

CARDING PRACTICES: WOOL AND SYNTHETICS

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What This Text Covers . . .

1. AUTOMATIC FEED Pages 1 to 8
All automatic feeds are identical in principle, whether they be for woolen, worsted, or synthetic carding. You'll learn here how they operate.
2. BREAKER CARD Pages 8 to 25
Starting with the metallic breast, you'll follow the travel of the stock through the breaker section of the set of cards. You'll also become acquainted with such attachments as the Peralta machine and the intermediate feed.
3. DRIVE AND SETTING Pages 25 to 37
Study the drive mechanism and the setting procedure carefully. While described here in connection with the breaker card, they are the same in principle for all woolen, worsted, and synthetic cards. You'll learn how to determine the relative surface velocity of the rolls and cylinders and how to use gages to set them accurately.
4. FINISHER CARD AND CONDENSER Pages 37 to 66
After a brief discussion of a finisher card, you'll come to the heart of the woolen system: the condenser. Both ring and tape condensers are described in detail. You'll learn how ring doffers are covered and how tapes in tape dividers are replaced. You'll also learn how to size roving accurately and how to calculate the production of a woolen card.
5. WORSTED AND SYNTHETIC CARDS Pages 66 to 80
Now you'll have a pleasant surprise: worsted and synthetic cards are not too different from the woolen cards as far as principles of operation are concerned. Since you won't have much trouble understanding their operation, you can concentrate on learning about the really different items, such as balling heads, and about production calculations involving slivers rather than roving. The text ends with some suggestions on successful cardroom management. These suggestions are applicable no matter what type of carding is being done.

Carding Practices: Wool and Synthetics

Woolen Carding

Today and Tomorrow

1. When you studied *Carding Principles*, you learned that there are over ten times as many cotton cards in the textile industry as there are woolen and worsted cards combined. This statistic is somewhat misleading, since the output of the average set of woolen or worsted cards is much higher than that of the average set of cotton cards. Because of their relatively high output, and because they can easily be adapted to work blends of synthetics and other fibers, woolen and worsted cards have an important place in the textile world, and men with a thorough knowledge of their operation are much in demand.

Granted that the study of woolen and worsted carding is worth while, the next question is how to go about it. Obviously, the answer is not so easy as in the field of cotton carding. That field is reasonably standardized, and only a few common makes of cards exist. But if you could visit every woolen or worsted mill in America, you would be unlikely to find two with exactly the same equipment. In one mill you might find cards that were built over a half a century ago. In another you might find modern cards, or even machines designed to process synthetic tow directly into sliver. In still other mills

you would find cards especially built or modified to handle specialty fibers, asbestos, or whatever the mill produces.

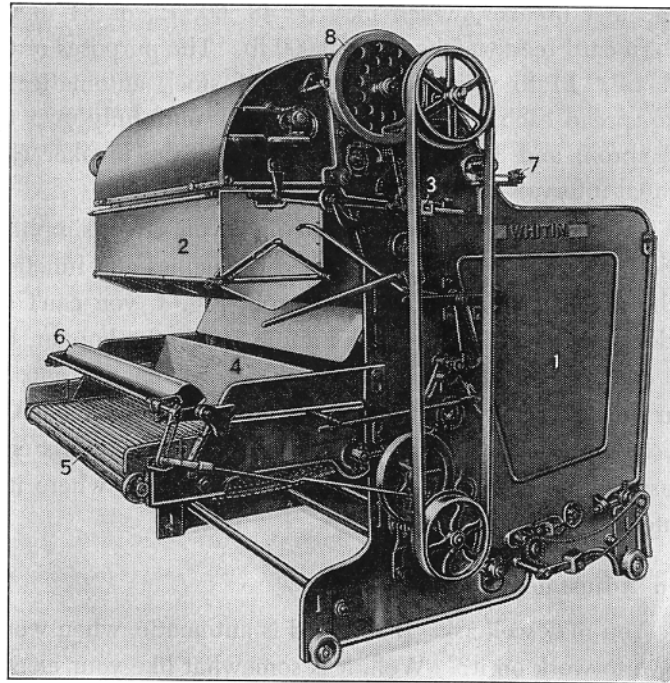
You will need a great deal of know-how in carding practices if you are to deal successfully with the problems of today and to face with assurance the problems that will arise with the new developments of tomorrow. Just as in other fields of knowledge, the foundation you get is all-important. If you have learned geography thoroughly, you can easily keep up with the changes brought about by war and diplomacy. Similarly, if you make a thorough study of today's carding practices, you can face the future with confidence.

What You Must Know

2. It would be a poor carpenter indeed who could not tell first-grade lumber from scrap, or hard wood from soft. The same is true of the carder. You must know your fibers—wool, synthetics, or whatever fiber or blend you are to process. In addition you must remember what you have learned about mechanical calculations so that you can calculate the speeds of card parts.

Most important, you must have some idea of how carding is related to the operation of the mill as a whole. If you are a management trainee, working from one part of the mill to the next, it is easy to see where carding fits into the picture. But if your main interest is in spinning, or even weaving, you may not realize the importance of carding. Yet it is difficult, if not impossible, to correct carding faults in subsequent operations. And your chances to get the cooperation of the carding overseer in preventing faults are much better if you know what you are talking about.

It doesn't matter whether you begin your studies of carding practices with woolen or with worsted cards. In this instruction text we'll begin with the woolen card, because carding is relatively more important in the woolen than in the worsted system of yarn manufacturing.



- | | |
|-------------------|---------------------------------|
| 1. hopper | 5. conveyer |
| 2. pan | 6. dabber |
| 3. movable weight | 7. comb adjustment |
| 4. pusher board | 8. clutch for spike-apron drive |

FIG. 1. AUTOMATIC FEED

The Automatic Feed

3. As you know, a set of cards begins with an automatic feed. Let's take a look at one of them and see how it works. The feed shown in Fig. 1, built by Whitin, is a characteristic modern automatic feed. The feeds made by other machine companies may differ from this one in certain details of construction, but not in general principles of operation. Of course, the feed is of extreme importance in woolen carding, because the quantity of stock fed determines the amount and size of the roving. The width of the feed matches the width

of the first breaker, which may be 48, 60, 72, or 84 in. A modern card feed weighs about 3,000 lb. The purposes of the feed are: 1) to weigh out batches of stock automatically; 2) to spread each weighed batch of stock uniformly over the feed apron; and 3) to feed the batches to the breaker card at equal intervals of time.

When you studied *Carding Principles*, you saw a simplified section through the feed and learned the names and functions of the main parts. In the photograph, Fig. 1, you can't see hidden parts, such as the spiked apron inside the hopper, but you can see the adjustments, which are all on the outside. Your objective now is to learn where the adjustments on the card feed are and how they are set. As we discuss each adjustment, you can refer back to Fig. 1 and see where it is located.

Feed Adjustments

4. You may well ask, "If the feed is automatic, when would I have to work on it?" Well, it is somewhat like your electric alarm clock. That, too, is automatic. Yet you must set it at the right time, and when you want to wake up at a different time, you must change the setting. Also, it needs maintenance once in a while. Proper settings and maintenance are also required for any automatic feed.

The most important adjustments on an automatic feed are: 1) the drive of the spike apron, which must start at a given moment, run at a given speed, and stop when the desired weight of stock has been deposited in the pan; 2) the setting of the stripping comb on the spike apron, which should strip off stock at such a rate that the pan will be filled evenly while the pusher board is returning to the starting point; and 3) the setting of the counterbalance weight, which regulates the amount of stock that will accumulate in the pan before the contents are dumped on the feed apron.

