective in Fig. 33. The lowering of the sickles $b_1$ with the winding-faller wire $b$, Fig. 31, is performed by the faller finger $o$ to which a chain $o_1$ is attached; the other end of this chain is fastened to a pulley $o_3$, also shown in Fig. 33. This pulley is loose on the tin-roller shaft and is at rest while drawing and twisting is being done, but, as soon as the tin-roller shaft begins to revolve in a reverse direction, a pawl causes the pulley $o_3$ to be connected to a ratchet wheel. The chain $o_1$ will then be wound up on the pulley, causing the faller finger $o$, shaft $b_2$, and sickles $b_1$ to move in such a direction that the faller wire $b$ will be lowered. The ratchet wheel $o_4$, by which this motion is performed, is as shown in Figs. 31, 32, and 33, provided with a small boss $o_5$, having a groove in which rests a clip spring $o_6$. For the purpose of increasing the friction between the boss and the spring the latter is provided with a lining $o_7$ of leather, as

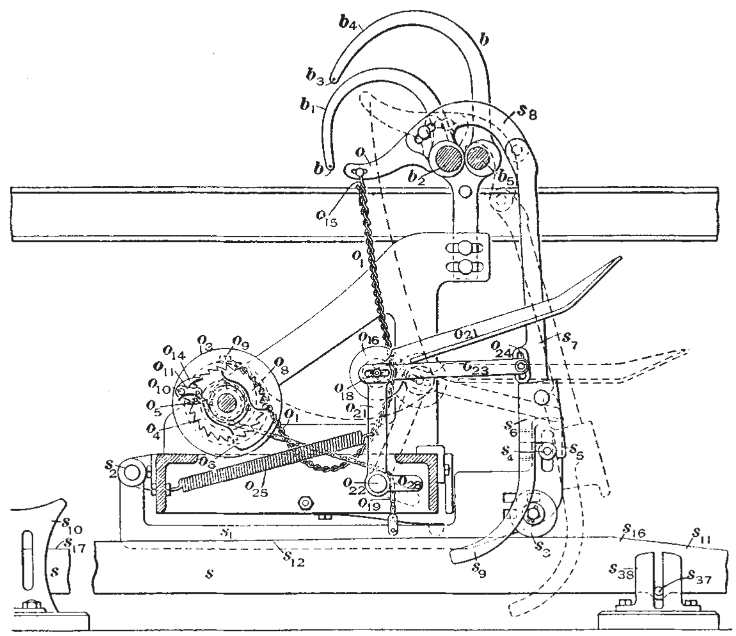


Fig. 31

shown in Fig. 32. The pulley $o_3$ is loose on the shaft and the chain $o_1$ is attached by a bolt $o_9$ to the highest point of its scroll-shaped boss $o_8$. One end of the pulley has a stud $o_{10}$ on which is pivoted an arm $o_{11}$, provided with two pins $o_{12}$, $o_{13}$ and a pawl $o_{14}$, shown in detail in Fig. 32; between these pins extends one end of the spring $o_6$.

**75. Starting and Stopping Winding-Faller Motion.**—During the drawing and twisting process the ratchet wheel $o_4$, Fig. 32, is revolving in the direction of the arrow. The spring $o_6$, by reason of the friction between it and the boss $o_5$, tends to revolve in the same direction and is therefore forced against the pin $o_{13}$. The pressure of the spring will swing the arm $o_{11}$ with the pawl $o_{14}$ into the position indicated by dotted lines, thus forcing the pawl out of contact with ratchet wheel. When the latter begins to revolve in the opposite direction, while the spindles are backing off, the spring $o_6$ will bear against the pin $o_{12}$ and thus force the pawl to engage with the ratchet wheel, which will then cause the drum $o_3$ to revolve with the tin-roller shaft, so that the chain $o_1$, Fig. 31, is wound on the pulley $o_3$ and the winding faller $b$ lowered.

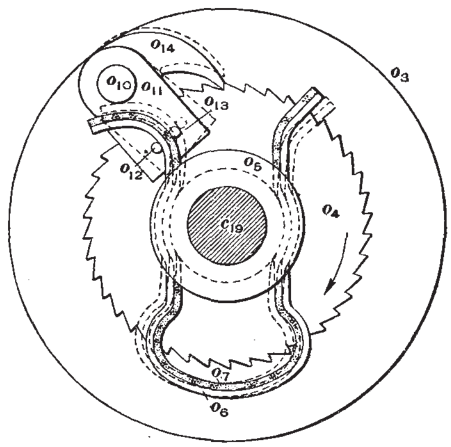

FIG. 32

**76. Speed of Backing Off.**—The speed at which the backing off is performed depends to some extent on the position of the faller finger $o$, Fig. 31. If the latter, when in its highest position, stands nearly vertical, it follows that the rate at which its extreme end descends will be slow, since it moves along the arc of a circle and, therefore, at first will follow a path nearly horizontal. On the other hand, if the finger $o$ is nearly horizontal while in its highest position, its extreme end will at once begin to move in a vertical direction and the descent will be quick.

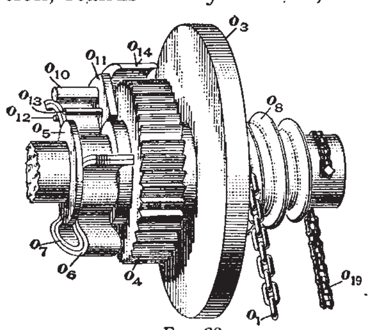

FIG. 33

During the operations of drawing and twisting the winding-faller wire is about 1 to $1\frac{1}{2}$ inches above the tops of the spindles. In order that the winding faller may be opposite the nose of the cop at the moment the yarn is beginning to be unwound from the spindle, it is necessary that the speed at which it is moving downwards should be slightly greater than that at which the unwinding yarn is descending spirally along the spindle. To shorten the time required before the faller begins to descend, the chain $o_1$ can be tightened, as required, by attaching a lower link of it to the hook $o_{15}$. The shorter the chain the earlier will the faller begin to descend, though the speed will remain the same. It is seen, from Figs. 31 and 33, that the groove in which the chain $o_1$ is wound on the pulley $o_3$ is not on a cylindrical, but on a conical boss; the speed at which the finger $o$ is pulled down will therefore gradually decrease. It follows that the winding faller $b$ will move slowly while backing off for the lower part of the bobbin, but assume its position at a quicker speed when backing the nearly finished bobbin.

**77. Adjustment of Winding-Faller Motion.**—The yarn is not

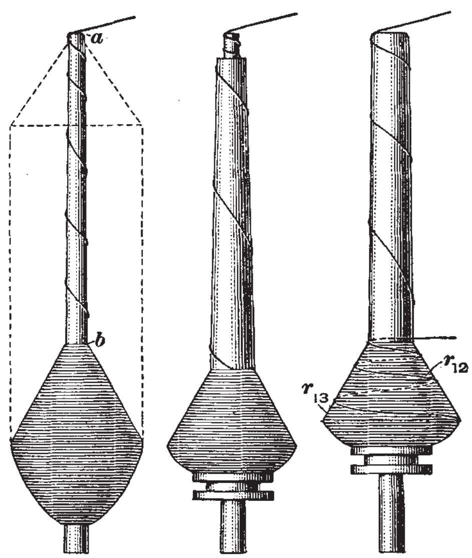


FIG. 34

always wound on the spindle itself, but may be wound on bobbins, and as the diameter of the spirals, formed by the yarn when building up a layer, vary in diameter, the rate at which the backing off is performed must be variable. This will be better understood by examining Fig. 34, which shows a cop and two bobbins wound in various ways. In view $(a)$ a cop is being built on the bare spindle into the form indicated by dotted lines. Sometimes the yarn is wound on bobbins, as in view (*b*), that is, with the end, or top, of the bobbin about $\frac{1}{2}$ inch below that of the spindle. The bobbin is placed in this position to prevent the yarn from being pulled off, when the bobbin is full, the spirals on the spindle keeping those on the bobbin in position. The faller must not come down until the thread is unwound from the spindle and has cleared the bobbin top, otherwise it will be broken; it follows, therefore, that a late, but quick, descent must be made. In Fig. 34 (*c*) there are only three turns on the bobbin, the end of which is level with the spindle point, and so an early and quick descent must be made.

**78.** Assuming that the winding-faller wire is to descend from a point 1 inch above the point *a* of the spindle point, Fig. 34 (*a*), and that the length of the spindle blade above the nose *b* of an unfinished cop is 6 inches, then the faller wire must travel a distance of 7 inches, to unwind the yarn from a portion *a b* of the blade, 6 inches long. When the cop is built up to within 1 inch of the top of the spindle, the faller wire must move 2 inches, while the yarn is wound from a portion of the blade only 1 inch long. As the distance moved through by the faller wire in these cases differs greatly, it is necessary that the winding faller should be moved down earlier while the building of the cop is in its final stage; this is done automatically by tightening the backing-off chain as the building of the cop proceeds. By means, which will be explained farther on, the *builder*, or *shaper*, rail *s*, situated under the carriage square, is lowered in the same ratio as the length of the cop increases. A chain $o_{19}$, fixed at one end to the arm $s_1$, has its other end fastened to the portion of the boss $o_8$ that is the smallest in diameter, as seen more clearly from Fig. 33. As the builder rail is lowered the chain $o_{19}$ is pulled down; therefore, the boss $o_8$ is turned and a corresponding length of the backing-off chain is wound on.

**79. Mechanism for Lifting Counter Faller.**—Simultaneously with the lowering of the winding faller the counter faller is lifted in order to maintain the tension on the yarn and prevent the formation of snarls. The parts that perform the lifting of the counter faller are shown in Fig. 35. To a segment *p*, fastened to the counter-faller shaft $b_5$, is attached one end of a chain $p_1$,

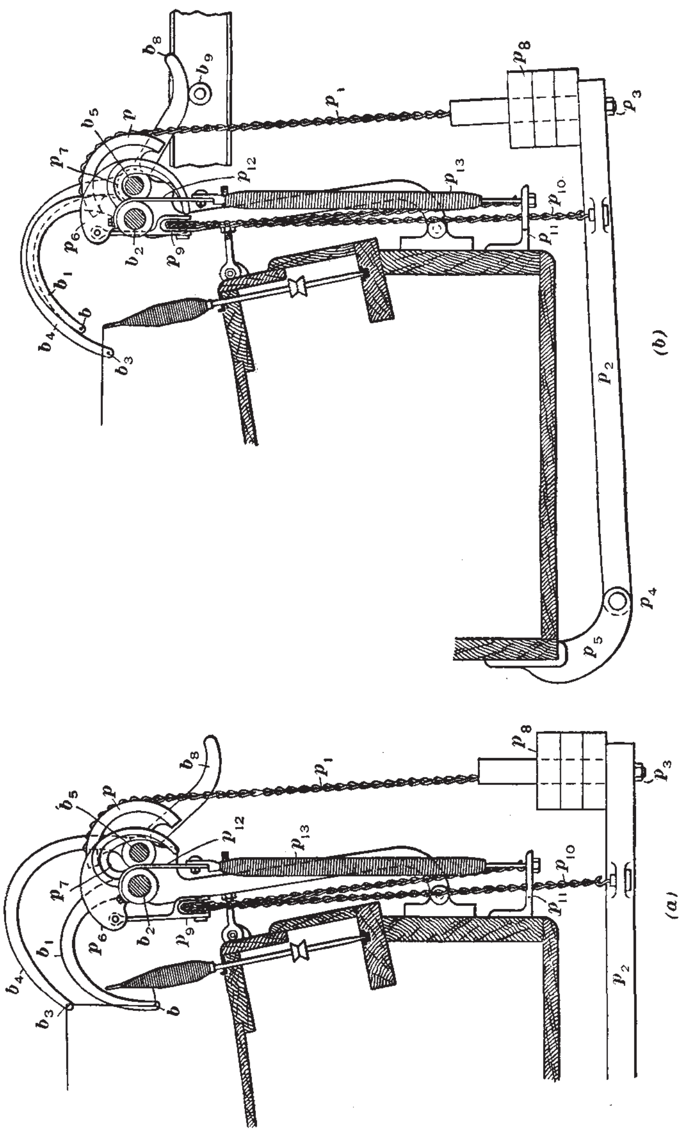


Fig. 35

the other end being fastened at $p_3$ to the weighted lever $p_2$; this lever is pivoted at $p_4$ to a bracket $p_5$ attached to the carriage. The downward pull of the lever $p_2$ may be adjusted by varying the number of weights $p_8$. To the winding-faller shaft $b_2$ is fastened a finger $p_6$, which, during drawing and twisting, makes contact with the upper surface of the counter-faller shaft at the recess $p_7$, as shown in Fig. 35 (*b*); the position of the winding faller is by this means fixed while these operations are performed. A pulley $p_9$, Fig. 35 (*a*), suspended from the finger $p_6$, carries a chain $p_{10}$ of which one end is fastened to the lever $p_2$ and the other to the bracket $p_{11}$. Attached to the boss of the finger $p_6$ there is a strap $p_{12}$ that is connected to the upper end of the spring $p_{13}$, which is fastened at its lower end to the bracket $p_{11}$. The spring, being under tension, tends to turn the winding faller shaft $b_2$ in a direction that will move the winding faller into a higher position, but the finger $p_6$ being in contact with shaft $b_5$ at the recess $p_7$ prevents such motion.

**80. Motion of Counter Faller.**—During the operations of drawing and twisting, when the faller leg $s_7$ occupies the position shown in dotted lines, Fig. 31, the free end of the lever $p_2$, Fig. 35 (*b*), is supported by the chain $p_{10}$. The tension on the chain $p_1$ is merely that caused by the weight of the counter faller, which is thus permitted to occupy its correct position below the yarn while these operations are taking place. At the moment when the carriage completes its outward run and the winding faller is pulled down by the finger $o$ and the backing-off chain $o_1$, Fig. 31, the pulley $p_9$ with the chain $p_{10}$ is lowered, as in Fig. 35 (*a*). The weight of lever $p_2$ will thus be thrown on to the chain $p_1$ and the segment $p$ will move downwards and raise the counter-faller wire $b_3$ against the under sides of the yarn, thus providing the necessary tension for winding and also preventing the formation of snarls. The amount of tension produced in the yarn will depend on the number of weights $p_8$ placed on the lever $p_2$. When the winding faller is at rest during spinning, the finger $p_6$ makes contact with the counter-faller shaft at the recess $p_7$, thus preventing the spring $p_{13}$ from lifting the winding faller too high.

**81.** When the carriage on its inward run reaches the roller beam and completes the winding of a stretch, the fallers must be unlocked. For this purpose the counter-faller shaft $b_5$, Fig. 35 (*a*), is provided with a relieving finger $b_8$ which is lifted on meeting the roller $b_9$, view (*b*), fastened to the side of the headstock. The counter faller will then be lowered and the segment $p$ raised, thus lifting the lever $p_2$ by means of chain $p_1$; the chain $p_{10}$ is then slack and the winding faller is allowed to rise into its position at rest by the pull of the spring $p_{13}$. There are, in general, six sets of fingers, segments, levers, springs, etc., combined to form the mechanism, shown in Fig. 35, along the whole length of the carriage.

**82. Locking Motion.**—In order that the builder rail $s$, Fig. 31, may have complete control of the winding operation, it is necessary that the winding faller shall at certain times be locked in its position. The means by which this is done is shown in Fig. 31. The lever $s_1$, which has its fulcrum at $s_2$, is supported by a roller $s_3$, resting on the edge of the builder rail $s$, and rising and falling with the latter. To the free end of lever $s_1$ is attached a roller $s_4$, against which rests the heel $s_5$ of the faller-leg foot $s_6$. This foot is fastened to the leg $s_7$, which by a bow $s_8$ is connected to the winding-faller shaft $b_2$, so that as the winding faller is pulled down the bow $s_8$ lifts the leg $s_7$. An angular lever $o_{21}$, pivoted on the stud $o_{22}$, has a stud $o_{18}$ on which the backing-off chain pulley $o_{16}$ is pivoted. The stud carries a connector $o_{23}$ that at its other end has a pin which passes through a slot $o_{24}$ in the faller leg. A spring $o_{25}$ is constantly pulling the lever $o_{21}$ inwards, so that when the bottom of the foot is lifted above the roller $s_4$ the leg is pulled inwards. It will then change from the position indicated by dotted lines to that shown by full lines, in which the heel $s_5$ rests against the roller $s_4$. The leg $s_7$ is raised, and the arm $o$ lowered as the backing-off chain is tightened.

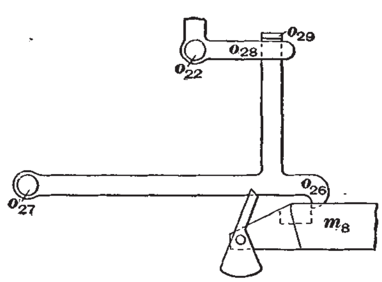

FIG. 36

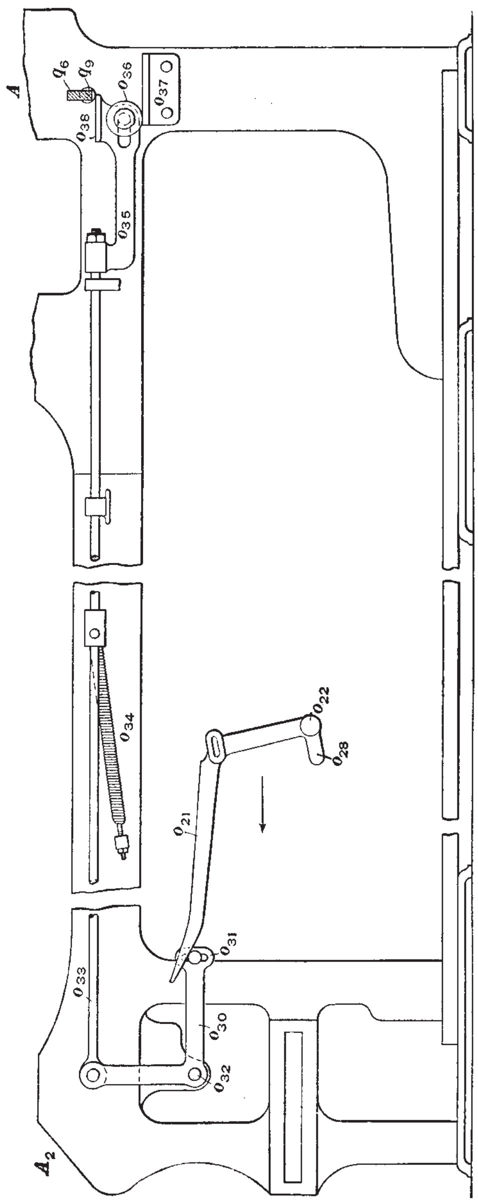


FIG. 37

The leg is unlocked as the toe $s_9$ comes in contact with the bracket $s_{10}$ at the end of the builder rail, known as the *knocker off*, when the carriage reaches the roller beam. The foot is thus pushed off the friction roller $s_4$, the leg, as it drops down, raising the winding faller.

**83. Holding-Out Catch.** — The backing-off and drawing-up friction clutches are actuated by the mechanism shown in Figs. 31, 36, and 37. The main part is the lever $o_{21}$ which, when the release takes place, moves rapidly from the position shown by dotted lines to that shown by full lines in Fig. 31. Before the carriage can be drawn in, it is necessary to lift the lever $o_{26}$, Fig. 36, termed *holding-out catch*. This lever is pivoted at $o_{27}$ and has at its free end a hook that engages a projection on the bracket $m_8$. The lever is moved free of this projection by the small arm $o_{28}$ of lever $o_{21}$, Fig. 31, which lifts the catch $o_{26}$ by the lip $o_{29}$.

**84. Release of Backing-Off Motion.**—The driving power required by the carriage during the backing-off process is transmitted to it through the friction clutch $q$, $q_7$, Fig. 38, which is set in action by means of the lever $o_{21}$, pivoted on the stud $o_{22}$, Figs. 31 and 37. The parts acted on by this lever are shown in Fig. 37 and are situated inside the headstock $A$ at the left-hand side, connecting with other parts that are situated in the tailpiece $A_2$. During the twisting process the lever $o_{21}$ is in its lowest position, corresponding to that indicated by dotted lines in Fig. 31, and it is moving with the carriage in the direction of the arrow, Fig. 37. During the final portion of the outward run the inclined surface of the lever meets the roller $o_{31}$ of the bell-crank lever $o_{30}$, pivoted at $o_{32}$, compelling the vertical arm of the lever to move to the right. The connecting-rod $o_{33}$ will therefore be pushed toward the headstock, simultaneously extending the spring $o_{34}$. At one end of the rod there is a casting $o_{35}$ with a roller $o_{36}$ that rests on the bracket $o_{37}$;

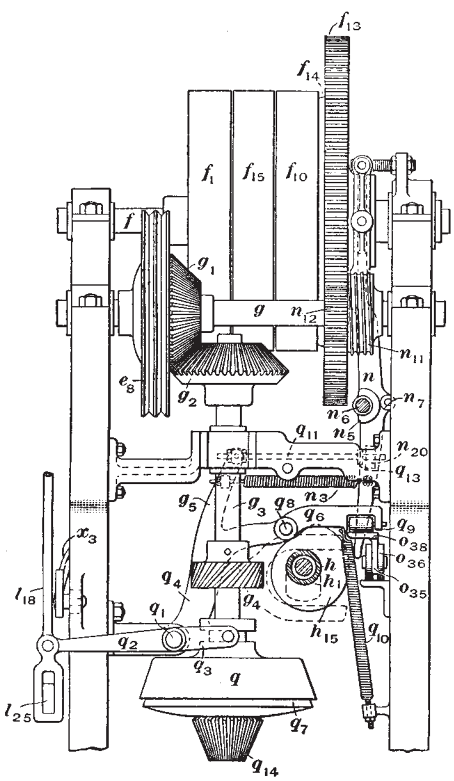

Fig. 38

the upper side of the casting is formed into a flat lip $o_{38}$ on which rests a roller $q_9$ attached to the arm $q_6$ of a lever that operates the drawing-in friction clutch, Fig. 38.

**85.** When the winding faller $b$, Fig. 31, is locked, the lever $o_{21}$ occupies the position indicated by full lines. As the change from the lower to the higher position is quickly done, there will be a sudden release of the bell-crank lever $o_{30}$, Fig. 37. In the latter view the lever $o_{21}$ has not reached its highest position and the lever $o_{30}$ has not, as yet, attained the position of rest into which it will be moved by the spring $o_{34}$. When it assumes the latter position the lip $o_{38}$ will have moved away from the lever arm $q_6$ and the latter be free to fall, thus allowing the spring $q_{10}$, Fig. 38, to act on the arm $q_6$. As the latter is fastened to the double-armed lever $q_4$, $q_5$, $q_6$ keyed to the shaft $q_1$, the arm $q_3$ will move downwards and place the shell $q$, keyed to the constantly revolving shaft $g_3$, in contact with the cone $q_7$. At the same time the rod $q_{11}$, which is fixed to the end of arm $q_5$ and passes through a projection $n_{20}$ on the backing-off lever $n$, Figs. 30 and 38, disengages the backing-off wheel friction clutch, since a collar $q_{13}$ on the rod $q_{11}$ bears against the projection $n_{20}$ and pushes the lever to the right.