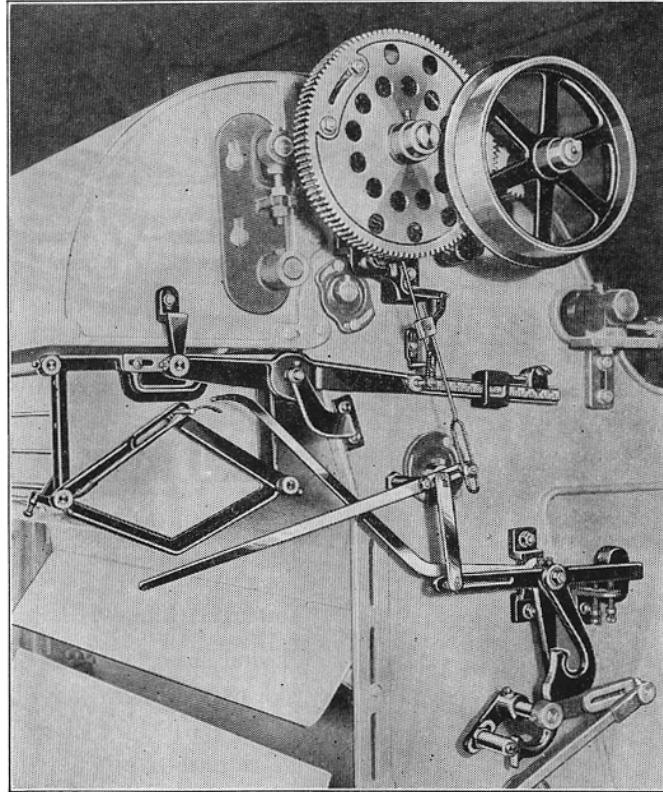


FIG. 2. PAN-DUMPING MECHANISM

Pan-Dumping Mechanism

5. You can see, in Fig. 2, that the pan-dumping mechanism is a rather complicated arrangement of levers. No useful purpose could be served by a detailed description of the mechanism. It is difficult to understand unless you can observe it in action. If, however, you work on an automatic feed and can observe the motions one at a time, the purpose of each lever becomes clear. Here, we'll confine our discussion to the major setting points.

Attached to the movable weight is a pointer that slides on a

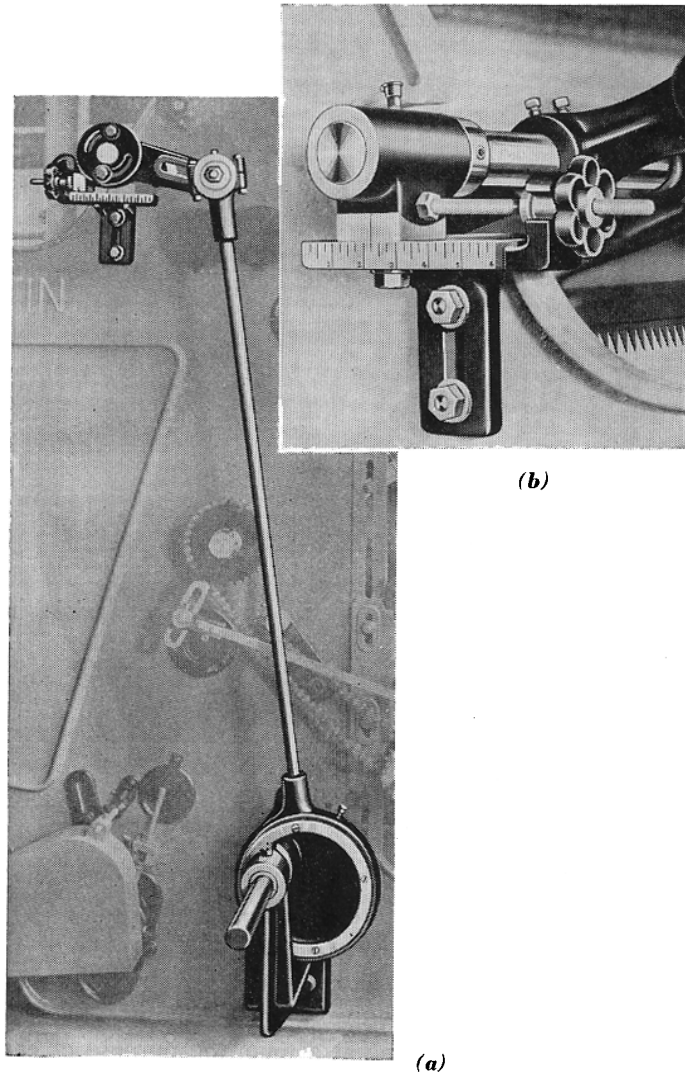


FIG. 3. COMB DRIVE AND ADJUSTMENT

scale. The setting of the pointer determines the weight of stock that will accumulate in the pan before it is dumped. For example, if the pointer stands at 10, the pan will dump its contents on the feed apron when 10 lb of stock has accumulated in the pan. When the pan drops and dumps the stock, the connecting levers throw out the clutch on the clutch gear. This stops the delivery apron until the pan is empty and has been raised again to receive more stock.

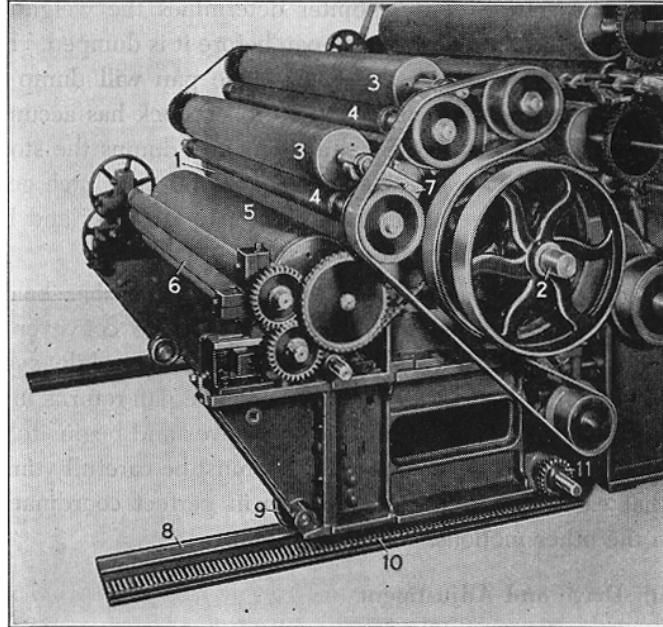
When the pan has dumped the stock, the pusher board, Fig. 1, moves forward. This action helps the conveyer to take the stock to the feed rolls. The dabber, meanwhile, evens the stock out. While all this takes place, the pan returns to its starting position, and the spike apron moves and begins to fill the pan again. The whole mechanism must be carefully timed so that each motion starts and stops in perfect coordination with the other motions.

Comb Drive and Adjustment

6. In order to see how the comb that strips the spike apron is driven, we'll have to look at the other side of the feed. As shown in Fig. 3(a), the comb is driven through a rod connected at the bottom to an eccentric on the main drive shaft, and at the top to a crank on the comb shaft. On other models of feed you may find a pulley-and-belt drive for the comb.

On each side of the feed is a handwheel applied to an adjusting screw for the comb. This arrangement can be seen more clearly if we go back to the drive side of the feed and look at the close-up, Fig. 3(b). The handwheels permit adjustment of the comb without stopping the feed. An important thing to remember is that both settings must be alike. When the pan fills too quickly, the comb should be set closer to the delivery apron—not so close, however, that the pan isn't full when the pusher board returns to its starting point.

The automatic feed has no individual drive motor but is driven, as a rule, from a pulley on the metallic breast. We



- | | |
|--------------------|-----------------|
| 1. breast cylinder | 6. feed rolls |
| 2. cylinder shaft | 7. worker stand |
| 3. workers | 8. track |
| 4. strippers | 9. roller |
| 5. lickerin | 10. rack |
| | 11. gear |

FIG. 4. METALLIC BREAST

will now have a look at this breast. Later we will study the drive of the whole unit.

Metallic Breast

7. The metallic breast, sometimes called the garnett breast, is considered standard equipment on all modern woolen cards. The breast of today has many improvements over older models. The purpose of the metallic breast is to open tangled lumps of fibers in the stock, to remove as many of the burs and shives as possible, and to take the hard wear which is too severe for card clothing. These functions must be taken into

consideration when you select the wire for the various parts of the breast. You may refer to Fig. 4 for the location of the parts.

All breast rolls, with the exception of the feed rolls, are surface-wound with wire. Surface winding eliminates the cutting of grooves in the rolls. It also allows you to replace the wire without altering the original roll diameters.

The feed rolls are made of steel, and the wire is wound on them so that the teeth of the two rolls interlock. This prevents the lickerin from plucking stock through the feed rolls and assures the delivery to the breast cylinder of stock that is well and evenly opened.

8. The stripper stands are bolted to grooves on the face of the arch, to provide fixed alignment across the cylinder. The only adjustment is a vertical one. The workers, on the other hand, are adjustable both vertically and horizontally. With the vertical adjustment the workers can be set to the breast cylinder; with the horizontal adjustment they can be set to the stripper rolls. The breast workers, strippers, and lickerin are usually set to the cylinder and to each other with a No. 28 gage. The gages used, and the setting procedures, will be discussed later.

The modern breast is set upon tracks and rollers, making it readily movable. You'll have to move the breast sometimes, as, for instance, when it becomes necessary to remove the tumbler from the first breaker. A rack forms part of the track and meshes with a gear which can be turned with a ratchet handle.