### DRAWING IN OF CARRIAGE

**86. Mechanism for Drawing In of Carriage.**—The parts that are active in drawing in the carriage and their connections with other parts are shown in Fig. 38. This illustration shows also an end view of the casting $o_{35}$, roller $o_{36}$, and lip $o_{38}$, shown in Fig. 37. While the carriage is on its outward run the shell $q$ is kept out of contact with the cone $q_7$, by the cam $h_{15}$, fastened to the sleeve $h_1$, the cam being in contact with the roller $q_8$ on lever $q_6$. Some of these parts are also shown in Fig. 13. When the carriage reaches the end of its outward run the cam-shaft with its cams makes a half-revolution, the clutch would engage but for the fact that in the meantime the lip $o_{38}$, Fig. 37, has moved under the roller $q_9$ so as to support the arm $q_6$ in place of the cam.

**87. Engaging Drawing-In Motion.**—When the shell $q$, Fig. 38, engages the friction cone $q_7$, as described in Art. **86**, the bevel wheel $q_{14}$, compounded with the cone $q_7$, gives motion to the bevel wheel $q_{15}$, Fig. 12, which is fixed to the scroll shaft $q_{16}$ on which are mounted the drawing-in scrolls $q_{17}$. While the latter by means of the ropes $q_{19}$, fastened to the carriage, as shown in Fig. 7, draw in the carriage, the check-scroll $q_{18}$ is delivering the check-rope $q_{20}$ under a uniform tension, the check-scroll being similar to the drawing-in scrolls. The rope $q_{20}$ passes round the pulley $q_{21}$ and then back to the carriage to which it is fastened. In Fig. 12 the scrolls $q_{17}$ are full and $q_{18}$ is empty, indicating that the carriage is drawn in.

**88. Purpose of Check-Rope.**—The check-rope is unwound from its scroll $q_{18}$, Fig. 12, while the drawing-in ropes $q_{19}$ are being wound up, and vice versa. The check-rope $q_{20}$, after passing over a tension pulley $q_{21}$, Fig. 7, is attached to the carriage; the bearing of the tension pulley may be moved along a slot in the tail-piece by means of a screw for the purpose of adjusting the tension in the rope. The object of the check-rope 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 ropes, that is, the drawing-in scrolls might, were it not for the check-rope, 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 ropes.

The check-rope 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-rope 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 given the check-band by screwing back the tension pulley round which it passes, the more gently the carriage will come to a stop at the finish of the drawing in. If the check-rope is too loose, there will be a certain play that will cause the carriage to stop with a jerk.

**89. Action of Drawing-In Scrolls.**—The drawing-in scrolls $q_{17}$, Fig. 12, have a different action from the drawing-out, or draft, scrolls $i_7$, $i_{10}$, Figs. 12 and 14. With the drawing-out scroll the rope $i_8$ commences on the large diameter when imparting motion for the drawing out of the carriage and finishes on the small diameter. With the drawing-in scrolls the action is the reverse, the rope being wound first on the small diameter of the scroll, continuing to the large diameter, and finishing on the small diameter at the other end of the scroll. The small diameter of the scroll, with which the motion is commenced, enables the heavy carriage to start easily, afterwards moving more quickly and finally, while the rope is running on the small diameter, making it possible easily to check the momentum of the carriage. Any abrupt action with the consequent strain in the bands and the carriage are thus avoided without decreasing the average speed of the carriage.

**90. Disengaging Drawing-In Motion.**—There are two drawing-in scrolls $q_{17}$, Fig. 12, to one check-scroll $q_{18}$ for the purpose of relieving the tension on the drawing-in rope, as the latter has to supply power for driving the spindles as well as moving the carriage. When the carriage reaches the roller beam the cam-shell $h_1$, Fig. 38, turns and with it the cam $h_{15}$, which by means of roller $q_8$ raises the arm $q_6$ and so disengages the shell $q$. To supplement and relieve the cam the shell $q$ is also disengaged by the carriage itself; for this purpose the arm $q_2$ is attached to rod $l_{18}$ and is operated by it. When the carriage reaches the end of its inward run the rod is depressed by the lever $l_{95}$, as explained in Art. **62**, thus moving the arm $q_3$ with the shell $q$ upwards.

## WINDING

**91. Object of Winding.**—The motions required for making the cop are those that guide the yarn and turn the spindles. The process of winding is necessary in order that the yarn that has been delivered, drawn, and twisted may be built up in a suitable form on the spindles. Both the motions are in operation during the inward run of the carriage, and are closely related to each other.

**92. Construction of Cop.**—A small paper tube may be slipped over the spindle to support the cop, or, for weft material, a long wooden bobbin. The fact that a support is used for the yarn does not affect the description of the construction of a cop, since only the relative diameters are different. A full cop on a spindle is shown at $r$, Fig. 39. At the **nose** $r_1$ is the minimum diameter and at the **shoulder** $r_2$ the maximum. The **body** is the general name for the cylindrical portion from $r_2$ to $r_3$, while the **bottom** is the portion $r_3$, $r_4$, $r_5$, $r_6$, $r_3$. The cop is first started on the paper tube $r_7$ which is placed on the bare spindle; this tube stiffens the bottom by serving as a foundation for the cop. The **chase** of the cop extends from the nose $r_1$ to the shoulder $r_2$ and is the surface on which the yarn is wound. The terms nose, shoulder, and chase are applied to the cop during its formation, as well as to the full cop. During winding the nose will gradually move from the point $r_6$ to $r_1$, and the shoulder from $r_3$ to $r_2$; consequently the chase will move from $r_3$, $r_6$ to $r_2$, $r_1$.

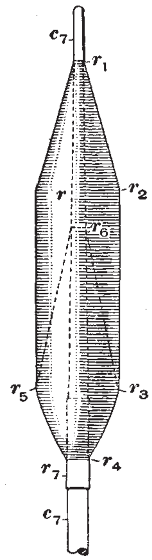

FIG. 39

**93. Construction of Cop Bottom.**—The cop bottom is built up as shown in Figs. 39 and 40. The maximum diameter of the cop bottom is indicated by the distance across from $r_3$ to $r_5$ and the maximum length of chase from $r_3$, or $r_5$, to $r_6$. In the diagram, Fig. 40, four lines similar to those at $r_4$, $r_8$, $r_9$, and $r_3$, are shown at each side of the spindle to represent layers formed during various stages in building up the cop bottom. The lines are not intended to be an accurate representation of the actual number and position of the layers and coils of yarn, but to illustrate some of the stages in the formation of the cop bottom. The layers of yarn, which are laid one on the other, cause the cop bottom to increase in diameter, while its bottom is formed conically by reason of each layer starting a little higher than the preceding one.

**94.** At the commencement a short length of yarn is wrapped round the tube, Fig. 40. At the end of the first draw the yarn is wound on to the tube or spindle, or both, so as to cover a length of about $1\frac{1}{4}$ to $1\frac{1}{2}$ inches, as at $r_4$, $r_{10}$. As each draw or stretch of yarn is added, it is wound in more open coils and will therefore cover a greater vertical distance. The lower point $r_4$ moves slower upwards than the upper point $r_{10}$, thus the chase $r_4\,r_{10}$ will gradually increase in length until it occupies the position $r_5\,r_6$, when it will be about 4 inches long, if the diameter of the cop is $2\frac{1}{2}$ inches. Such a length of chase is necessary to secure adequate firmness of the cop. The space between the coils in each succeeding layer gradually increases until the cop bottom is fully formed. The distance from $r_4$ to $r_5$ represents the maximum length of the side of the bottom cone and the distance $r_5\,r_6$ shows the maximum length of the top cone, or chase.

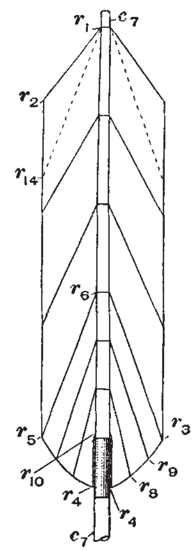

FIG. 40

**95. Binding Coils.**—The firmness of the cop may be still further increased by the following method of winding the yarn on the chase. The winding on the cop of the yarn produced during each draw begins at the nose and proceeds to the shoulder, and then back again to the nose, hence each draw begins and terminates at the nose; but the same amount of yarn is not wound on the chase in both layers. Thus, in the case of a stretch of from 72 to 90 inches, only about 12 to 18 inches of yarn is wound on while winding from the nose to the shoulder, which length forms 2 or 3 open spirals, termed **binding coils**, as shown at $r_{12}$, Fig. 34. The remaining 60 to 72 inches is wound on in close spirals as at $r_{13}$, Fig. 34. The binding layers tie the latter spirals together and act as a separator for adjoining layers, thus preventing the loosening of several layers at once during the subsequent unwinding of the cop. This formation makes the cop much more stable and prevents much waste in subsequent operations. The length of the chase is shortened during the building of the body, until the nose $r_1\,r_2$ is comparatively short, which enables a larger quantity of yarn to be used in the building of a cop of the same diameter and length. This may clearly be seen if it is supposed that the chase $r_5\,r_6$ is maintained throughout the cop; the chase of the top layer would then be $r_1 r_{14}$ and the material wound in the triangular space $r_2 r_1 r_{14}$ would be lost.

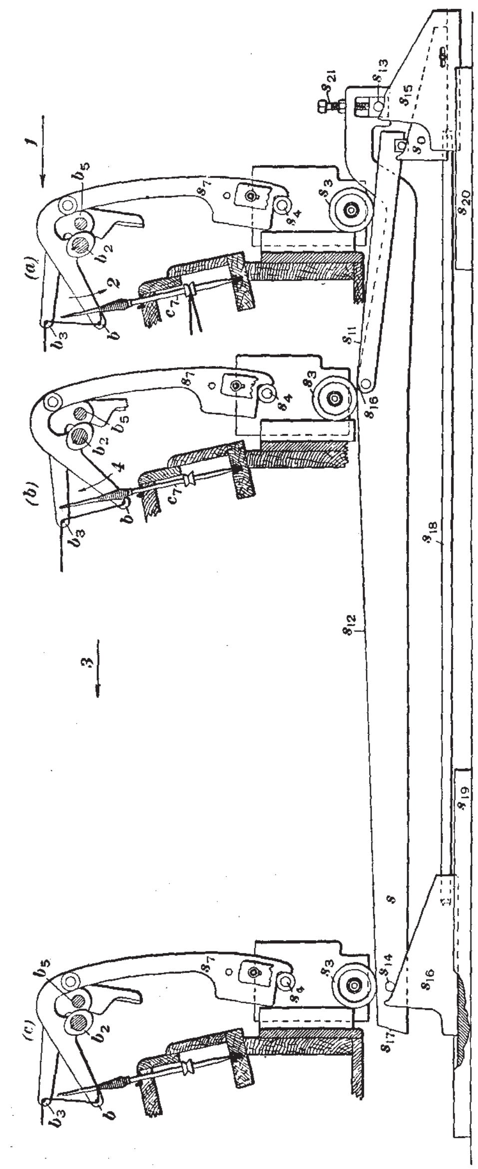

Fig. 41

**96. Builder, or Shaper, Motion.** The object of the **builder motion** is to control the formation of the cop or bobbin. When the faller leg $s_7$, Fig. 31, is locked, as described in Art. 82, any up-and-down motion received by the roller $s_3$ is transmitted to the winding-faller wire; but the motion is reversed, that is, if the friction roller $s_3$ is raised by travelling up an incline on the shaper rail $s$, the winding faller is depressed and vice versa. In Fig. 41 a portion of the carriage with the mechanism by which the winding faller is operated is shown diagrammatically in three positions on the builder rail, as at (*a*), (*b*), and (*c*); the faller-leg toe $s_9$

has been omitted so as not to obstruct the view of the roller $s_3$. The upper edge of the builder rail $s$, Figs. 31 and 41, is constructed so that the end at the tail-piece has a short incline $s_{11}$ which is from 15 to 18 inches long. Thus, at the beginning of the inward run, when the roller $s_3$ is passing up the incline $s_{11}$, the winding faller is depressed a corresponding distance, and the binding coils are wound on from the nose to the shoulder, as shown in Fig. 41 (*a*). Then follows a long decline $s_{12}$, of which the lowest point is on the same level as that of a corresponding point on the incline $s_{11}$, so that the winding faller rises and winds in close spirals the remainder of the stretch of yarn on to the chase from the shoulder to the nose. This is the procedure for one draw, but as each stretch of yarn is wound on the bobbin a little higher than the preceding one, the builder rail must be lowered correspondingly. The means by which the builder rail $s$ is prevented from moving longitudinally is shown in Fig. 31, which shows the pin $s_{37}$ in the builder rail engaging a vertical slot in the bracket $s_{38}$.

**97. Positions of Fallers During Winding.**—Three principal stages, or positions, of the faller during winding are shown in Fig. 41, in which view (*a*) shows their positions just as the carriage starts on its inward journey in the direction of the arrow *1*, while arrow *2* shows the direction of motion of the winding faller at this stage. The winding faller continues its downward movement until the roller $s_3$ reaches the shoulder $s_{16}$. Fig. 3 (*a*) shows an enlarged view of the positions occupied by the fallers and yarn just as the carriage starts on its inward run, and Fig. 3 (*b*) the positions of the fallers and yarn when the roller $s_3$ has reached the shoulder of the rail. The winding faller *b* moves downwards quickly because the inclination of the incline $s_{11}$ is considerable. As the portion $s_{12}$ of the builder rail is much longer than $s_{11}$, its inclination is, as a consequence, more gradual, and the direction of its inclination being reversed, the winding faller will rise gradually, as indicated by arrow *4*, Fig. 41 (*b*), while the carriage continues to move in the direction of arrow *3*. When the carriage has completed its inward run, arriving at position (*c*), the winding faller is at the top of the cop, as shown, winding being completed for one stretch or draw.

**98. Builder Plates.**—The builder rail is supported edgewise so that it will be stiff and free from deflection, which would be a very serious defect, as the shape of the face, which determines the position of the winding faller, would be materially affected. It is supported at each end by the shaper pins or studs $s_{13}$ and $s_{14}$, Fig. 41 ; these rest on inclined plates $s_{15}$ and $s_{16}$, termed *builder plates*, or simply *inclines*, which are made to slide backwards a fraction of an inch at the conclusion of each draw, thus lowering the shaper rail and raising the winding faller proportionately higher. These inclines are double, there being one at each side of the rail $s$. During the commencement of the cop, when the chase is very short, the studs $s_{13}$, $s_{14}$ of the shaper rail are nearly on the same level, but as the cop bottom becomes larger and is nearing completion the chase is lengthened, because the stud $s_{14}$ will descend more quickly than $s_{13}$ on account of the construction of their respective inclines. This has the result that the nose of the chase rises faster than the shoulder, making the chase longer. The position occupied by the shoulder on the cop is determined by the position of the ridge $s_{16}$ on the shaper rail, and the nose by the rear end $s_{17}$ of the rail ; therefore, to comply with the requirements, the end $s_{17}$ must be allowed to lower at a faster rate than the shoulder. To accomplish this result the upper part of the incline $s_{16}$ must be steeper than the corresponding part of the incline $s_{15}$. When the bottom of the cop is formed, the requirements are reversed, that is, the length of the chase must be shortened by allowing the ridge $s_{16}$ to be lowered at a quicker rate, the incline $s_{15}$ being constructed accordingly.

**99.** The back inclines $s_{16}$, Fig. 41, are made more concave than the inclines $s_{15}$ at the point that governs the construction of the cop bottom. After the cop bottom is built, the studs $s_{13}$, $s_{14}$ make contact with straight portions of their respective inclines ; but to ensure that the chase will be shortened while the body of the cop is being formed, the descent of the stud $s_{13}$ along the incline $s_{15}$ is faster than that of the stud $s_{14}$ along the back incline. Therefore, the long incline $s_{12}$ will be lowered at a slower rate than the short incline $s_{11}$. If the portions $s_{11}$, $s_{12}$ of the builder rail are in one piece, it follows that when the amount of slope at $s_{12}$

is increased to lengthen the chase, the inclination at $s_{11}$ is correspondingly decreased, that is, the short incline assumes a more nearly horizontal position. This causes the winding faller to lock, preparatory to winding, at a point too far below the correct position of the nose.

**100.** Since a builder rail in one piece does not allow the winding faller to lock at all times at the same place relative to the nose of the cop, it follows that the binding coils are not wound properly on the cop from the nose to the shoulder, which results in a less solid cop being formed. Further, if the binding coils are not accurately wound, there is always the danger, not only of the yarn coming off in several tangled layers, but the cops themselves are soft and liable to break across during handling. To obviate such defects the short incline $s_{11}$ is made separate, as in Fig. 41, and hinged at the ridge $s_{16}$, the hinged part being supported by a pair of plates $s_0$ placed immediately behind the front plates $s_{15}$.

**101. Connection of Inclines.**—The three pairs of inclines shown in Fig. 41 are moved together in the back and front slides $s_{19}$ and $s_{20}$, respectively, by a rod $s_{18}$. When spinning cops, which are generally of large diameter, the adjusting screw $s_{21}$ is moved in so as to lift the incline $s_{11}$ and shoulder $s_{16}$ well above the front incline $s_{15}$ to make a long chase. But should a change be made to spinning weft on bobbins, which are never more than about 2 inches in diameter, the screw $s_{21}$ would be turned so as to lower the shoulder, thus making the chase shorter.

**102. Movement of Builder Rail.**—The mechanism that gives the required backward movement to the inclines $s_{14}$, $s_{15}$, Fig. 41, is shown in perspective in Fig. 42, and in front elevation in Fig. 43. The single builder rail, that is, one with both the short and long inclined portions in one piece, is perhaps more used than the hinged rail, and gives good results, although it has the defects previously noted. With this rail, only the back and front inclines $s_{15}$, $s_{16}$, Fig. 41, are required, connected by the rod $s_{18}$. Fixed to the left-hand front incline $s_{15}$ is an arm $s_{22}$ with a nut, Fig. 42, through which the builder screw $s_{23}$ passes, which is supported in suitable brackets at its ends, as shown. The screw is operated by the ratchet wheel $s_{24}$, which is turned 1, 2, or more teeth, as required, at each draw of the mule. The ratchet wheel is also a change wheel, the sizes ranging from 25 to 50 teeth; these change wheels differ, however, in one

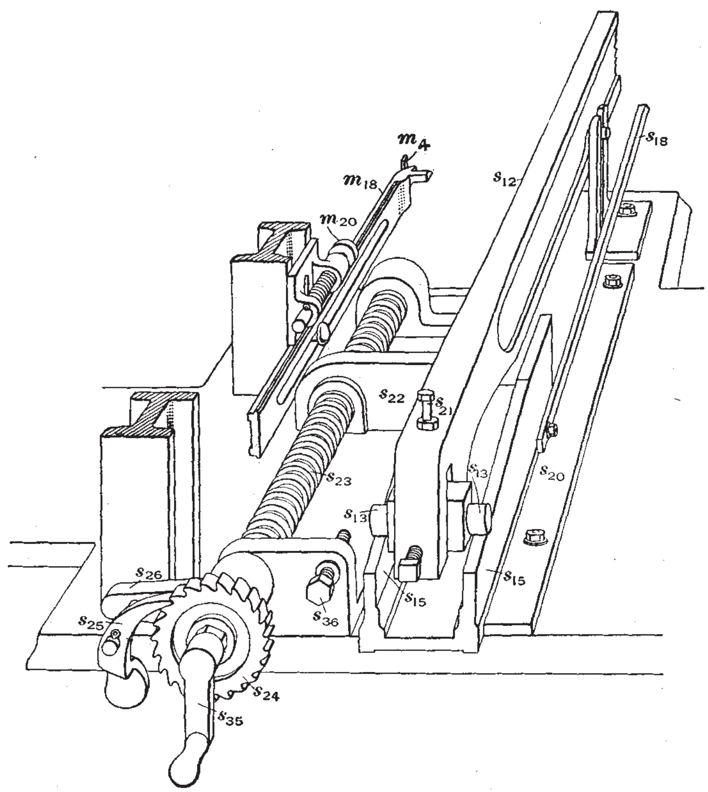


FIG. 42

respect from others in that the diameters remain unaltered, the teeth in the lower numbers being made larger. The wheel is turned at each draw by a pawl $s_{25}$, supported by an arm $s_{26}$, pivoted on the shaper screw. The lower half of the pawl is made heavy so as to keep the point of the pawl in gear with the teeth of the ratchet wheel.

**103.** As the carriage is drawn out the shaft $s_{27}$, Fig. 43, termed the *quadrant pinion shaft*, makes 3 or 4 revolutions, being driven by the bands $t_1$, $t_3$, Fig. 46, so that worm $s_{28}$ turns the segment $s_{29}$, which lifts the arm $s_{30}$, and, through the connecting wires $s_{31}$ and $s_{32}$, also the arm $s_{26}$ with pawl $s_{25}$. The

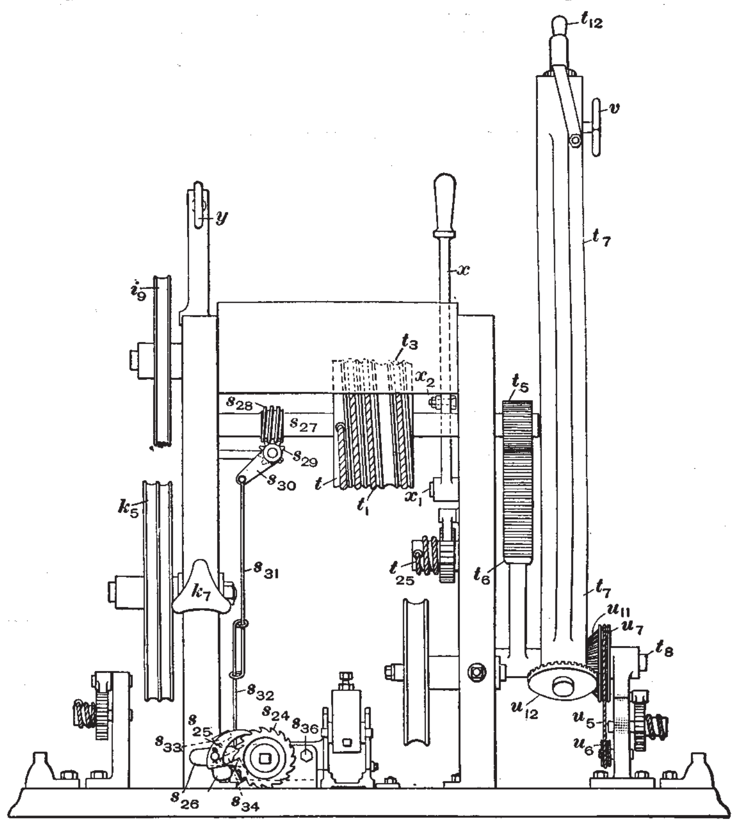


Fig. 43

distance that the ratchet wheel is turned by this pawl is regulated by the position of a long setscrew $s_{33}$, which passes through a short arm $s_{34}$, connected with the arm $s_{26}$, and rests on the bearing of the screw $s_{23}$. The position of the arm $s_{34}$, and with it the arm $s_{26}$ and pawl $s_{25}$, may be changed by turning the screw $s_{33}$ in the required direction. As the loops in the connecting wires $s_{31}$, $s_{32}$

must touch each other before the pawl can be raised, it follows that the higher the position of the pawl when at rest the shorter will be the distance that it can be lifted. The lower the position assumed by the pawl the sooner will the loops in the connecting wires $s_{31}$ and $s_{32}$ make contact and the greater will be the distance through which the pawl is lifted. By this means the pawl can be made to take any number of teeth up to five.