A clutch forms part of the feed-roll drive. This clutch makes it possible to discontinue the feeding of stock when necessary, as, for instance, when you want to clean out the card. Thus, in a modern breast you need not remove any belting in order to stop feeding stock. Also, the weighed stock on the feed conveyer is left intact.

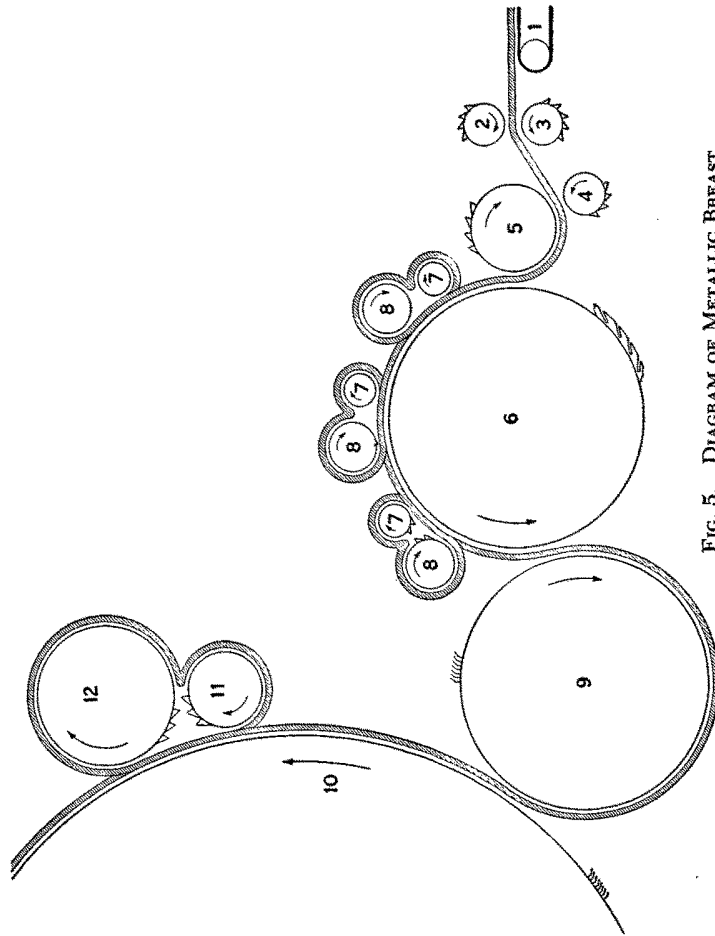


FIG. 5. DIAGRAM OF METALLIC BREAST

- 1. conveyer
- 2. top feed roll
- 3. bottom feed roll
- 4. feed-roll stripper
- 5. lickerin
- 6. breast cylinder
- 7. breast stripper
- 8. breast worker
- 9. tumbler
- 10. breaker cylinder
- 11. stripper
- 12. worker

Travel of Stock

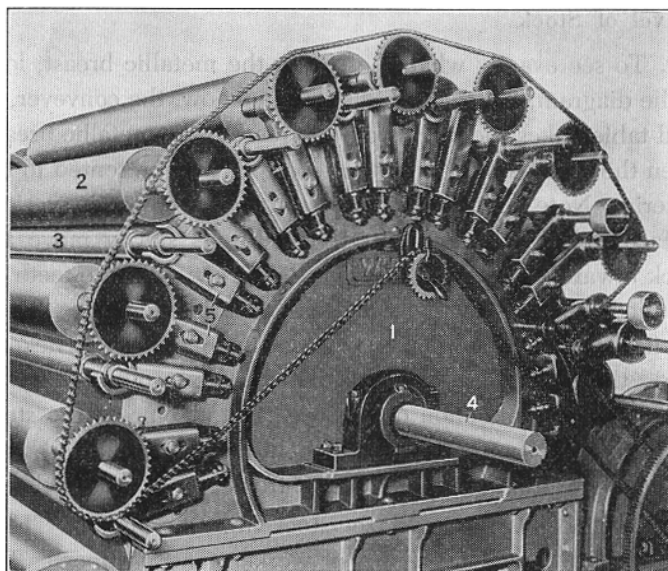
9. To see exactly what goes on in the metallic breast, look at the diagram, Fig. 5. As you already know, the conveyer, or feed table, takes the stock from the feed to the metallic breast. Then the stock is moved by the feed rolls and presented to the lickerin. Note how the wire teeth are arranged on the various surfaces. You can see that the feed rolls slowly move the stock toward the lickerin but that the direction of the teeth on the feed rolls is such that they tend to hold the stock. Thus, the first carding action takes place at this point. The lickerin strips the stock cleanly from the top feed roll. However, because of the direction of the wire teeth, some of the stock adheres to the bottom feed roll. This stock is removed from the feed roll by a stripper roll and transferred to the lickerin.

The breast cylinder takes the stock from the lickerin. Then the stock is carded by means of workers and strippers. The action, except as it is affected by the use of a looser setting and stronger wire, is exactly the same as on the regular card cylinder. If the various actions are not quite clear to you, it may be a good idea at this point for you to review the text *Carding Principles*.

Look at the diagram, Fig. 5, and compare the surface speed of each roll with that of the next. For instance, the tumbler surface must move faster than the surface of the breast cylinder, but not so fast as that of the breaker cylinder. Otherwise, the stock would not be transferred. You will save much needless experimentation if you think such problems over before you start to make changes and adjustments on a card.

Construction of Breaker

10. When you look at the construction of the breaker section, you must remember that it constitutes a whole card in itself. In other words, the second breaker in a four-card set is normally an exact duplicate of the first breaker. For that matter, the finisher cards do not differ much from the breaker,



- | | |
|-----------|-------------------------|
| 1. arch | 3. stripper |
| 2. worker | 4. cylinder drive shaft |
| | 5. poppet |

FIG. 6. BREAKER CARD

except in a few details. Therefore, let's study the first breaker carefully; then we won't have to repeat the general construction when we get to the other parts of the card.

Old cards were usually made 48 in. wide and were often built with the arches outside the drives. In Fig. 6 you see the side of a modern card, with the chain that drives the workers. The strippers are driven by a belt on the other side of the card. As you can see, modern card construction provides for outside drives, which permit closely fitting arches. The arches carry bearings that support the ends of the workers and strippers. On a card 60 in. wide the two bearings for a roll are only slightly farther apart than the bearings on the old 48-in. card. Consequently, there is less sag in the rolls on a card with modern outside drives than there was on a card with inside drives.

Other improvements, in both construction and materials, made possible a steady increase in card width. For some time it looked as if the 60-in. card would become standard in the woolen industry, but today 72-in. and 84-in. cards are frequently built.

The workers and fancy rolls of modern cards are made from aluminum, for lightness and ease in handling. Strippers and fancy clearers are made from strong steel tubing. Cylinders and doffers are made of iron. They are seasoned for several months and then ground carefully, so that their surface is true and remains true.

As you have seen, the workers on the card shown are driven by a chain. This is the arrangement on most modern cards, while older cards use a belt drive for the workers. The strippers are usually driven by a belt. Flat leather belts are generally used on Whitin cards to drive the strippers, while most Davis & Furber cards use V belts. If the arrangement on a card you are working with is not quite clear to you after you come to the end of this text, write to the manufacturer for information. In their literature, card builders stress the details that are peculiar to the cards they make but usually take it for granted that you are familiar with card construction and operation in general.

Stock Flow through the Breaker

11. As you have seen, the stock passes from the breast cylinder to the tumbler, from which it is stripped by the breaker-card cylinder. This carries the stock to the first worker, where it meets the points of the worker clothing. The points of the worker clothing operate against the points of the cylinder clothing, and the carding action begins. The stock is taken from the teeth of the worker by the stripper, which transfers it back to the cylinder. The cylinder carries the partially opened stock on its surface into contact with the next worker. This action is repeated at each pair of worker and

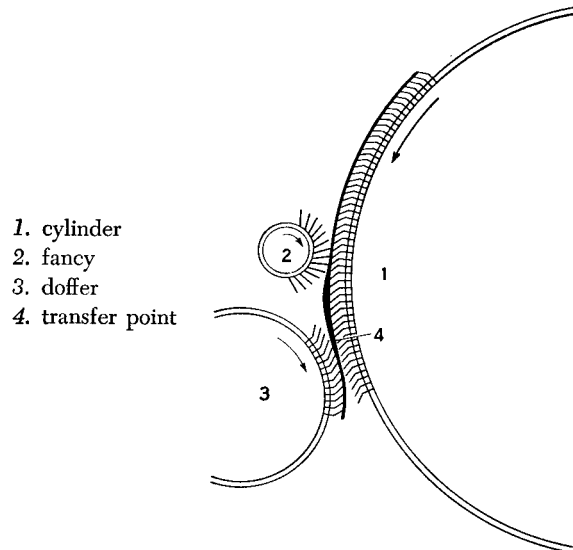


FIG. 7. STOCK TRANSFER

stripper rolls. The object of this carding is to open up the stock, clean the stock as much as possible, and rearrange the fibers in a web of uniform density.