**104. Movement of Inclines.**—When the builder screw $s_{23}$, Fig. 42, has moved the builder rail into its lowest position by moving the inclines $s_{14}$ and $s_{15}$ into a position farthest to the rear, the cops are full. Before commencing a new set of cops the shaper screw must be turned until the inclines are in their most forward position. This is done by the small handle $s_{35}$, Fig. 42, which fits on the square end of the builder screw. While holding the pawl out of contact with the ratchet the screw is turned to the left, moving the inclines quickly back to their forward position. The pawl may also be made to turn the ratchet by letting an incline on the carriage come in contact with a lever connected with the pawl and so turn the ratchet, but the method first described is the one mostly used on the mule under consideration.

**105. Winding Yarn on Cop or Bobbin.**—The building motion performs only the function of guiding the yarn on the spindles and does not affect in any way the turning of the spindles during winding. The speed at which the spindles revolve must be adjusted in accordance with the speed of the carriage when running in; that is, the spindles must revolve at a speed sufficient to keep the yarn between the carriage and the delivery rollers uniformly tight. Since the carriage runs at a variable speed and the yarn is wound on varying diameters of the cops or bobbins, the exact spindle speed is difficult to ascertain.

**106. Speed of Spindles During Winding.**—A diagrammatic section of the bottom of a cop is shown in Fig. 44, and assumed to be $2\frac{1}{2}$ inches in diameter and built on a spindle $\frac{3}{8}$ inch in diameter. The length of the draw is 78 inches, and 12 inches of yarn is required for the binding coils; therefore, $78 - 12$

= 66 inches of yarn must be wound in close upward spirals. To find the number of revolutions to be made by the spindles for the purpose of winding on the yarn, it is necessary to divide the length of yarn by the circumference of the spindle; hence, the number of revolutions made by the spindle to wind on the yarn is:

$$\frac{66}{\frac{3}{8} \times 3{\cdot}1416} = \frac{66 \times 8}{3 \times 3{\cdot}1416} = 56{\cdot}02$$

**107.** Each subsequent draw of yarn is wound on top of the previous one, in such a manner that after a short time the chase will assume the proportions of the trapezoid *a b d c*, Fig. 44, in which *a b* is the base line, or shoulder, and *c d* the nose. Thus, the speed of the spindle, when commencing to wind on the maximum diameter of the chase, must be correspondingly slow, and as winding on each of the lesser diameters takes place during each inward run of the carriage, the speed of the spindles must be correspondingly increased until the maximum speed for each chase is reached, when the winding terminates on the base spindle at the nose. In the following table is given the calculated speeds at which winding would commence on the shoulder of the various chases, it being understood that the speed must increase until the end of the nose is reached, at which point the speed should be at the rate of 56·02 revolutions for 66 inches. In Fig. 44 the diameter *a b* = $\frac{1}{2}$ inch, $a_1\, b_1 = \frac{3}{4}$ inch, $a_2\, b_2 = 1$ inch, each succeeding diameter being increased by $\frac{1}{4}$ inch until the maximum diameter $a_8\, b_8$ is reached, which is equal to $2\frac{1}{2}$ inches.

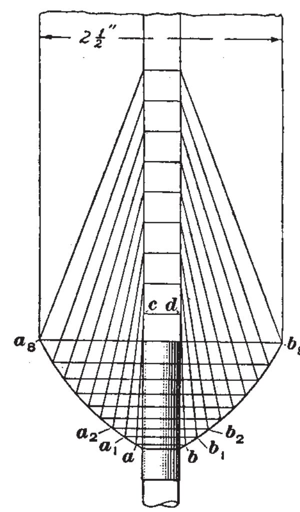

Fig. 44

From Table I it will be seen that the rate of decrease in the speed required is not uniform, since for the $\frac{1}{4}$-inch difference between the diameters of $2\frac{1}{4}$ and $2\frac{1}{2}$ inches, the calculated decrease in revolutions is only ·94 revolution, while the calculated decrease in revolutions when the diameter increases from $\frac{3}{8}$ to $\frac{1}{2}$ inch is 14 revolutions. Therefore, as the diameter of the cop bottom increases, the rate of increase in the spindle speed is less, so that when the diameter is doubled the required number of revolutions is in each case halved.

**108. Quadrant.**—The 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 up of the carriage. For this purpose a device termed the **quadrant** is employed. The principle of its action is based on the fact that if a winding drum suitably arranged in the carriage has a chain wound round it with its free end attached at a point near the tail-piece, then, as the carriage is drawn inwards the chain will be pulled off and the drum revolved. By raising the fixed end of the chain into various positions above the drum a variable motion is given to the drum. If this drum is used for the purpose of driving the spindles, while yarn is wound on them during the inward run of the carriage, it is possible to vary their total number of revolutions, as required.

TABLE I

INITIAL SPEEDS FOR CHASES OF VARIOUS DIAMETERS

| Diameter of Shoulder Inches | Number of Revolutions Required |
|---|---|
| $\frac{3}{8}$ | 56·02 |
| $\frac{1}{2}$ | 42·02 |
| $\frac{3}{4}$ | 28·01 |
| 1 | 21·01 |
| $1\frac{1}{4}$ | 16·81 |
| $1\frac{1}{2}$ | 14·00 |
| $1\frac{3}{4}$ | 12·00 |
| 2 | 10·50 |
| $2\frac{1}{4}$ | 9·34 |
| $2\frac{1}{2}$ | 8·40 |

**109. Action of Quadrant.**—The diagrammatic views, Fig. 45 (*a*) and (*b*), are intended to illustrate the working of the quadrant. In view (*a*) the winding drum $t_{13}$ is shown in three positions *1*, *2*, and *3*; *1* shows the winding drum in the position it occupies just as the carriage starts to run in; *2*, when the carriage is about half-way in; and *3*, when the carriage is in at the roller beam. The oblique lines $t_0$ represent the *winding*, or *quadrant, chain*, while $t_{10}$ is the *quadrant nut*, which, for the present, is to be considered as stationary and occupying the position shown. The thin, or narrow, portions of the lines $t_0$ represent the length of chain necessary to connect the quadrant nut and the drum when the carriage is in its extreme outward position, while the thick portions represent the length of chain that unwinds from the drum and revolves it in the direction of the arrow, while the carriage runs in, occupying the second and third positions,

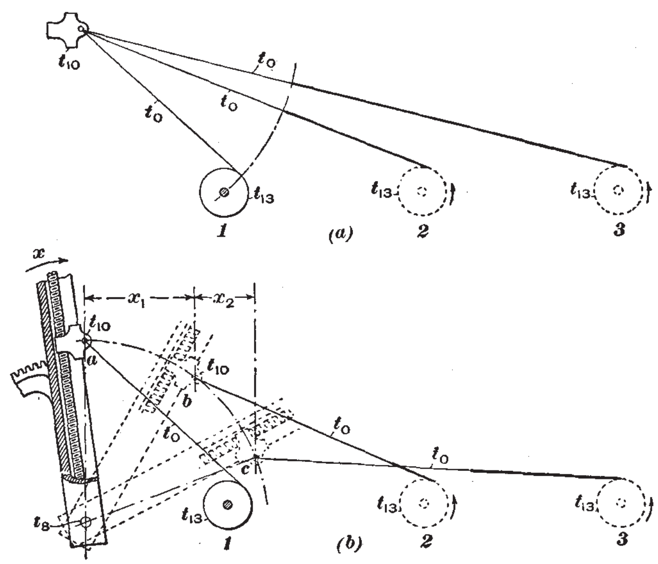


FIG. 45

respectively. By comparing the lengths of the heavy lines, it will be seen that, as the carriage runs in, the amount of the chain unwound increases. In other words, the length unwound when the carriage has arrived in position *3* is more than twice that unwound when in position *2*, notwithstanding the fact that the distance *1–3* is just twice *1–2*. This would tend to increase the speed of the winding drum and therefore also that of the spindles, as the carriage nears the roller beam, provided that the conditions were those shown in Fig. 45 (*a*).

**110.** The actual conditions that exist are shown, approximately, in Fig. 45 (*b*). In this case the nut $t_{10}$ is shown on a screw that may swing round the point $t_8$ in the direction indicated by the arrow $x$, as the carriage and the winding drum $t_{13}$ move inwards. When the drum occupies the positions *1*, *2*, and *3*, the quadrant nut occupies the positions $a$, $b$, and $c$, respectively. As a result of the inward motion of the quadrant nut $t_{10}$ there will not be as much chain unwound from the winding drum, in assuming position *2*, as was the case when in the same position in Fig. 45 (*a*). The amount unwound is indicated by the heavy portion of the line $t_0$ and varies as the quadrant nut is moved farther toward the roller beam during the formation of the cop bottoms. The amount of chain unwound from the drum, as it assumes position *3*, Fig. 45 (*b*), with the quadrant nut in position $c$, is also indicated by the heavy portion of the line $t_0$.

**111.** By comparing the amount of chain unwound from the drum, when arriving at positions *2* and *3*, Fig. 45 (*b*), it will be seen that the proportion is greater than that shown in view (*a*); consequently, the rate of increase in the speed of the drum is proportionately greater. It follows from this that the rate of increase in the speed of the spindles is also greater, and thus fulfils the requirement that as the diameter of the chase gradually decreases the speed of the spindle shall increase. The difference in the length of chain unwound from the drum as it assumes position *3* in (*b*), as compared with the length unwound at position *2*, is due largely to the fact that the horizontal distance moved by the quadrant nut in the second instance, as indicated by the distance $x_2$, is less than the distance moved in the first instance, as indicated by the distance $x_1$.

**112.** Although the quadrant does not actually drive the spindles, it is the controlling element during winding. The mechanism of the quadrant with its connection to the tail-piece is shown in Fig. 43 in elevation, and in Fig. 46 in side elevation. The quadrant $t_6$ consists of a segment wheel that is connected to the *quadrant pillar*, or *arm*, $t_7$ and supported by a short shaft, or stud, $t_8$. The quadrant is made to turn backwards and forwards on its centre, or to have an oscillatory movement, by the *quadrant pinion* $t_5$ engaging with the segment $t_6$. The pinion $t_5$ is fixed on a short shaft $s_{27}$ that extends across the tail-piece of

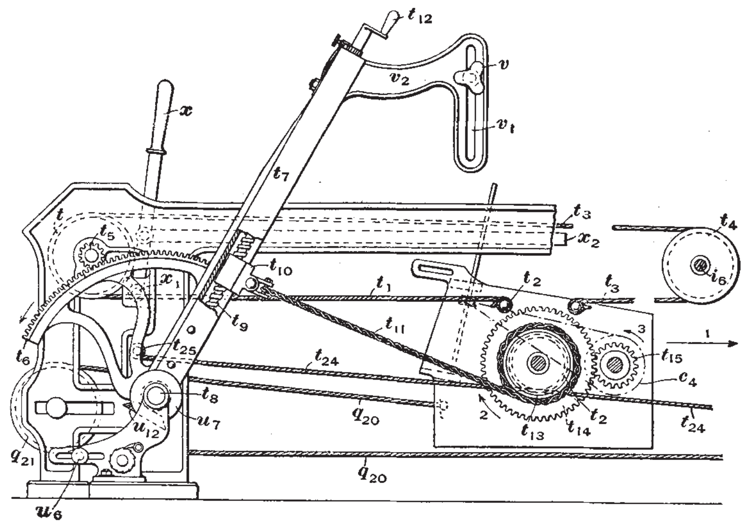


FIG. 46

the headstock and carries a scroll $t$, shown in Fig. 43. The scroll with its shaft is driven by the bands $t_1$ and $t_3$, known as *quadrant bands*.

**113.** The band $t_3$, Figs. 43 and 46, is attached at one end to the scroll $t$, makes a few turns round it, then passes backwards round a guide pulley $t_4$, which revolves loosely on the drawing-out scroll shaft $i_6$, Figs. 12, 14, and 16, and thence forwards to the stud and ratchet mechanism attached to the carriage. The other band $t_1$ is also attached with one end to the scroll $t$, but after being wound round the scroll in a direction opposite to that of $t_3$, it passes to the stud and ratchet mechanism $t_2$ carried by the carriage to which the opposite end is attached.

**114.** As the carriage is drawn out the scroll is caused to revolve on account of the band connection, so that the band $t_3$, Fig. 43, is unwound from the scroll and the band $t_1$ wound up; when the carriage is running in, the direction of rotation of the scroll is reversed. The drawing out of the carriage causes the quadrant pinion $t_5$ to turn in such a direction as to cause the segment of the quadrant to turn forwards in the direction of the arrow, thus raising the quadrant arm $t_7$ until its position during twisting is

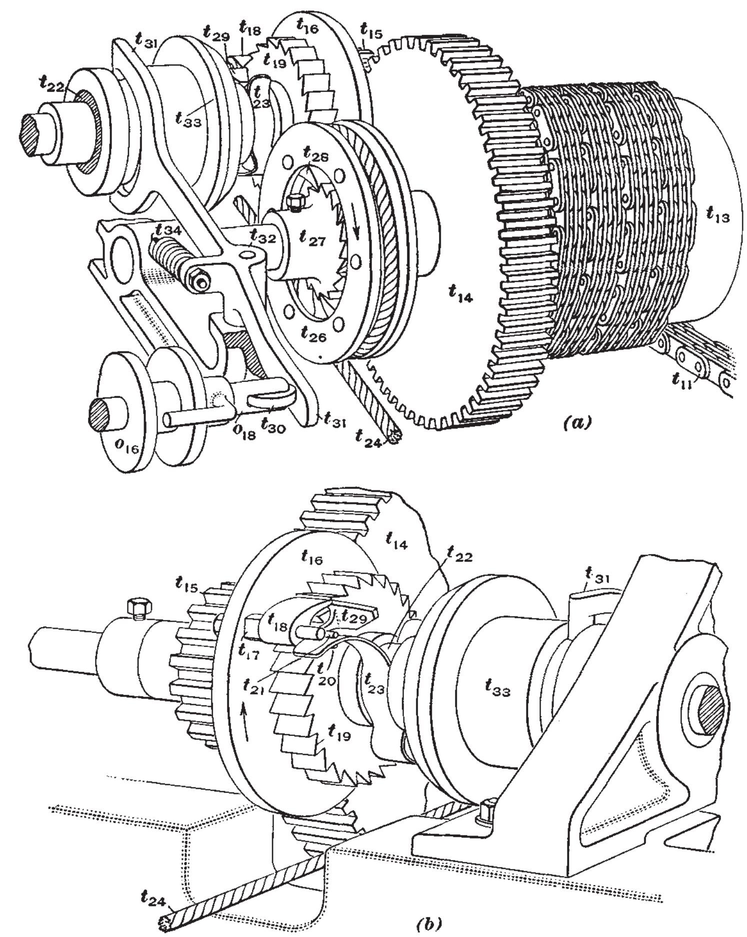


Fig. 47

about 15° forwards from the vertical. A good method of setting the quadrant is to have the arm vertical when the roller $s_3$, Fig. 31, is on the ridge $s_{16}$ of the builder rail $s$.

**115.** The quadrant arm $t_7$, Fig. 46, is hollow and carries a long screw $t_9$ which it supports at each end, and that may be turned by the handle $t_{12}$, as required. Mounted on the screw is the quadrant nut $t_{10}$, which is caused to rise or fall according to the direction in which the screw $t_9$ is turned. The quadrant nut is prevented from turning with the screw by being so constructed that a portion of it projects through a slot in the face of the quadrant arm. The nut is connected to a drum $t_{13}$ by a chain $t_{11}$, commonly known as the *winding*, or *quadrant, chain*. As shown in Fig. 5 the quadrant screw $t_9$ has a thread with variable pitch, the thread at the lower end having a much greater pitch than the portion near the top. Consequently, while the nut is in its lower position, it will move, vertically, a greater distance for each revolution of the screw than while occupying

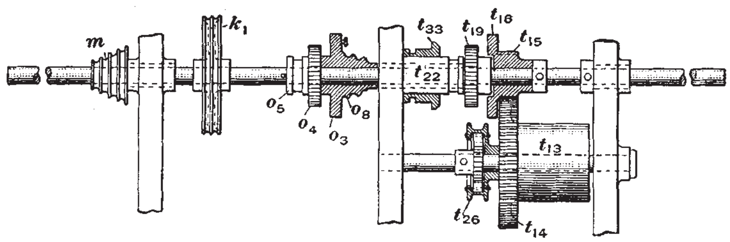


FIG. 48

a position higher up. The pitch is varied in this manner for the purpose of raising the nut more quickly during the earlier draws while the cop bottom is being formed. The drum $t_{13}$ is carried by a short shaft in the carriage square, and is compounded with a large spur wheel $t_{14}$, termed the *winding-drum wheel*, that engages with a smaller spur wheel $t_{15}$ loose on the tin-roller shaft. The spur wheel on the tin-roller shaft is compounded with the *winding click disc* $t_{16}$. The disc carries a stud $t_{17}$, Fig. 47 (*b*), on which is pivoted a pawl $t_{18}$, that during winding is in contact with a ratchet wheel $t_{19}$ fastened to the tin-roller shaft. The end of the stud $t_{17}$ projects beyond the pawl $t_{18}$ about the same distance as the two studs $t_{20}$ and $t_{21}$, which project from the pawl. Fixed to the framing in close proximity to the winding ratchet wheel is the boss $t_{22}$, Figs. 47 and 48, provided with a groove in which rests a clip spring $t_{23}$, Fig. 47, variously termed *friction spring*, *winding spring*, or *click spring*. One end of this spring projects upwards and passes between the studs $t_{20}$, $t_{21}$. A general idea of the number of parts assembled on the tin-roller shaft, and their relative positions, may be had from the plan view, Fig. 48; in this view those parts that are loose on their respective shafts are shown in section.

**116. Driving Spindles During Winding.** — When the carriage is out, a considerable length of the winding chain $t_{11}$, Fig. 46, is wound on the surface of the drum $t_{13}$. When the carriage runs in, as indicated by the arrow *1*, the quadrant chain unwinds from the drum, causing the latter to revolve, together with the winding-drum wheel $t_{14}$, in the direction indicated by the arrow *2*, and as the large winding-drum wheel $t_{14}$ gears with the small wheel $t_{15}$, the latter will revolve in the direction indicated by the arrow *3*, together with the disc $t_{16}$, as these parts form one piece. When this disc is revolving in the direction of the arrow, Fig. 47, the pawl $t_{18}$ is brought into contact with the ratchet wheel $t_{19}$ by reason of the spring $t_{23}$ retarding the stud $t_{20}$. As the ratchet wheel $t_{19}$ is secured to the tin-roller shaft, the tin roller $c_4$ will also revolve and drive the spindles by means of bands, as shown in Fig. 46, the direction of rotation of the tin roller in this case being the same as during the drawing-and-twisting period.

**117.** When the carriage has completed its inward run, the quadrant chain $t_{11}$, Fig. 46, is almost entirely unwound from the winding drum $t_{13}$. The chain is rewound on the winding drum during the outward run of the carriage by a winding-drum band $t_{24}$. Referring to Figs. 46 to 49, the winding-drum band is attached to a stud-and-ratchet mechanism $t_{25}$, Fig. 46, in the tail-piece, and passes backwards, making a turn round the pulley $t_{26}$ which is loose on the winding-drum shaft; thence backwards to the back of the headstock and over a pulley, a weight being attached to the free end of the band. The tension given to the band by means of the weight produces sufficient friction to turn pulley $t_{26}$ and the ratchet wheel $t_{27}$ through pawls $t_{28}$ in the direction of the arrow, Fig. 47. As the ratchet wheel is fixed to the winding-drum shaft, the winding drum is also revolved in a direction that will rewind the chain on the drum $t_{13}$.

Changing the direction of the winding drum also changes the direction of rotation of the wheels $t_{14}$ and $t_{15}$, as well as the disc $t_{16}$, consequently throwing the pawl $t_{18}$ out of contact with the ratchet wheel $t_{19}$. The pulley $t_{26}$ being loose on the shaft to which the winding drum is fixed, it follows that when the carriage is being drawn in it is rotated by the rope $t_{24}$ at a speed varying in accordance with the speed of the carriage, whereas the ratchet wheel $t_{27}$,

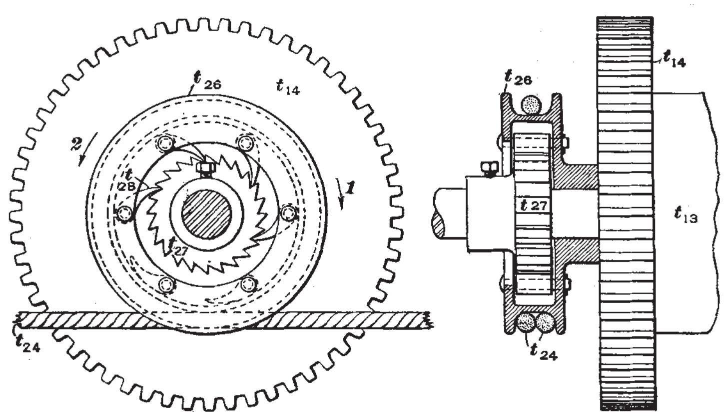


FIG. 49

which is fixed to the winding-drum shaft, is rotated at an increasing speed as the carriage is drawn in by reason of the motion of the quadrant lever $t_7$. As the speed of pulley $t_{26}$ is greater than that of the ratchet wheel $t_{27}$, the pawls $t_{28}$ slip over the backs of the teeth of the ratchet wheel.