The more workers and strippers there are on a set of cards, the better the results. Consequently, the trend has been not only to wider cards, but also to larger cylinders. While cylinders with a 48-in. diameter were once generally used, cylinders with a 60-in. diameter are standard today. You can always remove a few pairs of workers and strippers from the 60-in. cylinder when working with stock that needs less carding action. It is not likely, however, that cylinders with a diameter over 60-in. will come into general use, because it would be too hard to reach the top of such cards for servicing and maintenance.

Fancy and Doffer

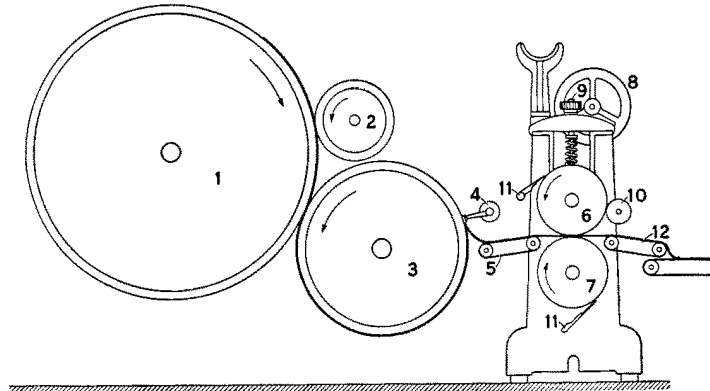
12. After the stock has been combed by the workers and the cylinder, it becomes imbedded in the teeth of the cylinder

wire. This makes it necessary to use a fancy before the doffer. The fancy, shown in Fig. 7, is a brush with long wires that work back to back with the cylinder wires. To understand the action of the fancy, you must consider its setting, its direction of rotation, and its surface speed in relation to that of the cylinder. Remember that the fancy prepares the stock for transfer. It lifts the fibers to the tips of the cylinder wire so the doffer can take the stock and deliver it in the form of a sheet. The fancy and the cylinder are the only two rolls of the card that touch one another. To be effective, the fancy must have its wires set about $\frac{1}{32}$ to $\frac{1}{16}$ in. into the cylinder wires and must have a slightly greater surface speed than the cylinder. Both surfaces move in the same direction at the contact point.

The doffer surface moves in the same direction as the cylinder surface at the transfer point. However, the doffer surface moves much more slowly than the cylinder surface. Therefore, the stock is not only transferred from the cylinder to the doffer, but the thin film of fibers carried by the cylinder clothing is condensed into a somewhat more substantial web. The web is detached from the doffer by the doffer comb. This comb, which consists of a steel blade with a serrated edge, is given a rapid, chopping, up-and-down motion. The web is then deposited either directly on the intermediate feed or on the feed table of the Peralta machine, when such a machine is used.

Peralta Machine

13. Consider, for a minute, the stock normally fed to a woolen card. It often consists partly of shoddy, which, no matter how well the garnetts have done their work, is likely to contain some hard threads. There may be not only noils, or short fibers removed from worsted wools, but also large quantities of undesirable burs. In fact, the web may not only contain undesirable fibers, but may look as if someone had



- | | |
|-----------------------|--------------------------|
| 1. breaker cylinder | 7. bottom press cylinder |
| 2. fancy | 8. pressure wheel |
| 3. doffer | 9. pressure gage |
| 4. doffer comb | 10. wiping roll |
| 5. feed apron | 11. cylinder cleaners |
| 6. top press cylinder | 12. delivery apron |

FIG. 8. PERALTA MACHINE

swept the floors in a carpenter shop and in a tailor's work-room and sprinkled the sweepings over the web. While burs, hard threads, and the like will not do any great harm to the metallic breast and the rugged clothing of the first breaker, they will injure the finer clothing of the finishers. Also, of course, they will be harmful later on, in spinning and weaving. The Peralta machine, Fig. 8, was developed to destroy the undesirable substances in the web.

The principle of the Peralta machine is simply to crush to dust all burs, straw, tar lumps, rags, hard-twisted threads, entangled bunches of fibers, knots, pieces of hard skin—anything that is thicker and harder than the web of stock. This is accomplished by squeezing the card web between two steel press cylinders. Let's look at the Peralta machine in a little more detail.

14. The web leaving the doffer drops on a slat apron, which carries it between the press cylinders. The enormous but

evenly distributed pressure does not harm the loose fibers, but it crushes to dust all bodies of greater bulk. After passing between the press cylinders, the web continues on another slat apron, which delivers it to the intermediate feed. When the web is fed to the following card in the set, the crushed impurities are dusted out.

The press cylinders are cleaned by long strips of felt held in position by blades. These cleaners must be adjusted correctly if they are to keep the cylinder surfaces clean. Some stocks tend to stick to the press cylinders and must be wiped off. The delivery apron tends to act as a wiper for the lower press cylinder. For the top press cylinder, however, a small wiping roll is provided, usually set to the cylinder with a No. 30 gage.

A pressure wheel is provided on each side for applying additional pressure to the top press cylinder. The cylinder itself weighs a ton, and the scale on the pressure wheels reads from 1 to 5 tons. Experience has shown that a pressure between $2\frac{1}{2}$ and 3 tons is sufficient to pulverize the undesirable objects in the stock. In adjusting the machine, be sure to set it so that the pressure is the same on both sides of the machine.

The cylinders of the Peralta machine are driven by a train of gears. The first gear in the train is driven by a belt-and-pulley drive from the first breaker. Change gears are provided to adjust the speed of the aprons and the rolls so you can coordinate them with the speed of the breaker and the speed of the intermediate feed. The web from the breaker should not be so slack as to form folds, nor should it be drafted. The Peralta machine is designed only for a crushing action, not for drafting or condensing.

The Peralta machine is installed on tracks at the delivery end of the card. It can be removed by a ratchet while the card is stripped. And when carbonized wool, synthetics, or any other stock without impurities is being processed, it can be left out of the card set.

Intermediate Feeds

15. From the breaker card or the Peralta machine the stock comes to the intermediate feed. This is the last part of the breaker unit, and a very important one. The intermediate feed permits the woolen card system to fulfill objectives that are directly opposed to objectives of a worsted or cotton carding system. Let's see what these objectives are and how they are achieved.

In worsted and cotton carding, a major objective is to make the fibers as nearly parallel as possible. This parallelization of the fibers is essential if you want to spin fine, strong yarns. The stock is usually fairly uniform. Further blending, if necessary, can be accomplished later by doubling and drafting. In woolen carding, however, the objectives are quite different. For one thing, the stock must be prepared for spinning—there is no doubling later on. And since the stock usually consists of a mixture of short and long fibers, it must be thoroughly blended or you'll get uneven yarn. For another thing, the fibers should be for the most part crisscross, rather than parallel. This arrangement assures the lofty structure of woolen yarns and keeps the short fibers anchored in the yarn. The purposes of the intermediate feed are therefore 1) to blend the stock, just as the doublings in drawing would, and 2) to arrange the fibers at an angle to the direction in which they previously traveled through the breaker card.

On very old woolen cards, the objectives of the intermediate feed were achieved by pulling the card web through a trumpet to form a sliver. A simple balling attachment rolled the sliver into balls. The sliver was then pulled off the balls and arranged crisscross on the feed apron of the finisher unit. Of course, this handwork was uneconomical and uneven. The work is now done by mechanical devices built to achieve the same objectives. The two most common devices are 1) the

Apperly diagonal-sliver feed and 2) the Scotch broad-band feed. Let's look at them in detail.