**118. Safety Device for Winding Motion.** — To ensure that pawl $t_{18}$ does not engage before the proper time, a safety projection $t_{29}$ is introduced which is operated from the stud $o_{18}$, Figs. 31 and 47 (*a*). Attached to the end of the stud is a small friction roller $t_{30}$, which bears against the end of lever $t_{31}$, pivoted on the stud $t_{32}$. The opposite end of this lever is forked and engages a groove in the boss of the conical collar $t_{33}$, which it may move to and fro in a horizontal direction on the tin-roller shaft. The collar bears against the projection $t_{29}$ of the pawl $t_{18}$, and only allows the latter to engage the ratchet wheel $t_{19}$ when the collar is in the position shown in Fig. 47 (*b*). When winding is completed, the winding-faller leg is unlocked and the stud $o_{13}$ assumes a more forward position, as shown by dotted lines in Fig. 31. This allows the spiral spring $t_{34}$, Fig. 47 (*a*), which is attached to the lever $t_{31}$ at one end and to the carriage square at the other, to turn on the stud $t_{32}$, thus moving the forked end inwards, causing the collar $t_{33}$ to lift the projection $t_{29}$ and to disengage the pawl $t_{18}$ from the ratchet wheel $t_{19}$.

**119. Quadrant Nut.**—When a set of cops is first started, the quadrant nut $t_{10}$, Fig. 46, is in its lowest position on the screw $t_9$, and the quadrant arm $t_7$ is nearly vertical at the commencement of each new layer, being usually set a little beyond a perpendicular line passing through the centre of the stud $t_8$. The quadrant being in this position, considerable chain is unwound from the drum, as the carriage runs in, because the chain $t_{11}$ is nearly horizontal and the horizontal distance through which the quadrant nut moves, as the quadrant arm moves downwards on its centre, is very small, thus causing more chain to be unwound from the surface of the drum than when the quadrant nut is higher up on the screw. The unwinding of this great length of chain causes the spindles to revolve quickly, and they are thus able to wind the yarn properly on the comparatively small diameter on which winding commences.

**120.** As the bottoms of the cops increase in size, the required speed of the spindles, when winding the yarn at the large diameter of the cops, is less than at the small one, consequently a variable speed is required. When the quadrant nut, Fig. 46, is moved farther from the stud $t_8$, the chain is leaving its horizontal position, and the nut $t_{10}$ moves through a greater distance as the quadrant turns downwards. The horizontal distance traversed by the quadrant nut, as the carriage starts to run in, is also gradually increased, but as the carriage continues its inward motion the length of chain unwound from the drum $t_{13}$ increases because the quadrant nut is moving in a vertical direction as the carriage is approaching the roller beam, as explained in connection with Fig. 45. It follows from these conditions that only a slight amount of chain is unwound as the carriage starts to wind the yarn on the large diameter of the cops; but as the carriage approaches the roller beam, the yarn is continually being wound on a smaller diameter of the cops, and more chain is unwound. The speed of the spindles is therefore increased so that the yarn shall be properly wound on the small part of the cops. The quadrant nut is not raised continuously during the formation of the bottom, but only periodically, at the inward run of the carriage. When the cop bottoms are completed, the movement of the quadrant nut along the quadrant arm ceases.

**121. Counter Faller as Tension Indicator.**—The action of the counter faller during winding is to give the requisite tension to the yarn. If the number of revolutions given to the spindles are too few, due to the quadrant nut being too high, the counter faller will rise, since the draw of yarn will not all be wound on. On the other hand, if the quadrant nut is too low, and, as a consequence, the speed of the spindles is too great, the counter faller is pulled down by reason of the yarn being wound on too tightly; thus, the counter faller serves as an indicator as to the manner in which the position of the quadrant nut should be adjusted.

**122. Cop-Bottom Governing Motion.**—The term **governing motion** is given to the appliance that regulates automatically the position of the quadrant nut on the quadrant screw. The turning of the quadrant screw $t_9$, Fig. 46, is governed by the fallers. Attached to one of the central sickles $b_4$, Fig. 50, on the counter-faller shaft $b_5$ is a chain $u$ that passes downwards and round a small pulley $u_1$ carried by the lever $u_2$ which is pivoted at $u_3$; the other end of the lever is made heavy to keep the chain tight. After passing round the pulley $u_1$ the chain is attached to one of the sickles $b_4$ on the winding-faller shaft $b_2$. In the carriage square is a pulley $u_4$, round which an endless band $u_5$ is passed; thence one end of the band is passed round one of the two guide pulleys $u_6$ to the pulley $u_7$ on the quadrant stud, Fig. 46. From the pulley $u_7$ the band is passed round the other guide pulley $u_6$, and back underneath the carriage, round the guide pulley $u_8$, at the rear of the headstock, and back to pulley $u_4$. The latter pulley is made to revolve as the carriage moves out, since the band remains stationary.

**123.** When backing off takes place the winding faller $b$, Fig. 50, is pulled down, which causes chain $u$ to hang slack and thus allows the heavy end of lever $u_2$ to drop; if at the same time the counter faller is pulled down during winding, by reason of the yarn being too tight, the lever $u_2$ is allowed to drop still farther, as is also the finger $u_9$ attached to it. The finger engages with the teeth of the star wheel $u_{10}$ fastened to pulley $u_4$ and

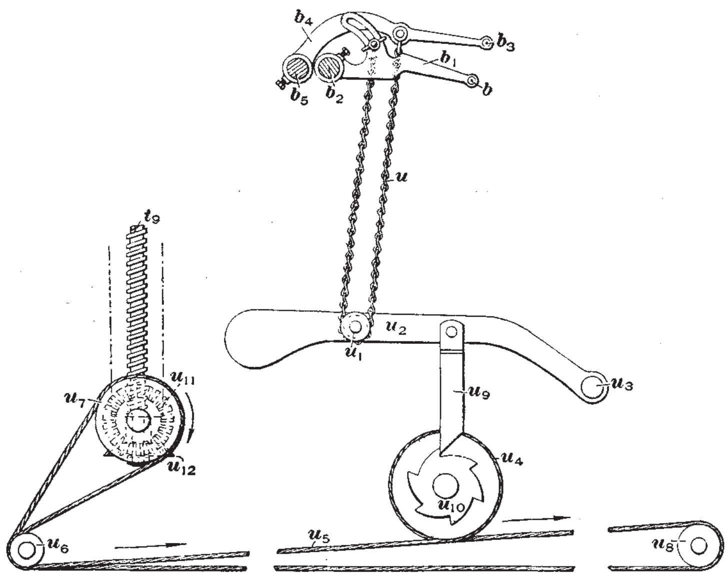


FIG. 50

thus stops the revolutions of the latter. When pulley $u_4$ is stopped, the band $u_5$ is held stationary on the pulley by reason of the friction between pulley and band, and the latter is therefore moved by the carriage as it travels inwards and thus turns pulley $u_7$, Fig. 50, in the direction indicated by the arrow. This latter pulley is fixed to a bevel wheel $u_{11}$ which gears with bevel wheel $u_{12}$ fastened to the lower end of the quadrant screw $t_9$; therefore, when the counter faller is pulled down, by reason of the yarn being too tight, the quadrant screw is turned and the quadrant nut raised to a higher position to give a decreased number of revolutions of the spindles at the next draw. When the cop bottom has been formed, several links of chain $u$ are taken up, thus raising lever $u_2$ so that finger $u_9$ is raised out of action with the ratchet $u_{10}$.

**124. Nosing Motion.**—After the cop bottoms are formed, the upward movement of the quadrant nut ceases, because the various diameters throughout the winding surfaces of the cops remain the same for each new layer of yarn as for the previous layer. But by reason of the taper of the spindles the nose of each succeeding chase will decrease in size and a device must be applied to control the winding at these places. If a speed of 56·02 revolutions per minute is required for spindles $\frac{3}{8}$ inch in diameter, it follows that more revolutions will be required when the nose reaches a diameter of $\frac{5}{16}$ or $\frac{1}{4}$ inch, as the cop is built. If this increase in revolutions were not made the cops would be built with soft noses. The mechanism by which the speed of the spindles is increased while the nose is being built is termed the *nosing motion*.

**125.** The nosing motion consists of a stud $v$, Fig. 46, termed a *nosing peg*, which is fixed in the required position in the slot $v_1$ of the bracket $v_2$, bolted to the end of the quadrant arm $t_7$. As each set of cops, or bobbins, increases in height, the peg is lowered so that it bears on the winding chain $t_{11}$ during the last few inches of the drawing up of the carriage. While the carriage is in this position the quadrant arm $t_7$ is drawn downwards into a position that will allow the nosing peg to make contact with the chain and deflect it. This will cause a greater length of chain to be unwound, which will increase the speed of the spindles just as the yarn winds on the nose of the cop.

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## STOP-MOTIONS

**126. Motion to Stop Carriage at Back Stops.**—The following three stop-motions are used on the mule: (*a*) One by which the mule can be stopped when the carriage is against the back stops when a condenser bobbin is empty and a full one is required to be pieced ; (*b*) one which can be operated when the cops or bobbins are full, when it is necessary to stop the mule on the inward run ; (*c*) and one by means of which all motion to the mule can be stopped.

The first stop-motion consists of a rod $w$, situated under the faller shafts $b_2$ and $b_5$, Fig. 1 ; the rod passes from end to end of the carriage and has fixed to it a bracket $w_1$, Fig. 51. The bracket is loose on the shafts and is capable of being moved for a distance of about 3 inches along them by means of the

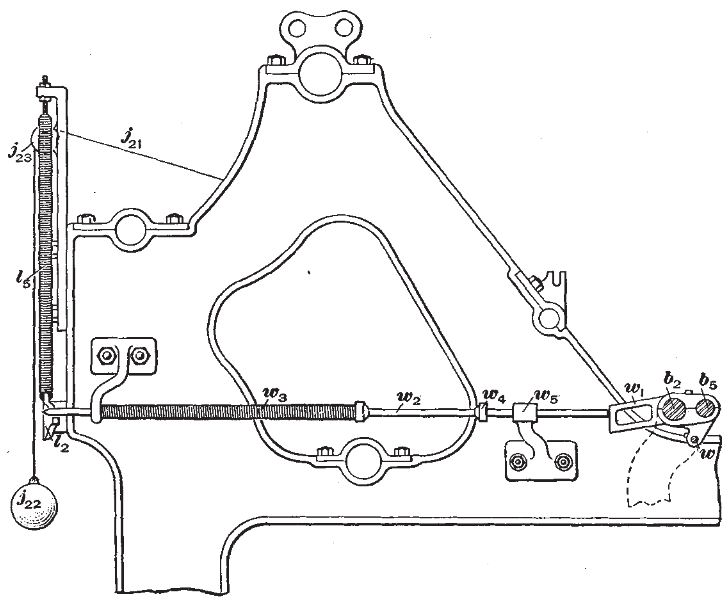


Fig. 51

rod $w$. When it is required to stop the mule, the rod $w$ is moved longitudinally into such a position that when the carriage is drawn up the bracket $w_1$ will meet the stop-rod $w_2$, and push it inwards. The other end of the rod will then pass over the end of arm $l_2$, which is bolted to the belt lever $l_3$ with the belt fork $l_4$, as shown in Fig. 21. The rod $w_2$ will then prevent the spring $l_5$ from moving the belt to the fast pulley $f_1$ when the cam-shaft with its cams change positions. To start the mule again, the rod $w$ is pulled into its first position, which removes the bracket $w_1$ from its position against the end of the rod $w_2$, and thus allows the compressed spring $w_3$ to push the stop-rod toward the carriage so that the shoulder $w_4$ comes against the bracket $w_5$. The other end of the stop-rod is then clear from the arm $l_2$, and the spring $l_5$ is free to move the belt on to pulley $f_1$.

**127. Motion to Stop Carriage for Doffing.**—The second stop-motion is operated from a lever $x$, which is pivoted at $x_1$, Figs. 43 and 46 ; to this lever is attached a long connecting-rod $x_2$, which passes along the inside of the headstock framing. At the other end of this rod is fixed a pin which passes through a slot in the framing and is attached to a piece $x_3$, Fig. 22. This piece has in it a slot $x_4$, through which projects a stud $x_5$, fixed to the framing. When the lever $x$ is pulled forwards, the outer end of the piece $x_3$ is depressed owing to the shape of the slot. In its lowered position the edge $x_6$ bears on the arm $q_2$, which is the outer arm of a lever, the inner arm of which controls the friction shell $q$, so that by this means the latter is disengaged and the drawing up of the carriage stopped.

**128. Motion for Stopping Countershaft.**—The third kind of stop-motion, by means of which the belt driving from the main or line shaft to the countershaft can be moved from the fast pulley on the countershaft to the loose one, or vice versa, is operated from the *setting-on handle* $y$, Figs. 4 and 43. The latter is connected to the front end of the rod $y_1$, which at its rear end is attached to the end of the lever $y_2$, pivoted at its lower end to the frame. A curved extension of this lever is connected to the lower end of a rod $y_3$, extending upwards to the strap-guide mechanism in the front of the countershaft for the fast-and-loose pulley $e_2$, Fig. 10. By moving the setting-on handle and rod in or out, the belt is moved from the loose to the fast pulley, and vice versa. This means of stopping the entire mule is necessary particularly during *doffing*.

## DOFFING

**129. Stopping Mule.**—**Doffing** is the removal of the full cops or bobbins and the preparing of the machine for the formation of a new set. When a set of cops or bobbins has reached the required size, the belt driving to the countershaft is thrown on the loose pulley, just as the carriage completes the twisting process or the backing-off motion, since there is enough momentum to allow the carriage to run in a part of the way. The carriage is stopped when the roller $s_3$ of the winding faller reaches the shoulder $s_{16}$ of the shaper rail $s$, Fig. 31, by throwing out the drawing-in friction, which is done by pulling handle $x$, Figs. 44 and 47, as previously explained. When the roller $s_3$ rests on the shoulder, the winding faller has completed its downward movement, being at the shoulder of the cops, after winding the binding spirals of yarn on the chase of the cops.

**130. Preparing for Doffing.**—A length of chain is pulled off the winding drum by lifting the pawl $t_{18}$, Fig. 47. The carriage is then allowed to run in for a distance of from 6 to 12 inches, and since the quadrant chain $t_{11}$, Fig. 46, is slack no winding is done. The winding faller is held down in the position shown by inserting a block of wood $z$ between the counter-faller shaft $b_2$ and the upper end of the faller leg $s_7$, as shown in Fig. 52. The counter faller is held down by the hook, or catch, $z_1$, which is mounted loosely on the winding-faller shaft, but which can be moved along the shaft and turned so that the curved end hooks into the curved part of the handle $z_2$, fastened to the winding-faller shaft. The handles $z_2$ and $z_3$ are for depressing by hand the counter faller and winding faller, respectively.

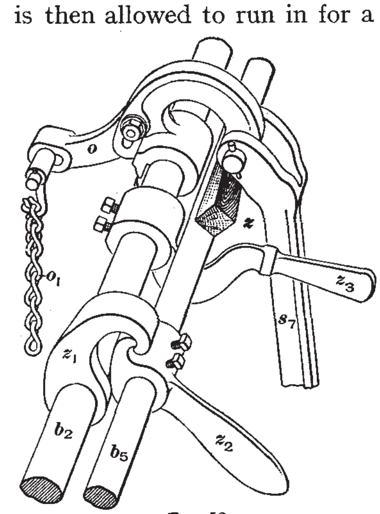

Fig. 52

**131.** The quadrant screw, Fig. 46, is now turned by the crank-handle $t_{12}$, after removing the pawl from contact with the ratchet wheel at the top of the quadrant arm, so that the quadrant nut will occupy its lowest position, ready for starting a new set.

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# TABLE II

## MOTIONS OF MULE AND THEIR ACTIONS AT MAIN POSITIONS OF CARRIAGE

Principal Parts and Motions

| Actions | Spindles (Tin Roller, Rim Bands and Rims) | Carriage and Scrolls | Rollers | Winding Faller | Counter Faller | Cam-Motion | Drawing-Out Motion | Slubbing Motion | Belt and Belt Fork | Jacking-Up Motion | Holding-Out Catch | Twist Motion | Easing Motion | Backing-Off Motion in Headstock (Friction and Lever) | Backing-Off Motion in Carriage Square (Tin Roller and Faller Leg) | Faller Shafts and Weights | Motion for Drawing In | Builder Motion | Quadrant | Winding Motion | Governor Motion |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Beginning of Draw | Slow speed for spinning | Highest speed on full diameter of scroll | Deliver at a speed equal to that of carriage | Is above the yarn | Is under the yarn | Cam is in its first position | Drawing-out clutch engaged by cam and spring. Scroll connected to wheels | Toothed clutch engaged to turn rollers. Slubbing wheel in gear | Belt is on pulley keyed on shaft and turns rims, bands, spindles, and side wheels for carriage and rollers | Out of action. Flat wheel revolves, but friction clutch disengaged | Hook in lower position | Twist wheel lowered into gear by lifting of drawing-in friction | Out of action. Swing piece on side of square lifter on belt-fork arm | Friction clutch inoperative by reason of drawing-out fork. Top fork pushes lever and cam away | Inoperative, as ratchet wheel turns backwards | Weights supported by chain from winding faller | Cam holding drawing-in friction clutch out of gear | Stationary | Rope winds on quadrant chain as carriage recedes, while quadrant drum and pinion raises the quadrant arm to a position 15° behind the vertical | As the faller leg is unlocking the conical collar is pushing the pawl out of contact with the ratchet wheel | Loose |
| Middle of Outward Run | do. | Begins to slow down on long slope of scroll | Stop as regulated | do. | do. | do. | do. | Slubbing-wheel pin disengages friction clutch and pushes wheel out of gear, allowing weight to return it to starting point | | do. | do. | Twist wheel remains in gear | do. | do. | do. | do. | do. | Worm on quadrant drum shaft pulls up pawl to move builder wheel and thus lower builder rail sufficient for next draw | | Pawl out of contact | do. |
| Last Few Inches of Outward Run | do. | Very slow on nose of scroll | Stationary | do. | do. | do. | do. | Disengaged | do. | Strong spring out of action by leg running up incline in tail-piece | Hook passes over catch at position occupied by carriage during jacking up | do. | do. | do. | Front arm pushes long rod under the arm of drawing-in friction to hold it out when cam turns | do. | do. | | | do. | do. |
| End of Outward Run and Beginning of Twisting | Fast speed for twisting | Stationary | do. | do. | do. | Cam-lever is depressed and cam moves into its second position | Drawing-out friction opened by cam. Scroll loose on shaft | do. | Moves to pulley on sleeve connected to big rim by means of highest part of cam | Finger knocked off allows tooth clutch to engage and move the rack. This meets buffer and pushes carriage in until leg drops off slide and spring disengages friction clutch. Rack pushed back by spring in tail-piece | | do. | Square comes under swing piece which drops vertically over it | do. Lever now kept away by cam | Inoperative | do. | Long rod now under lever to support it and hold clutch out of gear | Stationary | Quadrant arm 15° behind vertical | do. | do. |
| Twisting and Jacking Up | do. | Slight inward motion | do. | do. | do. | Stationary | Slightly turned by inward-moving carriage | do. | do. | | Hook engages catch at end of jacking up and carriage is held firmly | do. | Stationary | do. | do. | do. | do. | do. | do. | do. | do. |
| End of Twisting | Spindles slow down, stop, and slowly reverse | Stationary | do. | do. | do. | do. | Stationary | do. | Moved by spring to middle, or loose, pulley when released | Out of action | do. | Pin comes against belt-fork connection and twist motion stops | Arm lifts wheel into gear with worm | do. | do. | do. | do. | do. | do. | do. | do. |
| Easing | | do. | do. | do. | do. | do. | do. | do. | do. | do. | do. | Twist motion remains stationary | Turns the short shaft. Cam moves away to let friction lever in. Turns until pin pushes swing piece off and drops out of gear | do. | do. | do. | do. | do. | do. | do. | do. |
| Beginning of Backing Off | | do. | do. | Moves down as the yarn begins to unwind from the spindles into a position opposite the nose of the cop | Rises to take up the slack yarn made by unwinding, then keeps the yarn under tension during winding. Finally the faller descends into its first position | do. | do. | do. | do. | do. | do. | do. | Stationary | Friction clutch moves against double-speed pulley and turns it and rim bands backwards by reason of the spring pulling lever, the cam having moved away | Ratchet wheel engages pawl, winds on faller chain | Weights lowered by winding faller, causing them to pull up counter faller as the winding faller descends | do. | do. | do. | do. | do. |
| Middle of Backing Off | | do. | do. | | | do. | do. | do. | do. | do. | do. | do. | do. | | Chain pulls down faller finger and lifts faller leg | Counter faller up. Winding faller down | do. | do. | do. | do. | do. |
| End of Backing Off and Beginning of Drawing Up | Spindles stop and reverse to revolve in the usual direction, winding on the yarn according to diameter of cop | Moves slowly inwards, but increases rapidly in speed | do. | | | do. | Drawing-out band is pulled off from scroll turning the latter as carriage runs in. Friction clutch re-engaged by cam | do. | do. | do. | Hook lifted by lever connected to faller leg | Twist wheel lifted out of gear and is moved into initial position by weight | Cam released by lever. Spring moves shaft back to starting point | Connecting-rod from drawing-in friction now pushes it out | Faller leg drops on to roller at heel of foot. Front arm rises and releases long rod | do. | Long rod is released and spring pulls it from under drawing-in friction lever allowing it to set the clutch in action and draw in carriage | do. | As the carriage runs in it pulls the chain off the drum which revolves and by means of the wheels turns the tin roller | Faller leg moves collar sidewise. Turning of disc by quadrant causes the pawl to engage and turn the tin roller | do. |
| Middle of Drawing Up | | Maximum speed | do. | Guides the yarn on the chase of the cop, first to the shoulder, then back to the nose; then the faller rises | | do. | | do. | do. | do. | Hook up | Out of action | Shaft remains at starting point | Friction clutch still out of action | Faller leg rises and falls according to shape of builder rail | do. | | do. | | Turning the spindles | If counter faller is low enough the pawl comes against ratchet wheel and stops it, thus causing the band to move with the carriage and turn the quadrant screw, thus raising the nut |
| End of Drawing Up and Beginning of Next Draw | | Slowing down to the back stops | Engage at end of draw | | | Cam-lever returns to first position and cam moves into its first position | | Carriage pushes friction clutch into gear to turn rollers and slubbing gear-wheels | Cam moves away and spring moves belt on pulley. Keyed on shaft | do. | Hook dropped | Dropped into gear | do. | Cam and fork now keeps it out of action | Leg knocked off and unlocked | Faller leg unlocking raises winding faller. Roller and lever lowers counter faller | Cam and carriage lift friction clutch out of gear | do. | | Faller leg causes conical collar to lift out pawl | |

The builder motion should be reset so that the inclines $s_{15}$ and $s_{16}$, Fig. 42, will be in their foremost positions, as required, when starting a new set, i.e., the shaper plates are moved forwards by turning the shaper screw $s_{23}$ in the required direction by a crank-handle $s_{35}$ placed on the outer end of the screw, as shown in Fig. 42, until the bracket $s_{22}$ makes contact with the end of the screw $s_{36}$, which is adjusted according to the required form of the cop bottom. Before the screw can be turned back, however, the pawl $s_{25}$ must be removed from contact with the ratchet wheel. The chain *u*, Fig. 50, is next lowered to its working position; then the operator, by pulling the rim bands, winds a few turns on the spindle below the full cops or bobbins. Where spinning is done on the bare spindle, the cops are lifted up and a few turns are wound by hand in the proper place on the spindle, so that the yarn wound on during the remaining portion of the inward run will be the first layer of a new cop.

**132. Placing New Tubes or Bobbins on Spindles.**—As the cops or bobbins are being removed, a fresh supply of paper tubes or bobbins is placed on the spindles, one tube or bobbin to each spindle. Before the tubes or bobbins are forced down into position, the wooden block, or wedge, *z*, Fig. 52, should be removed to allow the winding faller to rise and assume its proper position for winding, which is controlled by the builder rail *s* and roller $s_3$, Fig. 31. The tubes or bobbins are now forced down into position on the spindles, so that the tops will be in line; the counter faller is then released. After making sure that the quadrant chain is tight, the carriage is run in slowly, the power being checked by the handle *y*, Fig. 4; otherwise, the carriage will bang in hard against the back stops. Immediately that the carriage is drawn in against the latter, the mule may be put in operation in the usual manner.

**133. Table of Mule Motions.**—As the various motions of the mule must of necessity be studied separately, it follows that their periods of action, relative to each other, cannot be clearly followed, and that the action of the mule, as a whole, cannot be seen mentally without a great deal of concentrated study and careful reasoning. To facilitate this study Table II is inserted, which shows at a glance what any particular motion is doing at any stage of the draw, or stretch. In the first column at the left the various actions of the mule are given in the order in which they are performed. The other vertical columns are set apart for the principal motions and parts of the mule.

**134.** The method of using the table may be illustrated by an example. For instance, it is desirable to know what the various motions are doing while the easing action takes place. Descending along the first column until the action Easing is found and then proceeding along the horizontal row, headed by it, until one meets the vertical column devoted to the particular motion in view, then this column will contain the required information. Proceeding, for instance, horizontally to the column headed Carriage, it is found that the carriage is stationary. Advancing to the column Rollers, the statement is found that these also are stationary. Proceeding successively to the other motions, it is seen that the winding faller is above the yarn and the counter faller under the yarn; that the cam and drawing-out motion are stationary, the slubbing motion disengaged, and so forth along the whole length of this row.

**135.** Sometimes it is of advantage to ascertain the action of a motion during the various stages of a draw. If this information is required about the twist motion, the column headed Twist Motion is consulted, then, on descending to the first division of this column, corresponding to the Beginning of Draw as stated in the first column, it is found that the twist wheel is lowered into gear by the lifting of the drawing-in friction. In the second division, corresponding to Middle of Outward Run, the twist wheel is still revolving and continues its operation up to the sixth division, corresponding to the row End of Twisting, where it is stated: "Pin comes against belt-fork connection." Consequently the twist motion comes to a stop. The reason for this may be seen by proceeding horizontally to the column headed Belt and Belt Fork, where it is stated that the belt is moved by spring to middle, or loose, pulley. The action of the twist motion may be studied in this manner along the whole column devoted to it.

**136.** In using the table it should be noted that if any statement, found in any of the vertical columns, occupies a space that extends over more than one division, then such statement is intended to apply to the horizontal rows crossed by said space. For instance, in the second column the statement "Spindles slow down, stop, and slowly reverse" occupies an open space extending across four horizontal rows. According to the first column these rows represent End of Twisting, Easing, Beginning of Backing Off, and Middle of Backing Off. Hence, it is to be understood that while these four actions are taking place the spindles are slowing down, stopping, and slowly reversing.

# WOOLLEN SPINNING

(PART 2)

## MODIFICATIONS OF MULE MECHANISM

### TWIST MOTION

#### MODIFIED DETAILS

**1. Operation.**—A variation of the twist motion described in *Woollen Spinning*, Part 1, is shown in Figs. 1, 2, and 3. Of these views Fig. 1 is a rear elevation of a portion of the headstock, showing the modified parts, Fig. 2 (*a*) is a side elevation of the mechanism, viewed from the inside of the headstock, while Fig. 2 (*b*) is a section through some of the parts shown in Fig. 2 (*a*), Fig. 3 is a side elevation of a portion of the headstock. On the rim shaft $f$ is a worm $f_6$, which drives the worm-wheel $l$, which is fixed on a short shaft $l_1$, supported by bearings in the casting $l_2$. The latter is pivoted on a stud $l_3$, that is bolted to the framing, so that the casting with the shaft $l_1$ can be raised or lowered, as required. To the rear end of this shaft is fixed a bevel wheel $l_4$, which drives another bevel wheel $l_5$, fixed to a short shaft $l_6$, carried by the casting $l_2$ in a position at right angles to the shaft $l_1$. The shaft $l_6$ passes through a hole in the bracket $l_7$, sufficiently large to allow the shaft to move up and down with the casting $l_2$; the bracket is made in one piece with the top half of the bearing for the back shaft $g$. On the outer end of the shaft $l_6$ is a small gear-wheel $l_8$, which gears with an internal gear-wheel $l_9$, usually termed the *twist wheel*.

**2.** The adjustable bolt $l_{10}$, at the end of the casting $l_2$, Fig. 2, rests with its lower end on the horizontal portion of a long vertical rod $l_{11}$; this is made in two parts, bolted together, so that the rod may be adjusted as to length, if necessary. The rod is free to move up or down and is guided and kept in position at its upper end by a small pin $l_{12}$, which passes through a hole in the rod; at its lower end the rod is guided by a bolt $l_{13}$, Fig. 3, which passes through a slot in the rod, the slot being of sufficient length to allow the required vertical motion. The rod $l_{11}$ is lifted by the end of the lever $q_2$, when the drawing-up friction shell is lowered to engage with the drawing-in friction cone. When the rod $l_{11}$ is raised, the toothed wheel $l_8$ is lifted out of gear with the twist wheel $l_9$.

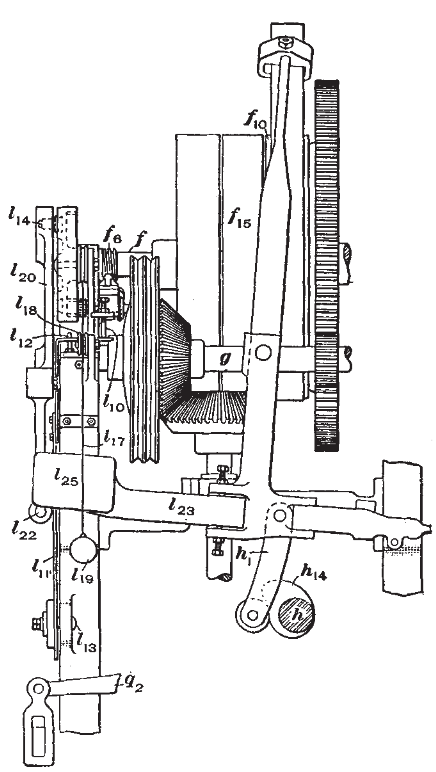


FIG. 1

**3.** The twist wheel $l_9$, Fig. 2, is provided with graduations along its edge that are numbered from 1 to 50; a circular slot is also made in the wheel, so that a stud, or pin, $l_{14}$ may be fixed at any point in the slot and adjusted until the correct position is found. On the outside edge of the twist wheel is cast a small stop $l_{15}$, view ($a$), which comes in contact with a similar stop $l_{16}$ on a plate bolted to the end framing of the headstock; when $l_{15}$ makes contact with $l_{16}$ the twist wheel remains stationary. To the boss of the twist wheel is attached a cord $l_{17}$, which is passed over a guide pulley $l_{18}$, Fig. 3, and is provided with a weight $l_{19}$.

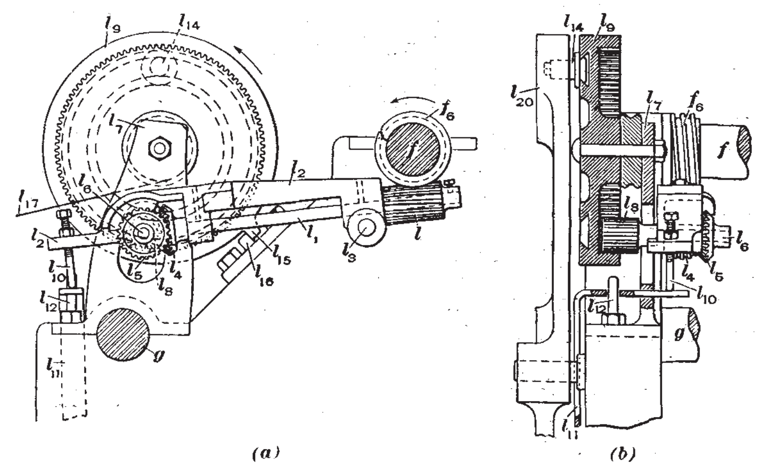


FIG. 2

During twisting, the wheel $l_9$ revolves in the direction of the arrow, Fig. 2 ($a$), but when the wheel $l_8$ is lifted out of gear, the weight $l_{19}$ will turn the twist wheel in the opposite direction until the stop $l_{15}$ meets stop $l_{16}$; by this means the twist wheel is compelled to begin its revolutions always at the same point.

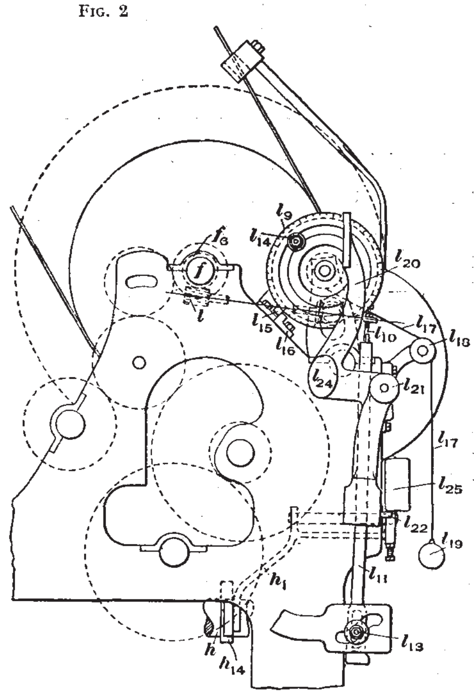

FIG. 3

**4.** As the twist wheel $l_9$, Figs. 1, 2, and 3, is revolved by the worm $f_6$, worm-wheel $l$, bevel wheels $l_4$ and $l_5$, and pinion $l_8$, the pin $l_{14}$ on the twist wheel comes in contact with the flat end of lever $l_{20}$, pivoted at $l_{21}$, and forces it outwards; the lower end with pin $l_{22}$ is then forced inwards, and free from the weight $l_{25}$ of lever $l_{23}$, which will then drop and move the belt from pulley $f_{10}$ to $f_{15}$. When backing off has taken place, the drawing-in friction clutch is engaged, resulting in the lever arm $q_2$ lifting the rod $l_{11}$, so as to disengage the gear-wheel $l_8$ from the twist wheel; the twist wheel is then pulled to its starting position by the weight and band $l_{19}$ and $l_{17}$, respectively. When the drawing-in friction is disengaged the rod $l_{11}$ drops and the weight of wheels $l_4$, $l_5$, $l_8$, causes the gear-wheel $l_8$ to engage with the twist wheel for the next draw. The weight $l_{25}$ with arm $l_{23}$ is raised into the position shown in Fig. 1 by the arm $h_1$, which is acted on by the cam $h_{14}$ fixed to the cam-shaft $h$. While the arm $l_{23}$ is raised, the heavy part $l_{24}$ of lever $l_{20}$ forces the lower end outwards, so that the pin $l_{22}$ will project under the weight $l_{25}$ of lever $l_{23}$, holding it in position until the pin is again withdrawn.

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### MULE AS TWISTING MACHINE

**5. Advantages.**—The ordinary **doubling** or **twisting frame,** which is a machine specially constructed for twisting two or more threads together, is superior to the mule as a twisting machine as regards quantity of work produced; it requires also less floor space. But the mule produces a better yarn, and by winding it on the bare spindle or inexpensive tubes, the cops may be sent away without requiring the return of bobbins, which is a great advantage in the export trade. With the *ring frame,* a later form of spinning machine, to be described farther on, the yarn has to be wound from bobbins into the form of hanks, which means additional expense. When occasion arises, the ordinary mule can, after certain changes are made, be used as a twisting frame; the required changes are made in the mechanism that performs the drawing out of the carriage and the delivery of the yarn. The scroll that must be used for drawing out the carriage, when the mule acts as a twisting machine, is one which will move the carriage at an even speed until it reaches within a few inches of the end of its outward run; then the scroll diameter decreases at such a rate that in half a revolution it is reduced from 11 to 2 inches, nearly.

**6. Driving Drawing-Out Scroll Shaft.**—The delivery rollers are arranged to deliver the yarn during the whole of the outward run, so that a length of yarn equal to the length of the stretch

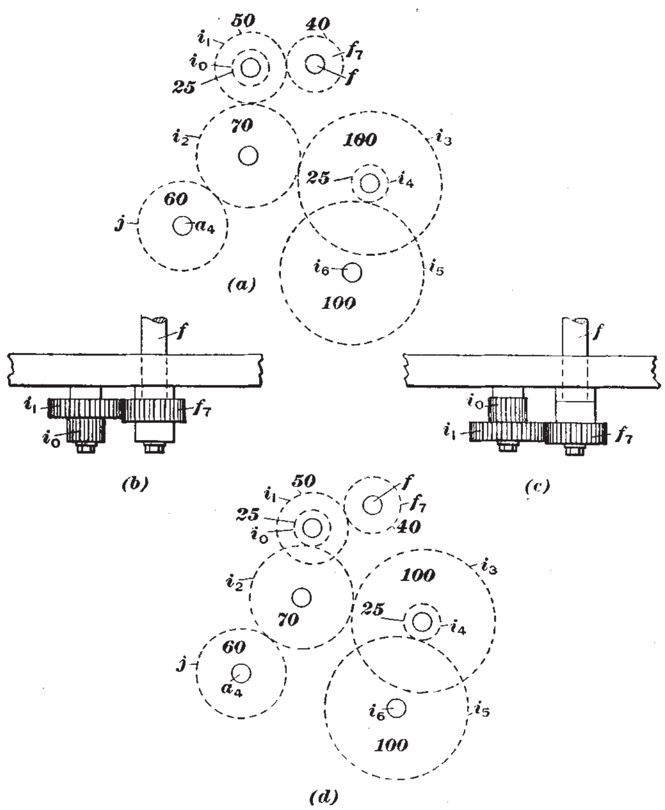


Fig. 4

is delivered for each draw. To adjust the speed of the carriage in accordance with that of the spindles and the delivery rollers, a suitable change must be made in the gearing that drives the bottom delivery roller. When spinning ordinary woollen yarns the gearing is as shown in Fig. 4 (*a*), corresponding to that shown in *Woollen Spinning*, Part 1, in which the gear-wheels have the following number of teeth: $f_7 = 40$; $i_1 = 50$; $i_2 = 70$; $i_3 = 100$; $i_4 = 25$; $i_5 = 100$; and $j = 60$. When the rim shaft $f$ is revolving at a speed of 240 revolutions per minute, the scroll shaft $i_6$ will make $\frac{240 \times 40 \times 25}{100 \times 100} = 24$ revolutions per minute. The arrangement of the wheels $f_7$, $i_0$, and $i_1$ is then as shown in plan in Fig. 4 (*b*).

**7.** If it is desirable to reduce the speed of the scroll shaft $i_6$, Fig. 4 (*a*), to 12 revolutions per minute, instead of 24, the gearing is arranged as in Figs. 4 (*c*) and (*d*). Here the wheel $f_7$ and the compound wheels $i_0$, $i_1$ are turned end for end on their respective shafts, so that they occupy the positions shown in Fig. 4 (*c*), the wheel $i_0$ of 25 teeth meshing with $i_2$, as in view (*d*). This arrangement is possible from the fact that the wheels $i_0$, $i_1$ are on a short stud that may be inserted in one of two slots provided for it in the framing. Assuming that the rim shaft $f$ continues to make 240 revolutions per minute, the speed of the scroll shaft will be $\frac{240 \times 40 \times 25 \times 25}{50 \times 100 \times 100} = 12$ revolutions per minute.

**8. Driving Delivery Rollers.**—With the gearing as in Fig. 4 (*a*), and the rim shaft making 240 revolutions per minute, the speed of the bottom roller shaft $a_4$ will be $\frac{240 \times 40}{60} = 160$ revolutions per minute. If the gearing is arranged as in Figs. 4 (*c*) and (*d*), the roller shaft $a_4$ will make $\frac{240 \times 40 \times 25}{50 \times 60} = 80$ revolutions per minute. These adjustments of the speeds of the carriage and the delivery rollers, relative to the speed of the spindles, are required since in twisting, a definite number of turns per inch must be inserted in a given length of yarn, which must be delivered at a speed depending on the speed of the carriage during its outward run. These conditions differ from those in spinning, where both drawing and twisting are performed, and where, therefore, the roving must be delivered rapidly, so that only sufficient twist can be inserted to give strength and to ensure good drawing.

**9. Speed of Spindles.**—The speed of spindles, in relation to the carriage, is governed by the size of the rim pulley or the change wheel $f_7$, Fig. 4. If the rim pulley driving the spindles is increased in size, then the speed of the spindles, and the number of turns per inch, will be increased, whereas, if the size of the change wheel $f_7$ is increased and the size of the rim pulley allowed to remain the same, the number of turns per inch will be fewer, since the speed of the carriage and delivery rollers will be increased relative to the speed of the spindles. In a mule where a 16-inch slow-speed rim on the rim shaft drives an 11-inch pulley on the tin-roller shaft, and the tin roller is 6 inches in diameter driving wharls $1\frac{1}{4}$ inches in diameter, the spindles will make practically $\frac{16 \times 6}{11 \times 1{\cdot}25} = 6{\cdot}98$, or 7 revolutions, nearly, to 1 of the rim shaft. Thus, if the rim shaft makes 100 revolutions the spindles will make $100 \times 7 = 700$ turns; and if the stretch is 78 inches, there will be $700 \div 78 = 9$ turns per inch of yarn, nearly.

The cops of yarn to be twisted are placed on pegs situated behind the mule, and the ends from the cops are passed over a rail fixed on the condenser bobbin stands, two or more ends, as required, being passed through each guide, and the yarn delivered at the required speed by the delivery rollers.

# MANAGEMENT OF MULES

## CALCULATIONS RELATING TO MULES

### SPEEDS OF PARTS

**10. Basis of Speed Calculations.**—The calculations for the mule refer principally to speeds, drafts, twist, production, changes in the sizes of wheels, and so on. In a number of cases where the calculations resemble those of machines previously described, the rules are omitted. In most cases machines are continuous in their actions, and their speeds are calculated in revolutions per minute, but the mule is intermittent and very few parts are revolving continuously for more than a brief period of time.

Since the length of time that the different parts are in action varies, some definite unit of time must be taken, in order that the relative speeds of the various parts may be calculated; therefore, the usual method is followed and the number of revolutions per minute is taken as a basis.

**11. Speed of Rim Shaft.**—When the speed of the main shaft and the sizes of the pulleys on the main shaft, countershaft, and rim shaft are known, the speed of the rim shaft may be found by rules previously given. The line shaft above a mule is running at a speed of 80 revolutions per minute; if this shaft carries a 36-inch pulley driving a 16-inch pulley on the countershaft, while a 20-inch pulley on the countershaft drives a 15-inch pulley on the rim shaft, the speed of the rim shaft is equal to $\frac{80 \times 36 \times 20}{16 \times 15}$ = 240 revolutions per minute.

**12. Speed of Spindles.**—In mule spinning, the rotative speed of the spindles is of great importance. When calculating this speed it is usual to make an allowance of 5 per cent. for the slip of the various bands, and to take the diameter of the wharve as the diameter at the bottom of its **V**-shaped groove. As the slip depends largely on the condition of the bands and pulleys, the value of 5 per cent. is only approximate; however, it is the value adopted in practical calculations. In a given mule a 16-inch small, spinning, or slow-speed rim on the rim shaft drives an 11-inch pulley on the tin-roller shaft, and the tin roller is 6 inches in diameter. If the wharls are $1\frac{1}{4}$ inches in diameter and the rim shaft makes 240 revolutions per minute, the theoretical speed of the spindles will be $\frac{240 \times 16 \times 6}{11 \times 1{\cdot}25} = 1{,}676$ revolutions per minute, approximately. If 5 per cent. is deducted to allow for slip, the actual speed of the spindles will be $1{,}676 - ({\cdot}05 \times 1{,}676) = 1{,}590$ revolutions per minute, nearly.

**13.** As factors that determine the size of the small rim, it should be mentioned that a sufficient amount of twist must be inserted in the yarn to allow it to be drawn while the carriage is running out. If the rim is too large and, therefore, too much twist is inserted, the friction between the fibres composing the yarn will be so great that it will prevent the yarn from being drawn. If an attempt is made to overcome this difficulty by increasing the speed of the carriage, it must be remembered that this speed is limited by several factors, such as excessive sidewise swinging of the carriage, and too many broken ends. Too high speed of the mule produces poor yarn, since the twist has not time to equalize itself over the whole stretch, and as a result the yarn is softer near the delivery rollers than at the spindles. The speed of the spindles may be reduced by using a rim pulley of smaller diameter. In practice, a satisfactory speed of the rim shaft is found to be from 220 to 250 revolutions per minute. This speed allows various sizes of the small rim to be used, the usual sizes being 12, 14, 16, and 18 inches in diameter ; the large rim may be either 24 or 28 inches in diameter. When the rim shaft is driven at a slow speed the rims of the larger diameters are used, but when the rim shaft is driven at a high speed the smaller-sized rims are used. When the spindles are driven by the large rim the speed calculations are made in the same manner as for the small rim.