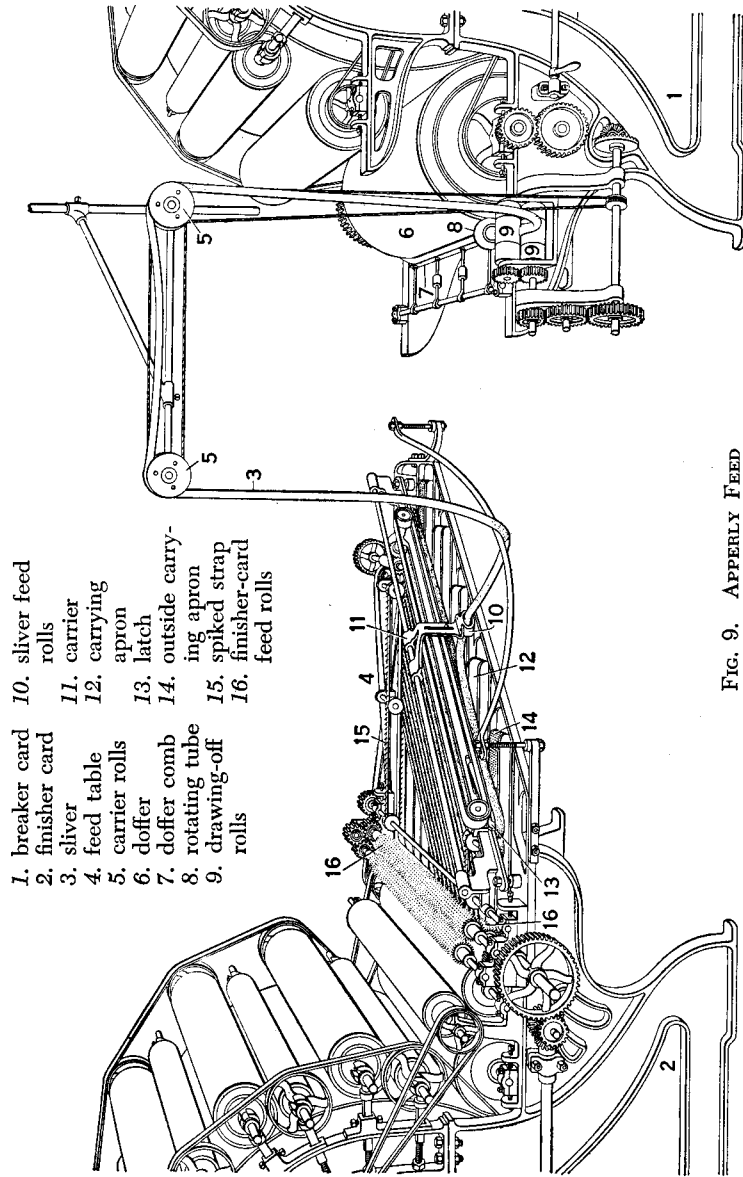
Apperly Feed

16. While it was very common in former years and is still found in many mills, the Apperly feed has been discarded by most card builders today in favor of the Scotch feed. We'll describe the Apperly feed in some detail; but if you do not expect to work with it, you may skim over this article and the next one and continue directly with the Scotch feed.

An Apperly intermediate feed is shown in Fig. 9, as installed on an old-time set of woolen cards. The feed is used between the breaker and the finisher in a two-card set, or between the first and the second breaker in a three-card set. It forms the web into a sliver and then blends the overweights and underweights. The blending is accomplished by placing a number of doublings of the sliver diagonally across the width of the feed table, or apron, on the finisher. Note, in the illustration, the overhead carrier rolls that support and transfer the sliver.

The stock that is taken from the doffer by the comb is twisted into a sliver by being passed through a rotating tube. This sliver is then drawn off between two steel rolls, which are driven by gearing from the doffer. The rolls must have the same surface speed as the doffer, to assure a strong and uniform sliver.

17. The feed unit contains two small feed rolls. These are supported by a carrier that slides back and forth on a rod extending diagonally across the feed table. As the carrier travels back and forth, the sliver is laid on the carrying aprons, which have a forward motion. Two latches are lifted by the carrier when it reaches the side of the feed, and these fall back into the loop formed by the sliver to keep it from drawing back when the carrier changes direction. The outside carrying aprons are studded with projecting wires which help hold



- 1. breaker card
- 2. finisher card
- 3. sliver
- 4. feed table
- 5. carrier rolls
- 6. doffer
- 7. doffer comb
- 8. rotating tube
- 9. drawing-off rolls
- 10. sliver feed rolls
- 11. carrier
- 12. carrying apron
- 13. latch
- 14. outside carrying apron
- 15. spiked strap
- 16. finisher-card feed rolls

FIG. 9. APPERLY FEED

the sliver. When the latches are lifted again, the slivers are held down by spiked straps, which travel in the same direction as the carrying aprons.

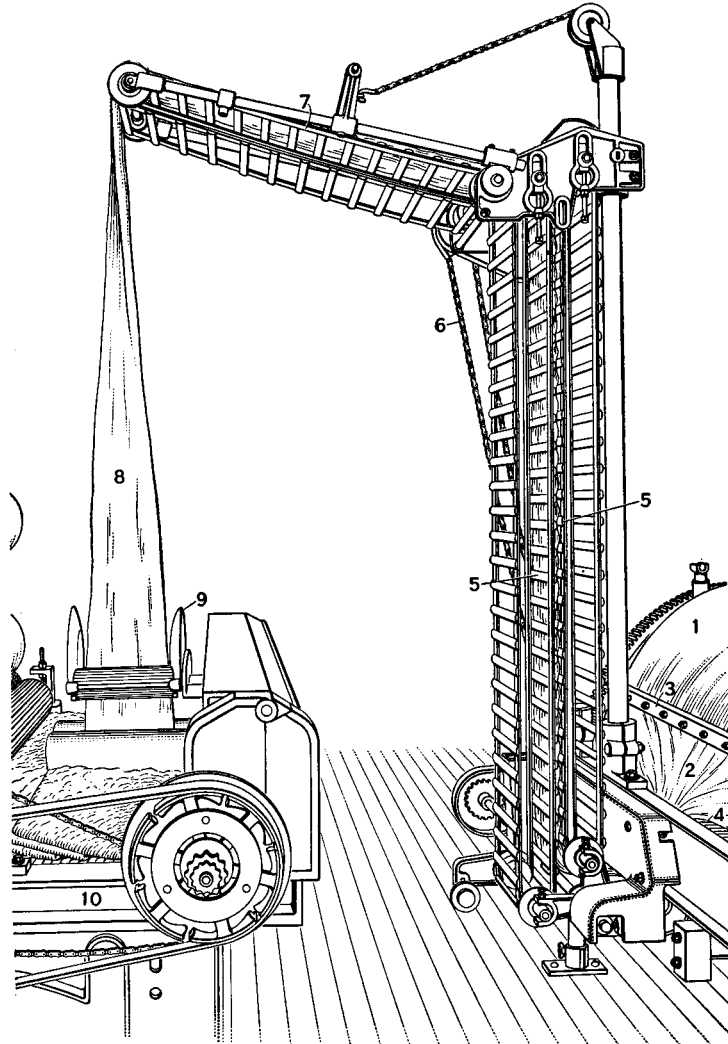
The stock is carried forward by the aprons until it reaches a pair of feed rolls which deliver it to the lickering of the card. The feed rolls are part of the intermediate feed and act as a unit with the aprons. Thus, a change made in speed of the feed rolls or in the amount of stock fed will not alter the speed of the card.

18. Variation from side to side in the thickness of the web on finisher cards is often caused by incorrect speeds of the aprons or the feed rolls of the Apperly feed. The surface speed of both must be alike. If the roll which drives the aprons is faster than the feed rolls, the slivers are forced to the long side of the feed table, causing the web on that side to be heavy. If the apron roll is too slow, the opposite is true. You can use a simple test to check the feed. Take a strip of paper as wide as one of the aprons, and start it between the feed rolls. Then put the paper on the apron and stick a tack through the paper and the apron. Now turn the feed rolls by hand. If the paper starts to buckle, the apron roll is faster than the feed rolls. If the tack starts cutting through the paper, the apron roll is slower than the feed rolls.

The major disadvantage of the Apperly feed is that it requires the web to be condensed into a twisted sliver. The next card in the set can work more easily on an open web. For this and other reasons, the Scotch feed has become the standard intermediate feed.

Scotch Feed

19. The Scotch feed differs from the Apperly feed in two major respects: 1) it gathers the web into a wide band instead of a twisted sliver; and 2) it places the band on the feed table parallel to the feed rolls, one layer of the band overlapping the



- | | |
|----------------------|------------------------------|
| 1. doffer of breaker | 6. drive chain |
| 2. web | 7. overhead apron |
| 3. doffer comb | 8. band of fibers |
| 4. supporting apron | 9. guard plates |
| 5. lattice aprons | 10. feed section of finisher |

FIG. 10. SCOTCH FEED

other. Therefore, the fibers are fed to the finisher in an open form, and at a right angle to their direction on the breaker. Some early Scotch feeds drew the web from the side of the doffer. The Scotch feed shown in Fig. 10, while an old model, is of the center-draw type, like all modern Scotch intermediate feeds. Except for some minor engineering differences, most modern woolen cards, as well as garnetts and some cards used for synthetic blends, use this type of intermediate feed. Let's see how it works.