**14. Speed of Back Shaft.**—When the speed of the main shaft, the sizes of the pulleys on the main shaft and countershaft, and the sizes of the rope pulleys on the countershaft and back shaft are known, the speed of the back shaft may be found by rules previously given. In the case of a mule where the speed of the line shaft is 80 revolutions per minute and it carries a 36-inch pulley driving a 16-inch pulley on the countershaft, while a 10-inch rope pulley on the countershaft drives a 12-inch rope pulley on the back shaft, the speed of the back shaft will be

$$\frac{80 \times 36 \times 10}{16 \times 12} = 150 \text{ revolutions per minute.}$$

**15. Regulating Draft.**—The amount of draft given to the roving depends essentially on the size of the roving relative to that of the spun yarn, and is governed by the position of the pin on the slubbing wheel. The amount of tension and twist given to any material during the time that it is being delivered by the rollers can be regulated by the two change wheels $f_7$, and $i_4$, Fig. 5, together with the scroll for drawing out the carriage. The change wheel $i_4$ is termed the *drag wheel*, since it regulates the *drag*, or

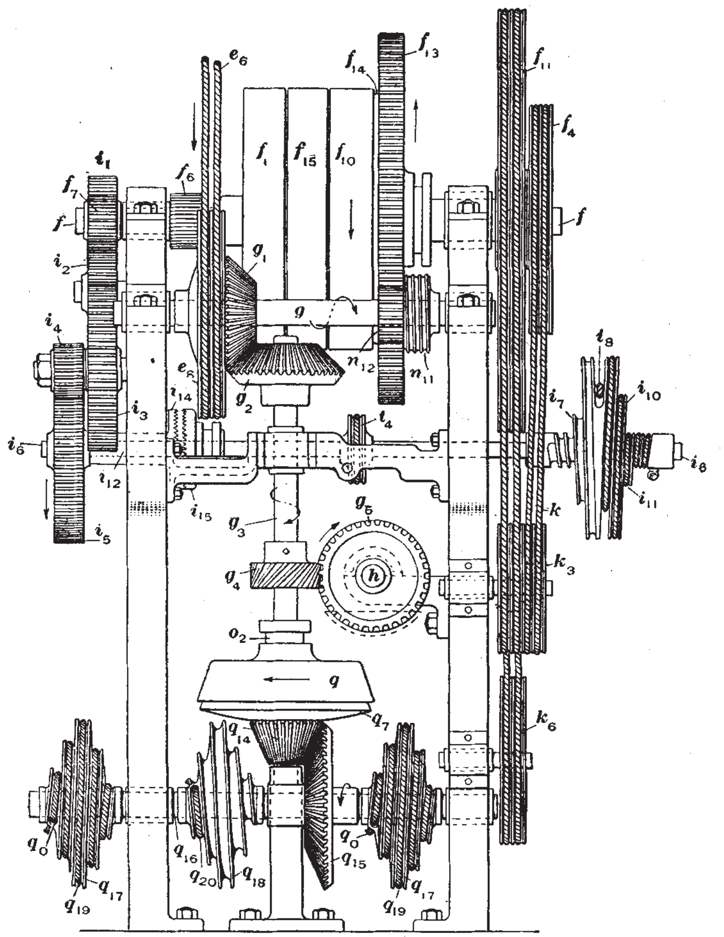


FIG. 5

tension, on the yarn between the delivery rollers and the carriage. As this wheel is a driver, it is increased in size to increase the speed of the shaft $i_6$ with the drawing-out scroll and, therefore, the outward run of the carriage. This increase of speed is allowable for materials of good quality; inferior materials will not stand this tension, and a smaller drag wheel must be used. A drag wheel is not often changed and the difference in size between the largest and smallest is not great, being only about 4 to 6 teeth. An increased speed of the carriage during its outward run amounts to a relative decrease in speed of the spindles; less twist will therefore be inserted in the stretch of yarn. It follows that to insert the required amount of twist the speed of the carriage must be decreased during its outward run, when spinning low, short materials, as compared with materials of good quality and long fibres, both materials being of the same counts. An increase in speed on long materials is advisable, so long as the drawing is satisfactory, since increased speed means increased production.

**16. Adjusting Drawing-Out Scroll.**—If roving is being delivered that will not admit of much drafting, it may be desirable to move the starting point of the scroll into such a position that the scroll will continue to wind the rope on its large diameter during a greater length of time, before it commences to wind on the low or smaller diameter, thereby making the carriage move rapidly for a greater distance at the start, but at no point faster than the delivery. This has the effect of allowing less twist to be inserted before the drafting of the roving commences. The same means of adjustment is also used to secure a satisfactory hardening of the yarn at the end of the draw by allowing the rope to wind for a longer period at the nose of the scroll.

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### CALCULATIONS RELATING TO TWIST

**17. Speed of Twist Wheel.**—In practice it is not usual to require the insertion of a definite number of turns per inch, except in special cases, when, for instance, a yarn of a certain appearance is required. In the case of the gearing shown in Figs. 1, 2, and 3, the worm-wheel $l$ has 26 teeth, bevel wheel $l_4$ 15 teeth, bevel wheel $l_5$ 30 teeth, gear-wheel $l_8$ 12 teeth, and the twist wheel $l_9$ 100 teeth; hence, the rim shaft would require to make $\frac{26 \times 30 \times 100}{1 \times 15 \times 12} = 433{\cdot}3$ revolutions for every complete revolution of the twist wheel. Thus the number of revolutions the rim shaft will make during the partial revolution of the twist wheel is governed by the position of the pin $l_{14}$ on the twist wheel $l_9$.

**18. Turns of Twist Per Inch.**—If, according to the calculations made in Art. **7** the spindles revolve at the rate of 1,590 revolutions per minute, being driven by the small rim, while the roving is being delivered and drawn, then the spindles will make $1{,}590 \div 240 = 6{\cdot}62$ revolutions for each revolution of the rim shaft. Assuming that the rim shaft makes 30 revolutions while the carriage is coming out, the spindles will make $30 \times 6{\cdot}62 = 198{\cdot}6$ revolutions. Therefore, if the length of the draw is 78 inches there will be $198{\cdot}6 \div 78 = 2{\cdot}54$ turns inserted per inch of roving. If the finished yarn is required to have 10 turns per inch, it follows that an additional number of turns of $10 - 2{\cdot}54 = 7{\cdot}46$ per inch must be inserted. The additional number of turns for the whole draw will be $7{\cdot}46 \times 78 = 581{\cdot}88$, or 582, nearly, which number must be inserted by the large rim.

**19. Speed of Large Rim.** — If the size of the large rim is 24 inches, then, using the dimensions given in Art. **7**, the speed of the spindles will be $\frac{240 \times 24 \times 6}{11 \times 1{\cdot}25} = 2{,}513{\cdot}45$, or nearly 2,514 revolutions per minute. If 5 per cent. is deducted to allow for slip, the actual speed of the spindles will be $2{,}514 - (\cdot 05 \times 2{,}514) = 2{,}388{\cdot}3$ revolutions per minute, or, approximately, 2,388. When the spindles are revolving at this rate, they will make $2{,}388 \div 240 = 9{\cdot}95$ revolutions while the large rim makes 1 revolution. Thus the large rim will require to make $1{,}362 \div 9{\cdot}95 = 137$ revolutions to insert the requisite amount of twist.

From a consideration of the many factors that enter into the question, such as changing the length of roving that is delivered for each stretch, the speed at which the carriage finishes the stretch, and so on, it will be seen that the graduations on the twist wheel cannot be said to indicate a definite number of turns per inch, or the number of revolutions made by the rim shaft in a given time. The twist pin only ensures that a constant number of revolutions will be given to the rim shaft during each draw.

### RELATION BETWEEN TWIST AND DRAFT

**20. Amount of Twist Required.**—The carriage commences the outward run at such a speed that the roving, as delivered by the delivery rollers, is under a slight tension, but practically no drawing is done and the spindles insert just sufficient twist to enable the roving to be satisfactorily drawn. If too much twist is put in prior to drawing, the fibres are bound tightly together so that when drawing commences the threads will break in large numbers. On the contrary, if the speed of the carriage is such on leaving the delivery rollers that the roving is drawn without sufficient twist being inserted, it is rendered very uneven and lumpy, since the thinner parts are drawn to a greater extent than the thicker ones, as they have not received sufficient twist and hence have not strength enough to hold together while the thick parts are being drawn. It is therefore important that, as nearly as possible, a sufficient amount of twist should be inserted before drawing commences and the remainder of the twist required should be inserted after drawing is completed. The amount of twist that should be inserted prior to drafting varies with the class of material being spun, but, speaking generally, the shorter the fibre the greater the amount of twist required, though the number of fibres composing the roving has some effect on the twist.

**21. Evening Action of Twisting.**—The roving received from the condenser is not of uniform thickness. The result is that the small amount of twist, inserted by the spindles before the rollers stop the delivery, will not be evenly distributed over the roving, those parts being twisted the most that offer the least resistance to twisting, that is, those that are the smallest in diameter, leaving the thicker portions practically unaffected. When the delivery stops and the spindles continue their revolutions, the roving is subjected to a further draft, the weakest places in the roving being affected to a greater extent by the drawing process. As the thin places have been strengthened by the twist inserted, the thick, soft, and untwisted portions are the weakest and, therefore, most affected by the drawing process. It follows that the drawing has an equalizing effect on the roving, the twist hardening the thin places and the drawing reducing the thick ones until they receive the required amount of twist. During drawing and twisting the long fibres of the roving are more affected by these operations than the short ones; consequently, the tendency is for the long fibres to take up a position lengthwise of the thread, near the centre. In this position they bind together the shorter and less affected fibres, so that the latter will act as a filling and form the face of the thread.

**22. Adjustment of Draft Relative to Twist.**—The production of good yarn depends to a great extent on subjecting the roving to the correct amount of draft. How far the latter is sufficient or not may be ascertained by the spinner by testing with his fingers the tension in the yarn as the carriage is coming out. When the drawing is being done too quickly to allow sufficient twist to be inserted, the threads feel slack or *draw soft*; the result is a twitty yarn due to the thin places being reduced in diameter and weakened instead of strengthened by twisting. This fault may be remedied by substituting a larger rim at $f_4$, Fig. 5, to increase the speed of the spindles, or a smaller change wheel at $f_7$ to decrease the speed of the carriage and delivery rollers. If too much twist is inserted, the fibres are prevented from sliding past each other and the threads are broken, or *pulled down*, so that a smaller rim at $f_4$, or a larger change wheel at $f_7$, is required. Moreover, the twisting or stiffening produced by the drawing must be at the right place, that is, the threads should gradually stiffen until the carriage stops; in this way the strongest yarn is obtained, since no amount of twist applied afterwards can compensate for bad drawing.

**23.** When spinning very short materials it is sometimes necessary to decrease the speed of the carriage before the rollers stop, so that there is no danger of the short fibres being pulled apart before the twist is put in. For the purpose of reducing the carriage speed the drag wheel $i_4$ is replaced by one having one or two teeth less, which causes the carriage to go at a slower speed without affecting the speed of the delivery rollers.

The amount of roving delivered for each draw depends on the size of the roving relative to that of the spun yarn. The two main factors that influence the count of the roving are the quality of the material and the type of the condenser used in the carding process. To condense the roving near to the count of the yarn requires a condenser of high efficiency, such as a tape or tandem. On low material this condensing to the count of the yarn is an advantage, since it is impossible to give it much draft on account of the shortness of the fibres or by reason of the cotton, when this is present. With a material that is uniform and of good quality, it is possible to stop delivery when the carriage has completed one-half of its traverse, and to draw the material during the other half of the traverse. On the Continent the practice is to draw for a distance of only 6 to 9 inches.

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### SPECIAL FORMS OF SCROLLS

**24. Angola Scroll.**—The **angola scroll** derives its name from the fact that it is largely used in spinning the cotton and wool mixtures, known as *angola mixtures*, the resulting yarn being termed *angola yarn*. The cotton causes the yarn to set or stiffen quickly in the drawing, and the angola scroll must therefore draw the carriage out for a sufficient distance before the yarn has an opportunity to set. Should the roving continue to be delivered at the same rate after the carriage has begun to slow down, as would be the case if the slubbing wheel were set for spinning angola yarns, and the drawing-out scroll were the one used in spinning ordinary woollen yarns, the yarn would be caused to coil round the spindle tops. To obviate this fault the angola scroll is used in which the drawing-out rope continues on the large diameter of the scroll for $1\frac{1}{2}$ to 2 revolutions, thus causing the carriage to be drawn out at the maximum speed for about two-thirds of the actual traverse of the carriage. The diameter then decreases very quickly toward the nose in about one-half of a revolution, 2 to 3 revolutions being made while the rope is winding on the nose.

**25. Blanket Scroll.**—A type of scroll which is not in common use is that known as the **blanket scroll**. It is, however, well adapted for spinning fine and soft materials, such as lambs' wool and fine short waste and blends of materials that require a fair amount of twist, both while the roving is delivered by the rollers as well as for the remaining part of the draw. With the blanket scroll the rope is on the large diameter for about two-fifths of the outward run, and the speed of the carriage diminishes more gradually than in the case of the ordinary or angola scroll, since the groove does not pass so quickly from the largest to the smallest diameter.

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### CALCULATIONS RELATING TO PRODUCTION

**26. Methods of Estimating Production.**—The production of mules may be estimated in the two following ways: (*a*) By taking into consideration the number of stretches per minute, the length of each stretch, the number of spindles per mule, the counts of yarn being spun, and the length of time run; and (*b*) by keeping an account of the weight of each doffing for a given period, adding the estimated amount on the spindles at the end of this time, and deducting the amount on the spindles at the beginning. Of the two methods, the latter is the more practical.

**27.** When making an estimate of the amount of yarn that may be produced by a certain number of mules in a given time by the first of the foregoing methods, it is necessary to make a deduction for the time taken for stoppages, doffing, cleaning, etc. In the absence of definite data obtained from similar mules operating under similar conditions to those under consideration, an allowance of 10 per cent. may be deducted. The estimated production may then be obtained by means of the following rule:

**Rule.**—*To find the estimated production, divide the product of the number of stretches per minute, the length of each stretch, in inches, the number of hours run, the number of spindles per mule, the number of mules, and the factor* $\frac{1 \cdot 5}{256}$ *by the counts of the yarn being spun.*

In the foregoing rule, the constant $\frac{1 \cdot 5}{256}$ is obtained by summarizing the following constants that would ordinarily appear in the calculation: in the numerator, the number of minutes in an hour and a factor allowing for the loss of 10 per cent. of the time run, and in the denominator, the number of inches in a yard and the number of yards in a hank; that is, $\frac{60 \times \cdot 9}{36 \times 256} = \frac{1 \cdot 5}{256}$.

EXAMPLE.—Find the total number of pounds produced in a week of 55 hours, making a deduction of 10 per cent. for stoppages, etc., by 6 mules of 400 spindles each. The yarn being spun is 15s Yorkshire skein and each mule makes $2\frac{1}{2}$ draws, or stretches, of 78 inches, per minute.

SOLUTION.—Applying the rule, the estimated production is

$$\frac{2\frac{1}{2} \times 78 \times 55 \times 400 \times 6 \times 1 \cdot 5}{256 \times 15} = 10{,}054 \cdot 69 \text{ lb. Ans.}$$

**28.** To find the production for a given length of time according to the second method, the following rule may be applied:

**Rule.**—*To find the production in a given time, find the total number of pounds doffed for the given time, add to this the estimated number of pounds on the spindles at the end of this time, and then deduct the number of pounds on the spindles at the commencement of this time.*

EXAMPLE.—Find the total number of pounds of yarn produced in 1 week by 6 mules that have produced 113 doffings of practically 55 pounds each. At the end of the week there is approximately 112 pounds of yarn on the spindles, while at the end of the previous week, or the beginning of the week under consideration, there was 150 pounds.

SOLUTION.—Applying the rule, the total amount of yarn produced is

$$(113 \times 55) + 112 - 150 = 6{,}177 \text{ lb. Ans.}$$

**29. Length of Yarn on Cop.**—If it is desired to determine, approximately, the number of yards of yarn on a cop, knowing the counts of the yarn and the weight of the cop, the following rule may be used, in which the factor 27·34 represents the weight of 1 yard of the yarn, in grains, obtained by dividing 7,000 grains by 256, the number of yards in a hank:

**Rule.**—*To find the number of yards of yarn on the cop, multiply the weight of the cop, in grains, by the counts of the yarn, and divide the product by 27·34.*

EXAMPLE.—Find the number of yards on a cop weighing 1,050 grains, the counts of the yarn being 12s Yorkshire skein.

SOLUTION.—Applying the rule, the cop contains

$$\frac{1{,}050 \times 12}{27 \cdot 34} = 460 \text{ yd., nearly. Ans.}$$

**30.** If the weight of the doffing is known, and also the number of spindles on the mule, the weight of the cop may also be found by means of the following rule, which gives the average length of yarn on a number of cops :

**Rule.**—*To find the average number of yards on a cop, multiply the weight of the doffing, in pounds, by the counts and the number of yards in the skein, and divide by the number of spindles on the mule.*

EXAMPLE.—Find the number of yards on each cop from a doffing weighing 60 pounds, the counts of the yarn being 12s Yorkshire skein and the number of spindles 400.

SOLUTION.—Applying the rule, the cop contains

$$\frac{60 \times 12 \times 256}{400} = 460 \text{ yd., nearly. Ans.}$$

**31. Number of Stretches on Cop.**—The number of stretches on a cop may be found by the following rule, if the weight of the cop, the count of the yarn, and the length of the stretch are known :

**Rule.**—*To find the number of stretches on a cop, multiply 1·32 times the weight of the cop, in grains, by the counts of the yarn and divide the product by the length of the stretch, in inches.*

The factor 1·32 is obtained by dividing the product of the number of yards per hank and the number of inches in a yard by the number of grains in a pound.

EXAMPLE.—Find the number of 78-inch stretches required to produce a 1,050-grain cop 12s Yorkshire skein yarn.

SOLUTION.—Applying the rule, the number of stretches required is

$$\frac{1{\cdot}32 \times 1{,}050 \times 12}{78} = 213, \text{ nearly. Ans.}$$

**32.** If the weight of the doffing is known, and also the number of spindles on the mule, the number of stretches on a cop may be found by the following rule:

**Rule.**—*To find the number of stretches on a cop, divide the product of the weight of the doffing, in pounds, the yards in 1 hank, the counts, and the number of inches in 1 yard, by the product of the number of spindles and the length of the stretch, in inches.*

EXAMPLE.—Find the number of 78-inch stretches on a cop, if the weight of the doffing is 60 pounds, the counts 12s Yorkshire skein, and the number of spindles on the mule is 400.

SOLUTION.—Applying the rule, the number of stretches required is

$$\frac{60 \times 256 \times 12 \times 36}{400 \times 78} = 212, \text{ nearly. Ans.}$$

**33.** The rule in Art. **32** may also be used for finding the number of draws required to produce a doffing of given weight.

EXAMPLE.—It is desired to produce a doffing weighing 58 pounds on a mule with 400 spindles, and a stretch of 72 inches, spinning yarn of 14s Yorkshire skein. How many stretches will be required ?

SOLUTION.—Applying the rule given in Art. **32**, the number of stretches required will be

$$\frac{58 \times 256 \times 14 \times 36}{400 \times 72} = 260, \text{ nearly. Ans.}$$

## INSTALLATION AND CARE OF MULES

### FLOOR SPACE AND POWER REQUIRED

**34. Floor Space.**—In order to economize in floor space, mules are generally arranged in pairs, with their carriages facing each other. The headstocks are not in the centre of the mule, otherwise the mules would have to be placed farther apart to allow room for the minders to pass between the front ends of the headstocks. The floor space required for a pair of mules depends on the length of the stretch ; if the latter is 7 feet, the width of the floor space occupied by a pair of mules is about 26 feet. The length of this space will depend on the length of each mule.

**35. Speed of Mules.**—The time required by a mule to make one complete draw varies from about 20 to 30 seconds. When spinning soft-twisted weft yarn a draw will be performed in from about 20 to 25 seconds, but when spinning hard-twisted yarn a period of from 25 to 30 seconds will be necessary. The speed of the carriage is limited to some extent by practical reasons, such as the time required in piecing up broken ends and also by the amount of vibration produced by the revolving spindles. The difference in the speed between spinning fine and coarse yarn is not so great as might be supposed, since the maximum speed is governed by the rate at which the carriage travels out, and the diameter of the small rim may be increased to ensure the correct drawing by inserting the requisite amount of twist in the case of material composed of short fibres.

**36.** When starting the spinning of a new blend of material into yarn, the spinner tests the drawing by touching the threads with his fingers, so as to estimate the tension that is being put on the yarn during the drawing. He will in this manner also be able to gauge the amount of twist, and the moment at which the yarn stiffens, as a result of the twist put in. The moment at which this stiffening begins is regulated by the scroll and the amount by the change wheel and the rim, so that the stiffening will take place gradually toward the end of the outward run. If the stiffening is insufficient, the yarn will be soft and uneven; if excessive, the threads are broken.

**37.** Provided that the quality of the material is good, there should be no difficulty for three persons to attend to 700 or even 800 spindles, it being understood that the condenser bobbins are well made and the roving sufficiently fine. When the roving does not spin well, there is a considerable amount of waste by reason of the threads breaking; numerous stoppages are necessary and the loss in production is considerable. Very often it is beyond the spinner's power to improve bad spinning, since the quality of the roving and the satisfactory results of the succeeding processes depend very largely on the carding engineer.

**38. Power Required for Driving Mules.** — The horsepower required to drive a mule varies during the different periods in its action. In general, it is estimated that each group of 100 spindles requires 1 horsepower for driving. When in a mule of 400 spindles the carriage begins its outward run, from 12 to 15 horsepower will be required; during the drawing-out process the power used will decrease to about 5 to 6 horsepower, but will increase to about 6 to 7 during twisting, and fall to about $\frac{1}{2}$ horsepower during backing off, increasing again to 1 or $1\frac{1}{2}$ during drawing up. The foregoing data show the relative amounts of power required during the different periods in the action of the mule; they will not apply to all mules, however, as the power

**TABLE I**

SIZES OF BANDS ON MULES

| Bands | Diameter Inch | Bands | Diameter Inch |
|---|---|---|---|
| Rim | $\frac{1}{2}$ | Winding | $\frac{1}{2}$ |
| Back-shaft | $\frac{1}{2}$ | Cop-bottom governing motion | $\frac{3}{8}$ |
| Drawing-out | $\frac{5}{8}$ | Squaring | $\frac{3}{8}$ |
| Drawing-in | $\frac{7}{8}$ | Spindle | $\frac{3}{32}$ |
| Check | $\frac{7}{8}$ | | |
| Quadrant | $\frac{3}{4}$ | | |

required varies considerably. A $4\frac{1}{2}$-inch double belt is used to drive the rim shaft; Table I gives the diameters of the various bands.

## RESETTING MULES

**39. Purpose of Resetting Mules.**—The work of levelling and erecting a new mule is that of the fitter; it is essential, however, that the overlooker should have a sufficient knowledge of this work to enable him to correct any defects that are liable to develop due to the floor being affected by the weight and vibration of the machinery, or to the constant movement of the carriage and other parts. The top floors of any building are likely to be most affected. As all stationary parts are fixed to the floor they must necessarily follow the course of the floor as it sinks; but as the floor does not sink equally at all places, it causes parts of the mule to get out of alinement. The best results are obtained by maintaining the mule in the position in which it was initially set. The bottom delivery roller, tin roller, faller shafts, and so on should be kept strictly level from end to end, so as to obtain true and easy running and prevent undue wear and strain.

**40. Resetting of Headstock and Frame Ends.** — In the first place, the headstock should be relevelled and all shafts in the headstock should be squared and made to run quite freely. The outer frame ends should then be set level with the headstock. This may be done by means of fine piano wire or by using three pieces of wood of equal height and placing one on the headstock and one on each of the frame ends, so that a clear line of sight may be obtained, the frame ends being adjusted until the three points are level. The places on the frame ends and on the headstock on which the pieces of wood are placed should be machined surfaces, and, if not of the same height, proper allowance should be made when cutting the pieces of wood.