The web is removed from the doffer by the doffer comb. Aprons placed beneath the comb support the web. The web is drawn forward to the center by a set of drawing-off rolls and is condensed into a band. Two lattice aprons are constructed with slats attached to two continuous belts. The band of fibers is held between the two aprons and lifted without strain. A chain driven by the breaker card moves the aprons. The driving mechanism is adjusted to take up the band as fast as it is passed forward by the drawing-off rolls. An overhead apron, likewise driven by the chain, supports and carries the web until it is over the feed apron of the finisher card. The overhead apron transfers the band from one card to the other without taking up too much space and leaves a passageway between the two cards.

20. After the band leaves the overhead apron, it passes downward between two curved guard plates, two feed rolls, and then two condenser rolls. The guard plates keep the band in correct position for the feed rolls. The purpose of the condenser rolls is to press the stock down evenly on the feed apron.

The feed rolls are held in a traveling unit, shown in detail in Fig. 11. The unit is supported above the feed apron and is driven from the finisher card by means of a belt. The purpose of this unit is to hold the feed rolls parallel to the feed apron and carry them back and forth across the width of the

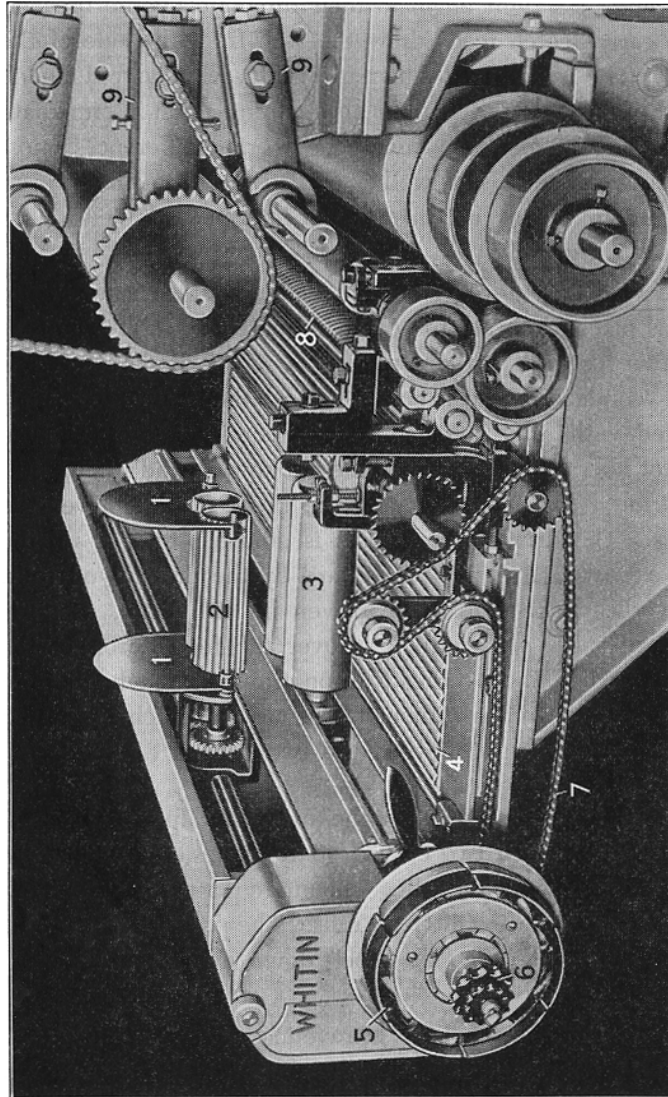


FIG. 11. FEED SECTION OF SCOTCH FEED

LEGEND FOR FIG. 11

- | | |
|--------------------|---------------------------|
| 1. guard plates | 5. expansion pulley |
| 2. feed rolls | 6. adjusting wheels |
| 3. condenser rolls | 7. chain drive |
| 4. feed apron | 8. feed rolls of finisher |
| | 9. poppets |

card so that the band of fibers is placed evenly on the feed apron. The speed of the feed apron is adjusted to permit each layer of the band of stock laid by the feed rolls to overlap the last layer of the band. In this manner an even surface, as well as a uniform amount of stock, is presented to the feed rolls of the finisher card.

Note, in the detailed illustration, that the driving pulley is an expansion pulley provided with adjusting wheels. This arrangement permits you to adjust the speed of the unit exactly. The feed apron is connected with the unit by a chain drive. The stock must be delivered to the feed rolls of the card evenly. It should not be delivered so rapidly that it bunches up in front of the feed rolls, nor so slowly that it is pulled apart. When stock is very poor, that is, when it consists mostly of short fibers, the band may break between the overhead apron and the feed rolls of the traveling unit. Special carrier rolls are available to support the band and should be installed when needed.

Drive of Breaker Section

21. As you have seen, there is a clean break in the set of cards at the intermediate feed. All the units up to and including the first half of the intermediate feed form one drive unit. For the time being, we'll forget about the end of the intermediate feed that is driven from the finisher or from the second breaker and study only the first drive unit. In a two-card set this unit is centered around the breaker.

There are so many different drive arrangements for the breaker section that it is hard to give general directions.

Therefore, we have reproduced in Fig. 12 the gearing of the first breaker section of a characteristic Whitin two-card set. The illustration has been placed on an insert so that you can keep the diagram before you while you study the gearing. If you study the explanations carefully, you should have little trouble in following the diagram. Later, to apply what you have learned, you can write to the manufacturer of the card you are working with and ask for a diagram. Or if this isn't practical, you can make yourself a rough sketch of your card and note the dimensions when the card is shut down. The principles you'll now learn can be applied to any card or garnett.

In setting up formulas and sample calculations, we'll take it for granted that you have studied the text *Mechanical Calculations*. Review this instruction text if necessary.

Speed of Main Cylinder

22. At the lower center of Fig. 12 is the main drive of the card. When overhead drive is used, the main drive consists of a fast pulley and an idler pulley. When an individual motor drive is used, the main drive consists of a sprocket driven by the motor. The main drive is placed on the shaft of the main cylinder of the card.

The main cylinder is driven at about 100 rpm for most purposes. On old, uncovered cards having a cylinder 60-in. in diameter, the speed may be lower, to prevent excessive fly. A modern, covered card may be driven faster when the stock run makes higher speeds desirable. What matters, of course, is the surface velocity of the cylinder rather than the number of revolutions per minute.

The surface velocity may be expressed in feet per minute (fpm), inches per minute (ipm), or inches per second (ips). In finding the surface velocity, you must consider the thickness of the clothing, as well as the diameter of the roll. This is not very important in calculations involving the cylinder, but it

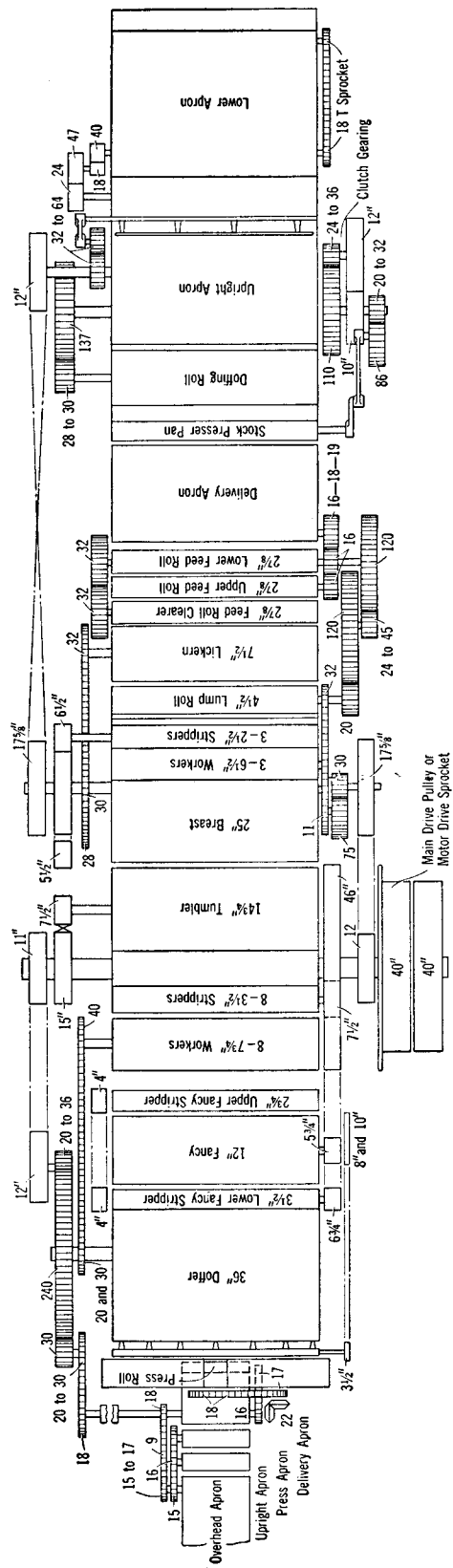


FIG. 12. GEARING DIAGRAM OF BREAKER SECTION

does make quite a bit of difference in calculations involving smaller rolls, such as the fancy. You can use the formulas given below to find surface velocity.