**41. Resetting of Roller Beam.**—Should the floor sink so as to carry with it the stands that support the ends of the roller beam, while the floor that supports the other stands remains in its original position, the bottom roller would tend to follow the bearing which had sunk. As this roller is constructed in such a manner as to be equivalent in some respects to a continuous roller, it will tend to bend along the arc of a circle and will be liable to rise slightly from some of the bearings at the end. This tendency is counteracted to a certain extent by the weight of the top rollers, but the fact remains that the rigidity of the bottom rollers is seriously affected, this being especially so since the bottom delivery roller is made in short sections, each of which extends between the supporting brackets. The sections are connected by one end of each section having a square socket and the other end a square extension that fits tightly in the socket of the contiguous section. The effect is to wear away the corners of the extensions so that they will fit loosely in the sockets. The stands that support the roller beam being made in two parts $a_7$, $a_8$, Fig. 6, it is possible to adjust the upper part to the desired height; any fine adjustment that cannot be obtained by this means is done by inserting packing, usually paper or cardboard, under the roller beam.

**42. Resetting of Carriage.**—The effect produced on the carriage by the sinking of the floor is more serious than is the case with the roller beam. If the carriage is allowed to get out of alinement the effect on the tin roller will be practically the same as in the case of the delivery roller, with this difference: if the

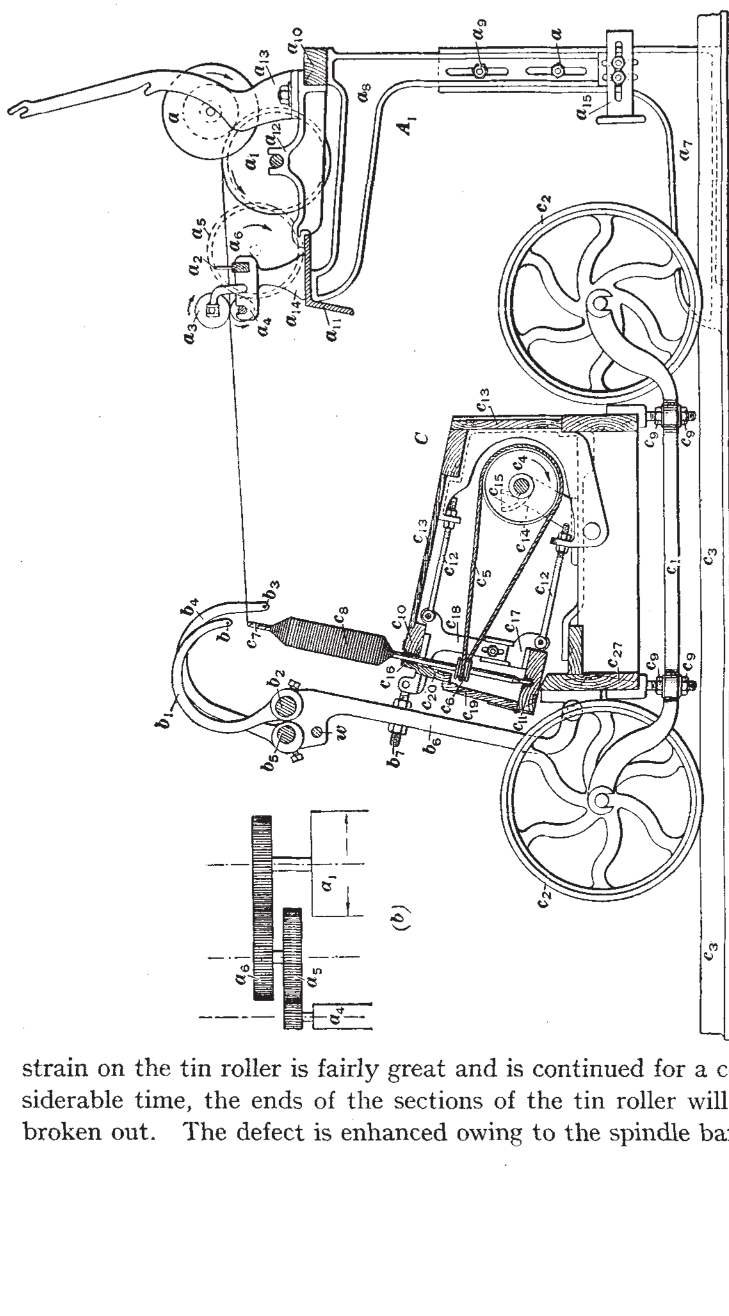

Fig. 6

strain on the tin roller is fairly great and is continued for a considerable time, the ends of the sections of the tin roller will be broken out. The defect is enhanced owing to the spindle bands always all pulling in one direction, and to the tin roller revolving at a high speed. Another result of this defect is the irregular driving of the spindles, resulting in the spinning of defective yarn. When levelling the carriage, it is not so necessary that all the supporting rails, or slips, shall be level, as that each individual slip shall be level from end to end. A spirit level is used to ascertain whether the slips are level at various points, and any variations are corrected by placing either paper or wood packing under the feet. Each slip is firmly secured by bolt-headed screws. If the floor is made from brick or stone, wood plugs or blocks must be driven into the floor to receive the screws. The carriage slips must be made quite straight, and set parallel to the headstock.

**43. Resetting of Tin Rollers.**—The tin rollers should be adjusted so that they are level and parallel to the row of spindles. They should also be at the correct height with respect to the spindle wharves, but this height cannot generally be altered after the mules are erected in the first instance. If the tin rollers are too high, the spindle bands do not pull evenly on the wharves and the spindles tend to dance or jump ; if the rollers are too low, the spindles run heavily owing to the downward pull of the bands.

**44. Topping of Spindles.**—When the slips have been levelled, the carriage itself must be levelled by adjusting the spindle points with respect to the front rollers ; this operation is often termed **topping.** In order to facilitate levelling, a wooden setting gauge of suitable size and construction should be used. It is usually about 9 inches long and 4 inches deep, with one corner cut out about $1\frac{1}{2}$ inches deep ; each edge of the gauge must be planed perfectly true, and, by screwing a metal plate to each planed edge, warping is prevented. To ascertain whether the upper side of the bottom delivery roller is $1\frac{1}{2}$ inches above the top of the spindles, the upper edge of the cut-out portion of the gauge is placed on the bottom delivery roller and the other end of that side of the gauge on the top of a spindle, the carriage having previously been drawn a sufficient distance from the roller beam. By placing a spirit level on the upper edge of the gauge it can be seen at once whether that part of the carriage is in the correct position relative to the rollers and whether all portions of the carriage are at the same height. Should this not be the case, the required vertical adjustment can be given to the portions requiring it through the nuts $c_9$, Fig. 6. To ascertain whether the carriage is level across its width, a straightedge may be placed underneath the carriage against the side framing, and by using a spirit level any irregularity can be detected and rectified through the nuts $c_9$.

**45. Resetting of Fallers.**—The faller shafts must be level, parallel to the row of spindles, and must work freely. The height of the shafts is governed by the lowest point of winding, while the distance between the shafts and the spindles is so adjusted that there is a minimum space of $\frac{3}{16}$ inch between the tops of the spindles and the faller wires, as the latter are rising or falling. The faller sickles should be adjusted so that the wires are at the correct distance from and parallel to the row of spindles. If the faller wires themselves are bent they should be straightened, and if they are nicked by the yarn they should be replaced.

**46. Renewal of Worn Parts.**—When resetting mules after they have been working a number of years, it is necessary to have many of the working parts either trued up or replaced by new ones. Bearings may require replacing or rebushing, carriage wheels may need turning up, and the slips may require replaning; roller stands may require new brasses, and shaper rails and plates may need refiling to the proper shape. A new shaper screw and nut may be required, and possibly a quadrant screw; the stud and bowl for the shaper slide may require either turning up or replacing; friction clutches may need re-covering; and clicks and catches must be examined and sharpened. Cam-bowls and studs must be replaced if necessary, and new cams provided if they are very much worn.

## CARE OF MULES

**47. Cleaning and Oiling.**—In order to achieve the best results it is very necessary that the mules should be cleaned and oiled at regular and stated intervals. In this respect the rollers and spindles should receive particular attention. Grease from the threads accumulates on the rollers and requires to be rubbed off every week or two. The gearing should be oiled at least once a week, and all quick-running shafts and spindle footsteps twice, while the spindle bolster rail and the tin roller should be oiled every morning.

**48. Care of Belts and Bands.**—The belts and large bands should be cleaned and dressed at regular periods to prevent slip and excessive wear, and to prolong their life and driving power. The bands should also be stretched before being put on, so as to prevent slip through excessive stretching of the band; this is especially advisable in connection with the rim band. Although there are arrangements for tightening the various bands when they stretch, there is a limit to the amount of slack that can thus be taken up; consequently, it is advisable, and in fact necessary, to have as much of the stretch taken out of the bands as possible before they are put on. The endless bands should be spliced so that they will be very little, if any, larger at the splice than at the regular diameter; the splice should also be fairly long, so that any slight increase in diameter will be gradual and that the splice will not give while the bands are under tension. Rim bands should last about 2 years, if properly cared for.

**49. Slippage of Belts and Bands.**—If the belts that drive from the main shaft become too slack or greasy, they will slip and cause the driven pulleys and shafts to run unevenly and at lower speeds. Slack squaring bands will cause the carriage to run out of alinement and cause many breakages of threads. The rim band driving the tin roller is liable to slip due to stretching, when new, or when there is a change from a damp to a dry atmosphere; but in any case it is easily detected and remedied. Perhaps most trouble is caused by the slipping of the spindle bands, as each spindle has its separate band. These bands are made from soft cotton twine, a fairly strong band being necessary for spinning heavy cops. In joining the ends of these bands a square or reef knot should be used, the overlapping length of band for the knot being at least $\frac{1}{2}$ inch; if too short, the ends have a tendency to unravel and cause the knot to come loose before the band is worn out.

**50.** A dry band running under fairly strong tension will cause little loss in speed, while one that has become greasy or stretched may cause a decrease in the spindle speed to such an extent that the amount of twist inserted may be 20 per cent. below that required. If the loss in speed will not reduce the twist to be inserted by more than 10 per cent. or produce cops so large in diameter as to rub against one another, the band may be allowed to run, since the effect on the appearance of the yarn is hardly noticeable, although its strength is affected. The winding of the yarn is affected by the varying tension to the same extent as the twist; thus a band that possesses the correct tension will build a much more solid cop than a band driving the spindles at a comparatively slow speed, in which case soft cops will be produced. If the twisting is done at a variable speed of the spindles, weak places will result, at which the yarn is liable to break. On the other hand, the spindle bands ought not to be too tight or the spindles will be drawn too strongly against the rear side of the sockets, causing an increased wear at this place and an increase in the driving power required. New spindle bands should, however, be put on very tight, as they will soon stretch.

**51. Other Means for Driving Spindles.**—The trouble caused by a number of separate bands driving the spindles in a mule has been sought to be minimized by having only one band for each section of the carriage situated at each side of the headstock. Then one band serves only for one section of the spindles, being passed alternately round the spindles and the tin roller. At each end of the tin roller the band passes round guide pulleys that by means of springs give the required amount of tension to the band. The reason why this method of driving is not desirable is owing to the fact that one band used for a great number of spindles does not wear nearly as well as the separate band used for each spindle; when it breaks it also causes more trouble and a longer time is required to replace it.

Attempts have also been made to drive the spindles positively by means of gear-wheels, the tin roller being replaced by a long shaft which, by means of a number of short shafts, one for each spindle, drives the latter through bevel wheels. This method has the serious defects of causing the brass spindle sockets to wear out rapidly, and to set up a vibration by the rapid revolution of the gearing, which is detrimental to the even and level drawing of the threads. The effect of such positive driving on the quadrant is also bad, often resulting in breaking of teeth on the quadrant and the quadrant pinion.

**52. Adjustment of Parts.**—All parts should be properly set and adjusted to act at the proper time for the counts of yarn being spun. Care should also be taken not to have an excessive or insufficient amount of tension, twist, roller delivery, jacking motion, or carriage gain. The spindle and roller speeds should not be too high, as this would be a detriment to the production of first-class yarn. The clutches and cone friction clutches should be carefully adjusted and well cared for. Special attention should be given to the leather coverings on the faces of the cones of the friction clutches to secure proper driving of the various parts, by seeing that they do not wear too thin to grip well.

**53. Locking of Winding Faller.**—To alter the locking of the winding faller, the plate for the loose incline is moved so as to change its relation to the front plate of the long rail. Moving the plate backwards toward the back of the headstock allows the winding faller to lock earlier, while moving the plate forwards produces the opposite effect.

**54. Slipping of Winding and Backing-Off Catches.**—If the wheels or pawls are worn, or if they slip, the winding and backing-off catches are liable to slip. This may also happen if the pawls are not set properly; if the springs are too weak or are not bent correctly; or if the leather friction lining is worn, or is soaked too much with oil, thus causing it to loose its grip.

**55. Setting of Quadrant Arm.**—The proper setting of the quadrant arm is an important matter, since its setting influences the shaping of the cop and the tension on the yarn during winding. The quadrant arm, to produce a solid cop with the chase at the correct angle, should be set exactly vertical, when the friction bowl which runs on the shaper rail is on the shoulder of the rail. If the shaper rail and plates are in a satisfactory condition, the chase will be straight and its surface perfectly even. The position of the quadrant arm, relative to the carriage, may be adjusted by means of the quadrant bands. These bands have one of their ends attached to ratchet wheels on the carriage; by winding up one of the ropes on its ratchet wheel and releasing that of the other rope correspondingly, the quadrant pinion will make a partial revolution. By this means the quadrant with its arm may be moved backwards or forwards as the case may require.

**56. Setting of Shaper Rail.**—The shaper rail influences directly the shape of the cop, and if the rail is adjusted properly a firmly built cop with the chase at the correct angle should result. When the shaper rail becomes displaced or the plates worn, the parts must be readjusted and repaired to give the desired shape of cop. If it is required to build the cops with a long chase and thus a cop with a firmer though shorter body, the front of the shaper rail must be raised by turning the vertical adjusting screw so as to move downwards; this will cause the winding faller to rise higher and wind the yarn to a higher point on the spindle. If it is required, when changing from cops to bobbins, to shorten the chase, so as to get more yarn on a given length of bobbin, the long incline must be lowered at the shoulder, by turning the adjusting screw so that it will move upwards. When the shape of the cop is incorrect the shaping mechanism can be adjusted to rectify such defects. In some cases the diameter of the cop at the bottom is too large, so that the bottoms of adjoining cops rub against each other, the diameter decreasing as the body of the cop is formed. To prevent this defect, the plates on which the shaper rail rests should be moved backwards so as to commence building the body of the cop earlier; and vice versa for the opposite case.

**57. Causes of Ends Breaking.**—The condensed roving from the carding machines may be both twitty and lumpy, no matter how careful and efficient the carding engineer may be. These defects are more likely to occur when carding low materials. In the case of good materials the twist that goes to the thin portions will probably cause the fibres to hold together and prevent the thread from breaking while the untwisted portions are drawn and twisted, but with low materials, where the fibres are usually very short the threads often break. In many cases it is found that the cost of producing yarns of low quality more than counterbalances the saving in the cost of the raw material, since the lower the quality of material the greater is the number of breakages and hence more waste is made, more labour is required, and the quality of the yarn is impaired by frequent piecing. To overcome the defect of twitty roving it may be condensed slightly thicker, so that the twitty portions will be thicker, but in this case the added strain caused by the increased amount of drawing required must be taken into account, as it is a common cause of bad spinning.

**58.** Twitty roving is not the only cause of ends breaking, since irregular drawing will have the same effect. Another cause of ends breaking is that due to too much twist being inserted without the jacking-up motion being brought into use or without the motion being properly adjusted. If too much tension is put on the counter faller, the ends will be broken during the inward run of the carriage. The tension on the counter faller must be adjusted to suit the class of material being spun. Breakage is also caused by the greater tension put on some threads by reason of the spindles being driven by bands tighter than others and thus made to revolve at higher speeds. Piecing broken ends should be done carefully if the strength and appearance of the yarn is to be maintained. The piecing should be done before the rollers stop delivering the roving for any one stretch, so that a minimum of drawing and twisting is lost.

**59. Waste.**—The amount of waste made in a spinning room is governed to a large extent by the care exercised in arranging the amount of draft given to different kinds and qualities of material. If the draft is not adjusted properly the ends will be constantly breaking, thus increasing the waste and also the labour in piecing up ends.

Generally speaking, the longer and coarser the material, the quicker the carriage should be drawn out. If the ends break close to the delivery rollers, it is an indication that the drafting is too slow. This is especially apt to be so in the case of long materials, as the long fibres become twisted sooner than short fibres and thus become more difficult to draw. On finer materials, if the roving breaks about half-way between the delivery rollers and the spindles when drawing, it is an indication that the carriage is being drawn out too fast. Short materials, such as those which are largely composed of waste, must be drawn much more slowly than longer materials. When the draft is set to conform to the grade of the roving, a mule should make very little waste. The spinners should be required to keep the waste off the floor and to keep the hard and soft waste separate.

**60. Obtaining Counts of Yarn.**—The count of the yarn is affected by the temperature and humidity of the spinning room and, as a consequence, when tested under varying conditions will be found to vary. Yarn spun in a moist atmosphere will be found to weigh heavier than yarn spun in a drier atmosphere ; this is due to the capacity of the wool to absorb moisture. The difference between the weight of the yarn, as it leaves the mule, and its weight finished, that is, its weight after scouring or washing, whether in the form of yarn or cloth, should be taken into account. This difference is termed *sinkage* and is often considerable ; its amount varies in accordance with the quantity of oil used and the amount of dirt it contains.

**61. Testing for Sinkage.**—It must be noted, however, that the spinning overlooker is not usually called upon to take this factor into account, since he is usually only required to spin the yarn to a given count. About 15 to 20 per cent. is generally allowed for sinkage, but the actual percentage allowed varies in accordance with the class of material. Should strict accuracy be required, a test must be made by taking a small sample of the material and washing it in a bath containing soap and ammonia. The sample is then rinsed in clean water, squeezed, and dried in an oven at a temperature of 212° F. When it ceases to lose weight, the difference between the original weight and the final dry weight represents the amount of sinkage. When the latter has been estimated, the yarn can be spun to a weight corresponding to the counts of the finished yarn plus the sinkage.

## CONSIDERATIONS AFFECTING PRODUCTION

### DEFECTIVE YARN

**62. Tracing Causes of Defects.**—There are many defects that may show themselves in the yarn and cops produced by spinning mules, and the tracing of the causes of these defects calls for considerable skill and judgment. The remedy for any particular defect may also call for considerable ingenuity, especially if the mule is an old one or has not received proper treatment. In the following articles are given the defects most commonly met with, together with their causes and remedies.

**63. Uneven Yarn.**—One of the most obvious defects that may be found in the production of the mules is **uneven yarn.** This may be caused by the mixing of long-stapled and short-stapled materials, in which case the only remedy is to use materials having a more nearly uniform length of staple. If the defect cannot be traced to the mixing room, it may be due to uneven roving, and this fault must be corrected, as far as possible, in the carding room. Uneven yarn is sometimes caused by excessive draft. The remedy is to vary the change wheels concerned, to suit the roving and yarn.

**64. Overstrained Yarn.**—Overstrained yarn will result if the winding faller unlocks too late, since there will not be enough yarn left to form the open spirals on the blades of the spindles ; this can be avoided by the proper adjustment of the bracket for unlocking the faller. Again, the counter faller may be too heavily weighted, thereby producing excessive tension on the yarn. The carriage may be overrunning, thus causing it to rebound. The check-band may need to be tightened. When the carriage strikes the catch too hard at the end of the outward journey the belt should be moved earlier from the fast pulley ; or if the drawing-in check band is too slack, it should be tightened.

**65.** If the counter faller is set too low, it may strike the yarn too forcibly during backing off and strain it. Sometimes the winding faller descends too rapidly during backing off, thus producing excessive tension on the yarn, in which case the backing-off chain must be lengthened so that the faller will be lowered later; sometimes the counter faller is too heavily weighted. If the quadrant is set too near the rear of the headstock, it sometimes causes strain on the yarn when the carriage has almost completed its inward run, because more than the required amount of chain will be unwound from the winding drum, thereby causing the spindles to rotate too rapidly. If overstrained yarn is caused by the carriage being out of truth, the carriage should be lined up and the bands should be adjusted.

**66. Snarled and Thick Yarn.**—Spindles inclined too much toward the rollers for the counts being spun, cause yarn to be drawn off the end when the set is filling, making the yarn rather thicker at the top of cop. This action is called *throwing-off* and may be remedied by changing the angle of the spindles with the vertical so that it will be more acute, thereby preventing the yarn from slipping off the ends of the spindles too easily. When an extra amount of twist is inserted with insufficient tension, **snarls** or small **kinks** are made and the tension should be increased. The bracket for unlocking the faller may need adjusting if the faller is unlocking too early at the end of the inward run, and the yarn must be wound on tight enough by keeping the quadrant nut in a low position.

**67.** It may be necessary to increase the amount of tension on the yarn during backing off by having the fallers weighted a little more heavily, or perhaps the backing-off chain may need adjusting so that the fallers will come into their winding positions more quickly. The use of a mixture of short-stapled and long-stapled material also tends to produce snarled yarn. On uneven yarn being produced, the twist inserted occurs chiefly at the weaker places and forms snarls that could be avoided only by keeping the yarn very tight between the spindle and the roller nip by means of the quadrant and governor motion. The weaker places, however, would not be able to withstand the increased pull.

**68.** Slack winding is another cause of snarled yarn. The snarls thus formed can always be distinguished, as they occur in the same place in every stretch and are generally to be found at about the middle of the chase on the cop. They are formed just as the mule gets in prior to re-engaging and are found in the length of yarn that is unwound from the spindle during the backing-off process. These snarls must not be confused with the small ones that should always appear as the mule re-engages, and that are so small that the counter faller always takes them out again as it rises during the backing off. These small snarls are essential to correct winding, for if there is not this degree of slackness there is always a danger of cutting due to the faller. Slack-winding snarls are most common during the formation of the cop bottom, and in bad cases they may be seen protruding from the cop bottoms like short bristles. Snarls may also be caused by careless piecing up, if the pieced portion is situated in the spiral formed round the spindle. The revolving spindle will cause the pieced part to be thrown outwards, so as to produce what is termed a *balloon*. This balloon will form a snarl when the mule backs off, unless it is stroked down with the back of the hand or a finger, in order to tighten it on the spindle blade.

**69. Slubs.**—The term **slub** is used to denote a lump or thick place that may occur on the yarn. One of the most frequent causes of slubs is a lack of care or skill in the piecing of the rovings when creeling. In this operation, when the end of roving from a full bobbin is pieced to the end of roving from a bobbin that is running empty, a long joining, forming a double thickness of roving, should be avoided. The hard twisting of the piecing should also be avoided and the piecing should be of the same thickness and have the same twist as the other part of the roving.