$$\text{FORMULA 1: } V_{ipm} = R \times [D + (H \times 2)] \times 3.14$$

$$\text{FORMULA 2: } V_{fpm} = \frac{R \times [D + (H \times 2)] \times 3.14}{12}$$

$$\text{FORMULA 3: } V_{ips} = \frac{R \times [D + (H \times 2)] \times 3.14}{60}$$

in which V_{ipm} = surface velocity, in inches per minute;

V_{fpm} = surface velocity, in feet per minute;

V_{ips} = surface velocity, in inches per second;

R = revolutions per minute of cylinder;

D = diameter of cylinder, in inches;

H = height of card clothing, in inches.

EXAMPLE 1. You have a 60-in. card cylinder covered with card clothing $\frac{3}{4}$ in. high. The cylinder is making 100 rpm. What is the surface velocity, in inches per minute?

SOLUTION. $V_{ipm} = 100 \times 60 \frac{3}{4} \times 3.14 = 19,075$ ipm, surface velocity of cylinder. Ans.

EXAMPLE 2. You have a 48-in. card cylinder covered with card clothing $\frac{3}{4}$ in. high. The cylinder is making 90 rpm. What is the surface velocity, in feet per minute?

SOLUTION. $V_{fpm} = \frac{90 \times 48 \frac{3}{4} \times 3.14}{12} = 1,148$ fpm, surface velocity of cylinder. Ans.

EXAMPLE 3. You have a 50-in. card cylinder making 100 rpm. The cylinder is covered with metallic clothing so low that you can disregard it in calculations. What is the surface velocity, in inches per second?

SOLUTION. $V_{ips} = \frac{100 \times 50 \times 3.14}{60} = 262$ ips, surface velocity of cylinder.

Remember these formulas. They are equally applicable to doffers, workers, strippers, lickerins, fancies, and other cylindrical parts.

Speed of Strippers

23. When you know the speed of the cylinder, it is easy to determine the speed of the strippers. The card diagramed in Fig. 12 has eight strippers, each $3\frac{1}{2}$ -in. in diameter, but only one is shown to prevent crowding the diagram. Each stripper has a $7\frac{1}{2}$ -in. pulley, driven by a belt from a 46-in. pulley on the main cylinder shaft.

Now, if you remember your mechanical calculations, you can set up a formula for the speed of the stripper.

$$\text{FORMULA: } R_s = \frac{R_c \times P_c}{P_s}$$

in which R_s = revolutions per minute of stripper;

R_c = revolutions per minute of cylinder;

P_c = diameter of pulley on cylinder shaft, in inches;

P_s = diameter of pulley on stripper shaft, in inches.

EXAMPLE 1. If the cylinder of a card geared as shown in Fig. 12 makes 100 rpm, what is the speed of the strippers?

$$\text{SOLUTION. } R_s = \frac{100 \times 46}{7.5} = 613 \text{ rpm, speed of strippers. Ans.}$$

Thus the speed of the strippers is more than six times as great as that of the cylinder. But, you say, the surface velocity of the cylinder must be higher than that of the strippers so that the cylinder can take the stock from the strippers. To see whether the strippers have the proper relative surface velocity, apply formula 1 of the preceding article.

EXAMPLE 2. The strippers of a card have a diameter of $3\frac{1}{2}$ in. and are covered with card clothing $\frac{3}{8}$ in. high. They make 613 rpm. What is the surface velocity of the strippers, in inches per minute?

$$\text{SOLUTION. } V_{ipm} = 613 \times 4\frac{1}{4} \times 3.14 = 8,180 \text{ ipm, surface velocity of strippers. Ans.}$$

As you can readily see, the surface velocity of the strippers is less than half that of the cylinder. No change pulleys are normally provided, as the speed ratio is seldom changed.

Speed of Doffer and Workers

24. The doffer takes the stock from the cylinder. In order to prevent the card from loading up, the doffer may have to be speeded up when the card production is raised. Note, in Fig. 12, that an 11-in. pulley on the cylinder shaft drives a 12-in. pulley on a stud. Fast to the same stud is a change gear, which may have 20 to 36 teeth. This change gear meshes with a 240-tooth gear on the doffer shaft. Taking all this into consideration, you can set up a formula for the speed of the doffer.

$$\text{FORMULA 1: } R_d = \frac{R_c \times P_c \times G_s}{P_s \times G_d}$$

in which R_d = revolutions per minute of doffer;

R_c = revolutions per minute of cylinder;

P_c = diameter of pulley on cylinder shaft, in inches;

G_s = number of teeth on change gear on stud;

P_s = diameter of pulley on stud, in inches;

G_d = number of teeth on gear on doffer shaft.

EXAMPLE 1. You have a card geared as shown in Fig. 12. The cylinder makes 100 rpm. You are using a 24-tooth change gear. What is the speed of the doffer?

$$\text{SOLUTION. } R_d = \frac{100 \times 11 \times 24}{12 \times 240} = 9.17 \text{ rpm, speed of doffer. Ans.}$$

The workers of the card are driven from the doffer by means of a chain drive. The sprocket on the doffer shaft may have 20 or 30 teeth, while the sprocket on each worker has 40 teeth. There are eight workers, but only one is shown in order not to clutter the diagram. The speed of the workers must be based on the doffer speed, which is variable because of the change gear. You can set up the following formula:

$$\text{FORMULA 2: } R_w = \frac{R_d \times S_d}{S_w}$$

in which R_w = revolutions per minute of workers;

R_d = revolutions per minute of doffer;

S_d = number of teeth on change sprocket on doffer shaft;

S_w = number of teeth on sprocket on workers.

EXAMPLE 2. The doffer on a card geared as shown in Fig. 12 makes 9.17 rpm. You are using a 20-tooth sprocket on the doffer shaft. What is the speed of the workers?

SOLUTION. $R_w = \frac{9.17 \times 20}{40} = 4.59$ rpm, speed of workers. Ans.

When you know the speed, you can use a formula you have already learned to determine the surface velocity.

EXAMPLE 3. The workers of a card have a diameter of $7\frac{3}{4}$ in. and are covered with card clothing $\frac{3}{8}$ in. high. They make 4.59 rpm. What is the surface velocity of the workers, in inches per minute?

SOLUTION. $V_{ipm} = 4.59 \times 8.5 \times 3.14 = 122.5$ ipm, surface velocity of workers. Ans.

Note how very slow the surface of the worker moves. The clothing on it travels at 122.5 ipm, as compared with the 19,080 ipm of the cylinder. For all practical purposes, the carding action is the same as if the worker clothing were at a stand-still while the cylinder clothing passed it at tremendous speed.

Practice Problems in Card Calculations

25. We could fill another fifty pages, just calculating the speed and the surface velocity of every cylinder, roll, apron, and so forth on the gearing diagram shown in Fig. 12. Little purpose would be served by this procedure. Chances are that the card or garnett you have to work with is geared somewhat differently, and our formulas would not apply. You should be able, if you have followed the text carefully, to set up your own formulas. Try to do so for the practice problems below. Check the results you get with the answers given at the end

of the text, and try again if your first answer is wrong. If you should want to make some practice calculations for the card you work with, use a tachometer (a little instrument which measures speed) to check your calculations when the card is in operation.

1. In the gearing diagram, Fig. 12, a 12-in. pulley on the main cylinder shaft drives a $17\frac{5}{8}$ -in. pulley on the breast cylinder shaft. Suppose that the main cylinder is making 120 rpm.
 - a) What is the speed of the breast cylinder?
 - b) What is the surface velocity of the 60-in. main cylinder, in feet per minute? The cylinder is covered with clothing that is $\frac{3}{8}$ in. high.
 - c) What is the surface velocity of the 25-in. breast cylinder, in feet per minute? You can disregard the metallic clothing of the breast cylinder in this calculation.
2. In the gearing diagram, Fig. 12, a $17\frac{5}{8}$ -in. pulley on the breast cylinder shaft drives a 12-in. pulley on the drive shaft of the automatic feed. What is the speed of this drive shaft if the main cylinder of the card makes 90 rpm?
3. In the gearing diagram, Fig. 12, the same belt that drives the strippers from the 46-in. pulley on the main cylinder shaft also drives a $5\frac{3}{4}$ -in. pulley on the fancy. The cylinder makes 100 rpm.
 - a) What is the speed of the fancy?
 - b) What is the surface velocity of the 12-in. fancy, in feet per minute? The 12-in. diameter includes the clothing; that is, the fancy is a $9\frac{1}{2}$ -in. roll with $1\frac{1}{4}$ -in. clothing.