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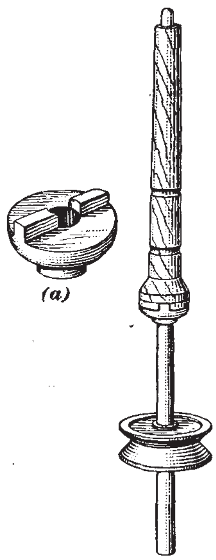
## DEFECTIVE COPS

**70. Defective Cop Bottoms.**—If the bottom cone, or base, of the cop bottom is too long, it can be shortened by lowering the ridge, or shoulder, or highest portion, of the builder rail; in some cases this is done by adjusting the builder plates, while in others the upper portion of the front and back plates, or the portion used during the formation of the cop bottoms, must be filed so that the starting point of both the front and back studs of the builder rail will be lower, while the finishing points remain unchanged.

**71.** If the bottom cone of the cop bottom is too short, it can be lengthened by raising the ridge, or shoulder, of the builder rail ; this can be accomplished in some cases by adjusting the builder plates, while in others the upper portion of the front and back plates must be filed so that the starting point of both the front and back studs will remain unchanged, while the finishing point will be lowered. The filing of the builder plates or builder rail is a very difficult operation, since it is essential that accuracy be obtained, and should never be attempted except in rare cases, and even then only when no other remedy is possible. When the cop bottoms are too long, too much waste is made. In tube-bottomed cops bad bottoms are sometimes caused through imperfect fittings of tubes or through their not being properly pushed down.

**72. Incorrect Chase.**—If the chase of the cop is too long, it can be shortened by lowering the front end of the long rail, by turning the adjusting screw at the front in the required direction. This decreases the height of the shoulder of the builder rail, so that the winding faller will not be depressed so far. If the chase of the cop is too short, it can be lengthened by allowing the winding faller to be depressed more, by increasing the height of the front end of the long rail ; this is accomplished by turning the adjusting screw at the front end of the rail in the required direction and increases the inclination of both long and short rails. In some makes of mules the adjusting screw for altering the difference in height between the two ends of the builder rail is situated at the rear instead of at the front. When this is the case, the inner end of the rail must be raised to shorten the chase and lowered to lengthen it. In this case the short incline is also provided with an adjusting screw at the front, so that extreme positions of the traversing bowl can be set level.

**73. Incorrect Adjustment.**—If the bobbins are not correctly adjusted on the spindles, as to the height above the bolster, but are placed too low, then a portion of the yarn will be wound on the spindle. When the bobbins are held in place by yarn wound round the spindles, the bobbins are liable to be incorrectly placed by a careless attendant. To prevent this a variety of devices, called *clips*, have been introduced. One of these, as shown in Fig. 7 (*a*), consists of a malleable iron disc provided with a rib that engages a corresponding groove in the bobbin base. The edge round the lower end of the hole in the disc is peened with a hammer so as to decrease the diameter. The disc is then hammered into position on the spindle by means of a tube of suitable length. Fig. 7 (*b*) shows the disc and bobbin in position on the spindle.



(*a*) (*b*)

Fig. 7

**74. Soft Cops.**—The most frequent cause of soft cops is the insufficient weighting of the counter faller. If the softness is only at the nose of the cop, the spindles do not revolve fast enough during the latter part of the winding, and the action of the nosing peg should be made more keen ; that is, the peg should be made to depress the winding chain to a greater extent. It may be necessary to tighten the backing-off chain. Another cause of soft cops is slack winding, which will be indicated by the presence of snarls in the yarn in addition to the softness of the cops. In this case the quadrant nut should be lowered and the governing mechanism should be adjusted. Sometimes the chase of the cop must be increased in length. Occasionally the shoulder of the builder rail becomes so worn as to be almost flat, causing the cops to be too large in diameter, in addition to being soft; in this event the shoulder should be re-pointed. Soft cops are caused in some cases by slack rim bands, slack or oily spindle bands, and by the cylinders being loose or slipping ; the remedies in these cases are obvious. A very objectionable kind of soft cop is caused by the pitch of the binding coils being too fine. The fewer binding coils that can be put on, the greater will be the pitch and the greater will be the angle at which they cross the ordinarily wound thread; hence, the greater will be the binding effect on the cop.

**75. Ridgy Cops.**—**Ridgy cops** may be caused if the bowl that slides on the builder rail is so worn as to have an irregular outline; this can be remedied by using a new bowl or by having the old one turned down so as to be regular. If the hole in the centre of the bowl, or the stud on which the bowl is mounted is worn, a new bowl or stud should be used or the old ones should be repaired so as to work properly. Sometimes the bowl requires adjusting so that the whole width of its face will rest on the rail. The bowl on which the boot leg rests may be so badly worn that a new one is necessary; or it may be possible to repair the old one, as in the case of the bowl that runs on the builder rail.

**76.** Irregularity in the movement of the winding faller, resulting in ridgy cops, may also result, if the threads of the builder screw have become worn. A new screw will then be needed, as will also be the case if the threads are burred or otherwise accidentally damaged, unless the screw can be repaired easily and properly. The builder screw may be so bent that the nut that works on the screw will bind, in which case it will only be necessary to straighten the screw so that the nut will work easily. Sometimes the builder-screw threads and nut are so clogged with hardened oil or waste that the nut cannot move freely.

**77.** If the surface of the builder plates is worn irregular, the winding-faller motion will be incorrect and it will be necessary to either use new plates or to file the old ones carefully so as to produce a regular surface. The winding faller may not work smoothly on account of binding in some of the bearings, due to the shaft being bent or out of line or the bearings being clogged, too small, or out of truth; sometimes some of the winding-faller bearings are worn to such an extent that the shaft does not work properly, in which case it will be necessary either to repair the worn bearings or to use new ones. Further, some of the faller couplings may be loose.

**78. Badly Packed Cops.**—The lack of sufficient care in the packing of the cops is likely to result in crushed or broken cops, or the bores may be destroyed and skewering rendered impossible. Cops can be handled with the greatest safety when packed in boxes, as is generally done with fine and very coarse counts. For coarse and medium counts, skips are generally used, but damage is often done to the cops by the bending of the skips when they are being moved about. When packing the outer rows, the noses of the cops should be placed outside so that the cop bottoms may not be damaged.

## RING FRAME

### CONSTRUCTION AND ACTION

#### PRINCIPAL PARTS AND THEIR FUNCTIONS

**79. Passage of Material Through Machine.**—The spinning machine called **ring frame** differs from the mule in the method by which twist is imparted to the yarn, and in the manner of winding the yarn after it is spun. The most striking difference is that the operations of drawing, twisting, and winding are performed simultaneously and continuously in the ring frame, while the mule operates intermittently, the winding being accomplished after the drawing and twisting operations have been completed. A type of ring frame, as made by Messrs. Sykes, is shown in perspective in Fig. 8, while Fig. 9 is a cross-section of the machine, composed of two half-sections taken at different points, so that as many of the parts as possible may be seen. The condenser bobbins *a* from the carding machines are placed on the drums *b*, the journals of the bobbins resting against the stands *c*, so that as the drums revolve the bobbins are revolved with them and the roving unwound at a constant speed whether the bobbins are full or almost empty.

**80.** When the roving leaves the bobbins, it passes through a pair of slowly revolving feed-rollers at *d*, and then through a rapidly revolving tube $e$ to the front, or drawing, rollers $f$; these latter rollers revolve at a greater speed than the feed-rollers, so as to produce the required draft, which may be such that the roving may be made 2 to 4 times finer. After leaving the front rollers the thread passes through the thread guide $g$ to the bobbin $h$, which is fitted on the spindle $i$. While the roving is being drawn, during its passage from the feed-roller to the front rollers,

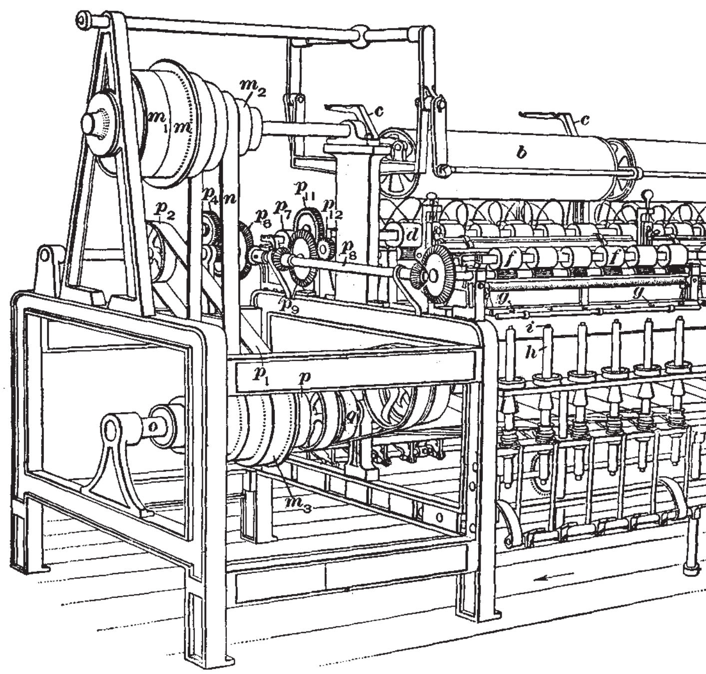



Fig. 8

it is acted upon by two beaters $j$ and $j_1$, which, as they revolve, come in contact with the roving, causing it to vibrate and thus give to it some of that fullness which is characteristic of woollen yarns. The beaters are employed to supply the vibration that is caused in the mule by the yarn slipping over the top of the spindle.

**81.** The drafting of the roving between the feed-roller and front rollers would be impossible if the tube $e$ which is made to revolve at a speed of about 2,000 revolutions per minute did not, temporarily, insert sufficient twist to enable the fibres to hold together, since the distance between the nip of the feed-rollers and that of the front rollers is about 20 to 24 inches and thus very much greater than the average length of the fibres. The rollers

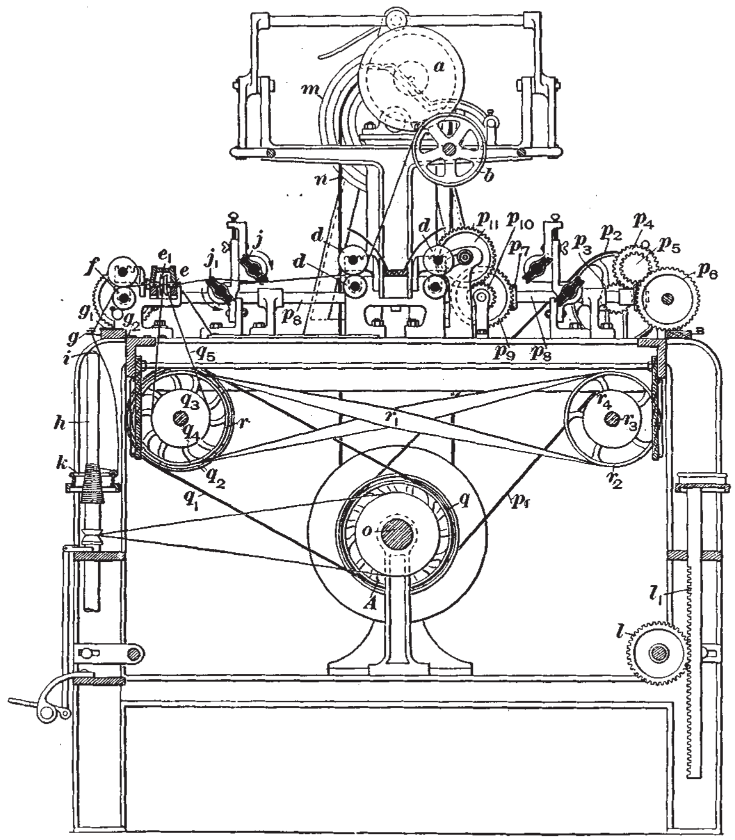



FIG. 9

are set so far apart in order that a yarn of maximum softness may be produced. The yarn, after it leaves the thread guide and before it is wound on the bobbin, is passed through a device known as a *traveller*, which rotates at a high speed round a ring *k*. The centre of this ring, from which the spinning frame derives its name, coincides with the axis of the spindle. By means of the traveller revolving at a rapid rate the required amount of twist is inserted in the yarn. Winding the yarn in a suitable form on the bobbin for the next process is accomplished by traversing the ring which carries the traveller in a vertical direction, by means of a pinion $l$ and rack $l_1$, of which there are a suitable number placed along each side of the machine. While the ring is moving up and down, the bobbin remains in the same place, simply revolving with the spindle.

**82. Thread Guides.**—The wire, or guide, $g$, Fig. 9, serves to give the yarn its correct direction relative to the ring. The guide consists of a piece of wire bent so that it forms a smooth circular loop, so placed that the point on the loop with which the yarn makes contact is directly over the centre of the spindle. The guide is so shaped that the yarn can readily be slipped into the loop, but cannot of itself fly out of it. Each thread guide is screwed into a wood flap $g_1$, that is hinged at $g_2$. There is usually one flap similar to $g_1$ for each guide. Each flap can thus be thrown up out of the way, irrespective of any other part, so that the bobbin may be doffed or removed from its spindle. From the thread guide the yarn passes to the traveller $k_1$ shown enlarged in Fig. 10; it is a steel clip, mounted on each ring $k$, round which it is free to revolve.

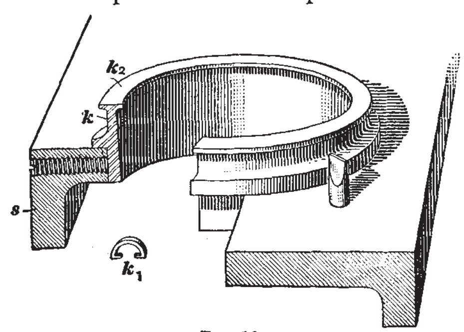


FIG. 10

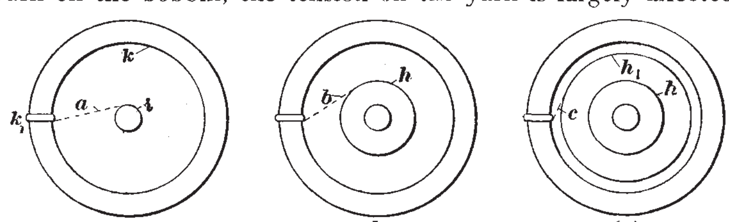
**83. Travellers and Rings.**—The rings on which the travellers are mounted are made of steel. They should be forged from the solid, made perfectly smooth, and as nearly round as it is possible to make them, so that they will offer the least resistance to the traveller. The traveller is sprung over the flange $k_2$, which prevents it from leaving the ring as it travels round the latter. The holes made in the ring rail $s$ for the reception of the rings are bored accurately to fit, and are spaced to correspond with the *gauge*, or distance from centre to centre of the spindles, usually about 5 inches. Each ring is pressed into its hole until its middle flange rests on the upper surface of the ring rail, and each ring is then secured in place by a screw, as shown.

**84. Action of Traveller.**—When seeking to understand the manner in which the traveller inserts twist in the yarn, it should be remembered that the bobbin on which the yarn is wound revolves at a high speed, the number of revolutions per minute remaining constant throughout the building of the bobbin ; also, the front rollers deliver a constant length of yarn per minute. Assuming that the spindle is making 6,000 revolutions per minute and is winding the yarn on an empty bobbin 1 inch in diameter, the surface speed of the bobbin will be $1 \times 3{\cdot}1416 \times 6{,}000 = 18{,}849{\cdot}6$ inches per minute. If the speed of a 1-inch front roller is 140 revolutions per minute, the length of yarn delivered per minute will be $1 \times 3{\cdot}1416 \times 140 = 440$ inches of yarn, nearly. Therefore, the tendency of the bobbin will be to wind on 18,849·6 inches of yarn in the same time that only 440 inches are delivered, and this maintains a tension in the yarn, which tension, being transmitted to the traveller, causes the latter to revolve round the ring on which it is mounted.

**85.** The bobbin revolves at a much higher speed than is required to wind on the yarn delivered by the rollers, and if the traveller $k_1$ were stationary the resulting tension would break the yarn. But as the traveller is free to revolve, it will follow the spindle and revolve nearly at the same speed. The amount of yarn wound on the bobbin will therefore be proportional to the number of revolutions made by the bobbin relative to the traveller. As the rollers in the example quoted deliver 440 inches of yarn per minute while the circumference of the bobbin is $1 \times 3{\cdot}1416 = 3{\cdot}1416$ inches, the number of revolutions of the bobbin necessary to wind the yarn on the bobbin will be $440 \div 3{\cdot}1416 = 140$ revolutions per minute, nearly. In this case the traveller would lag behind the bobbin by the number of revolutions required for winding the yarn, and consequently would make $6{,}000 - 140 = 5{,}860$ revolutions per minute, as it is carried round by the bobbin by means of the yarn. This will have exactly the same effect as if 440 inches of yarn were held firmly at one end by the nip of the front rollers, while the other end was twisted 5,860 times by the revolving traveller. The number of turns per inch in the yarn is therefore ascertained by dividing the revolutions made by the traveller per minute by the length of yarn delivered by the rollers in that time, which in the present instance gives $5{,}860 \div 440 = 13{\cdot}3$ turns per inch.

**86. Variations in Amount of Twist Inserted.**—Since the diameter of a full bobbin exceeds that of an empty one, and since the bobbin makes the same number of revolutions per minute throughout the time that it is being filled, it follows that its surface speed will be greater when full than when empty. Consequently, when the bobbin is nearly full it will tend to wind on more yarn; to counteract this tendency it is necessary that the difference in speed between the bobbin and the traveller shall be decreased. The latter should therefore make more revolutions per minute when the bobbin is nearly full in order that the same amount of yarn may be wound on the bobbin; this increase in speed of the traveller will also result in more twist being inserted in the yarn. But calculations show that the increase in twist is usually less than 1 per cent. of the total number of turns per inch and is so small as to be quite negligible in practice.

**87. Tension on Yarn.**—During the process of winding the yarn on the bobbin, the tension on the yarn is largely affected




(a) (b) (c)
FIG. 11

by the ratio between the respective diameters of the bobbin and the ring. This is shown in Fig. 11 (*a*), the circles at *k* representing the ring and the circle *i* the outside of the spindle. The yarn as represented by the dotted line *a*, in being passed from the traveller $k_1$ to the spindle *i*, nearly coincides with the radius of the ring ; hence, in this case the pull on the yarn tends to draw the traveller to the centre of the ring instead of causing it to revolve round the ring as desired. If a bobbin *h* is placed on the spindle, as in (*b*), the yarn in passing from the traveller to the circumference of the bobbin will assume a position represented by the dotted line *b*, in which case the pull on the yarn will tend to revolve the traveller round the ring rather than draw it toward the centre of the ring.

**88.** For the same reasons, a bobbin that is larger in diameter, by reason of being filled or nearly filled with yarn, will draw the traveller round the ring with less tension on the yarn than in the case of an empty bobbin. This is shown in Fig. 11 (*c*), in which the direction of the yarn, when winding on the full bobbin $h_1$, is represented by the dotted line *c* ; consequent on this variation in tension, the effect of the traveller on the yarn is not quite the same throughout the filling of the bobbins. The same effect is obtained by reducing the diameter of the ring as by increasing the diameter of the bobbin, the use of a smaller ring causing the direction of the yarn to depart farther from the radial line and thus reducing the tension between the spindle and the traveller. Hence, when spinning fine counts of yarn, rings of smaller diameter are used, as it is desirable to exert a smaller pull on the yarn.

**89. Spindles.**—The spindles are required to revolve at very high speeds while carrying bobbins that are liable to be out of balance, simultaneously being subjected to the tension or pull of the yarn and of the bands that drive them. To permit the attainment of such high speeds in face of the adverse conditions specified, the spindle is specially constructed and given a certain amount of flexibility by which it is allowed to assume a curved form so that it is able to find its own best centre of rotation within certain limits, thus preventing the excessive vibration and wear that would result from an attempt to rotate an unbalanced mass at a high speed by means of a spindle carried in rigid bearings.

**90. Driving.**—Motion is given the ring frame, Figs. 8 and 9, by the belt from the line shaft to the fast and loose pulleys $m$ and $m_1$, respectively. A belt $n$ from the 5-step pulley $m_2$ drives a similar pulley $m_3$ fixed on the tin-roller shaft $o$. By means of these pulleys the tin-roller shaft and the parts connected with it may be driven at different speeds. A pulley $p$ on the tin-roller shaft drives by belt $p_1$ to pulley $p_2$ fixed on to a shaft on which there is also a gear-wheel $p_3$. The latter drives the front roller through compound carrier gear-wheels $p_4$ and $p_5$, and compound gear and bevel wheel $p_6$ on the bottom front-roller shaft. The bottom feed-roller $d$ on the same side of the machine is driven from a bevel wheel $p_7$ through gear-wheels $p_9$, $p_{10}$, and $p_{11}$, the latter driving a gear-wheel $p_{12}$ placed on the bottom feed-roller shaft, as shown in Fig. 8. A larger gear-wheel on the latter shaft meshes with a similar one on the adjoining bottom feed-roller shaft and thus drives the latter.

**91.** A pulley $q$ on the tin-roller shaft $o$, Figs. 8 and 9, drives by means of the belt $q_1$ the pulley $q_2$ fixed on the shaft $q_3$. The latter shaft extends the full length of the machine and has as many band pulleys $q_4$ fixed to it as there are spindles on that side of the machine ; a band $q_5$ from each of these pulleys drives the wharl $e_1$ on each tube. The pulley $r$ on the shaft $q_3$ drives by means of the crossed belt $r_1$ a pulley $r_2$ on the shaft $r_3$ ; on the latter are fixed a number of pulleys $r_4$ that drive the tubes on that side of the machine. The up and down motion of the ring-rail is produced by means of the gear-wheel $l$ and rack $l_1$, but the connection of the wheel $l$ with the other mechanism is not shown. The beaters $j$, $j_1$ are driven by bands from pulleys placed on the shafts $q_3$, $r_3$. Each row of beaters is fixed to one long shaft which extends the full length of the machine. The bobbin drums $b$ are driven from the gear-wheel $p_{11}$ through suitable gearing which is not shown. The driving mechanism for both beaters and bobbin drums is on the opposite side of the machine to that containing the main driving mechanism. The yarn produced on the ring frame is hard twisted and only suitable for making warps, and as yet no soft weft yarns have been produced. It is, however, probable that in time soft weft yarns may be satisfactorily produced on the ring frame. The advantages of the ring frame, compared with the mule, are: increased output per spindle, since spinning is continuous; an increase in draft; and more economic working, since less skilled labour is required. The ring frame, being much simpler in construction and easier to drive, requires less cost for repairs and general upkeep; it requires also less floor space and can thus be more conveniently installed.