Poppets for Setting

26. As you can see in Figs. 6 and 11, the rolls of the card are held in bearings. These bearings, because they resemble the dolls in a puppet show, are called poppets. (The word *poppets* is an old form of *puppets*.) The shank that holds the bearing forms the body of the poppet, while the bearing itself forms the poppethead. The purpose of this arrangement is to permit the bearings to be moved up and down, and in some cases, sidewise too.

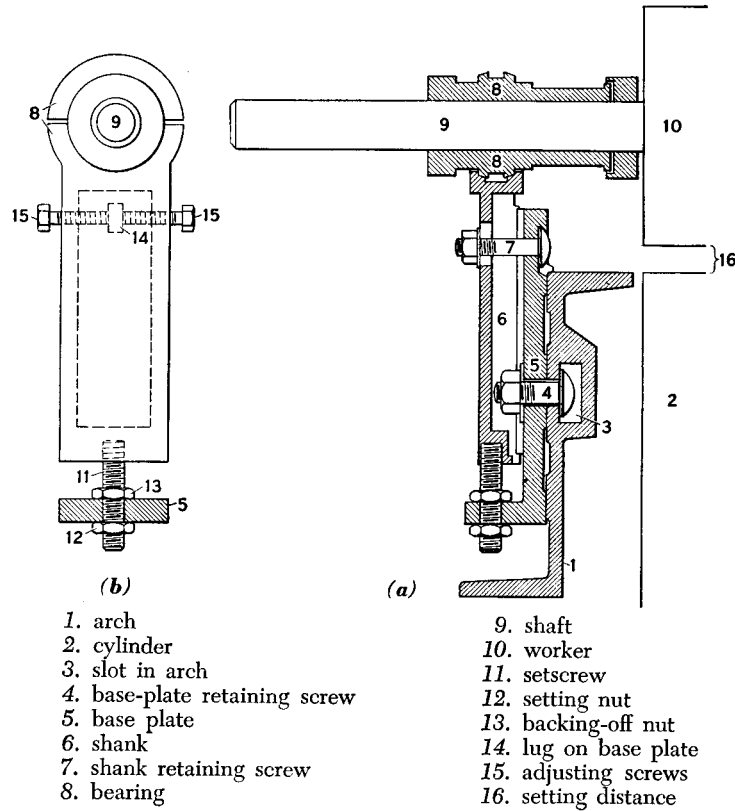


FIG. 13. POPPETS FOR CARD ROLLS

There are several poppet arrangements, differing only in details. The section in Fig. 13(a), which shows the arrangement of the worker poppet on a Davis & Furber card, will serve as a good example. As you have seen, a closely-fitting arch covers the cylinder. In a slot in the arch is a retaining screw that holds the base plate for the poppet. When you loosen this base-plate retaining screw, you can move the base plate sidewise to any position on the card where it is wanted.

The shank, or body, of the poppet rests on the base plate and is held in place by a retaining screw. Since the head of

the poppet holds the bearing in which the worker shaft rests, any movement of the shank will move the worker. A setscrew is let into the bottom of the shank. The setscrew is held to the base plate by two nuts. These are called the setting nut and the backing-off nut. They provide the only adjustment normally made on a worker.

A stripper poppet must also be movable sidewise so the stripper can be set to the worker, as well as to the cylinder. In sketch (*b*) of Fig. 13 a section of a stripper poppet is shown. The body of all poppets is hollow, to make room for the nut of the base-plate retaining screw. In a stripper poppet, a lug protrudes from the base plate into this hollow space. Adjusting screws work against the lug. You can move the poppet, and hence the roll, sidewise by means of these screws.

Setting Procedure

27. When the card is running, the surfaces of the cylinder and the rolls pass each other at great speed. If the setting distance between them is too loose, no carding action will take place. If the setting is too tight and the surfaces touch each other, severe damage will result. Consequently, the settings must be made carefully, and they must not change while the card is running.

Before you can set the worker with a poppet such as the one shown in Fig. 13(*a*), you must slightly loosen the nut on the shank retaining screw 7. Then, if you want to make the setting wider, loosen the setting nut 12 and tighten the backing-off nut 13. If you want a closer setting, loosen the backing-off nut and tighten the setting nut. After grinding, a closer setting is usually wanted, because the height of the wire is reduced a little.

Once the setting is made, check it with the card gage. The card gage is simply a strip of steel, usually about 1 in. wide and 8 in. long. It has a number stamped on it which indicates its thickness, the number being the same as that of card-

clothing wire of a diameter equal to the thickness of the gage. For example, the thickness of a No. 30 gage is the same as the diameter of No. 30 wire. Remember that the higher the number, the thinner the gage will be. If the gage is bent out of shape in any way, it is useless as a measuring instrument. Do not use such a gage!

28. Insert the correct gage between the cylinder and the worker and make the setting. Then go to the other side of the card and make the setting there. Set the worker good and tight against the gage. Check the distance all the way across the card. Then tighten the backing-off nut 13 as tightly as you can. This will open the setting a little and prevent the nuts from coming loose during carding. Check the settings once more, turning the worker as you test. If the settings are all right, tighten the shank retaining screw.

The exact arrangement of poppets or setscrews may vary, but the procedure is always the same: 1) Make the setting close with the setting nut. 2) Tighten the backing-off nut to relieve the closeness of the setting and to hold the setting.

In setting the stripper, first set it to the cylinder, proceeding just as in setting the worker to the cylinder. Then use the adjusting screws 15 to set the stripper to the worker.

When the card is set, turn it over by hand, to make sure that there are no wire surfaces that touch each other (except those of the fancy and the cylinder, of course). Do not run the card until you are satisfied that all settings are right and all nuts are tight.

Because there are so many different types of stock, it is impossible to say which gage number to use on a particular card. Generally speaking, a No. 28 gage is used on the breaker and a No. 30 gage on the finisher. On each card, the workers near the beginning of the card are set loosely to the gage, the workers on top are set medium-tight, and the workers near the end are set tight. In other words, the workers

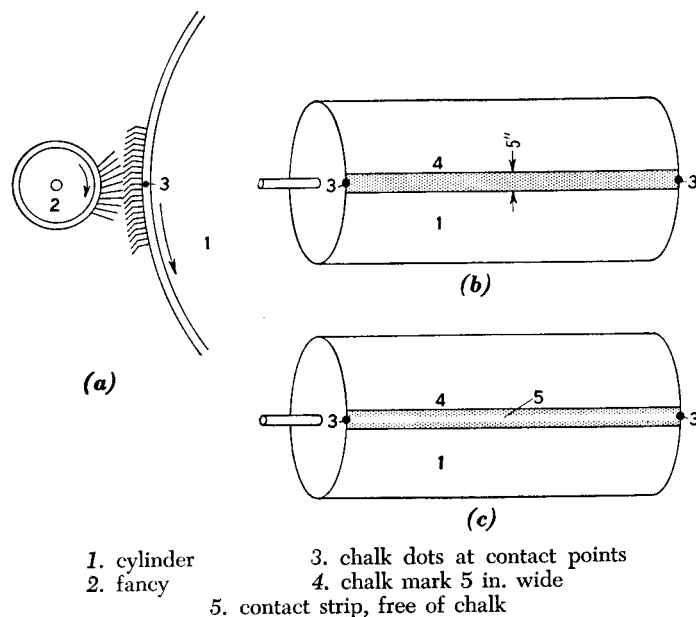


FIG. 14. CHECK FOR FANCY SETTING

are set to provide a progressively more intensive carding action. The strippers, which have no carding action, are set evenly throughout each card.

Setting the Fancy

29. You can expect more trouble with the fancy than with any other part of a woolen card. Therefore, we'll go into great detail with this roll. The fancy is the only roll of the card that is set with the belt off. As you'll see, you must revolve the fancy by hand in order to determine the depth of the setting.

Let's look at the method used by most carders to set the fancy. First, set the fancy to the cylinder with a No. 32 card gage. Then mesh the fancy wire into the cylinder wire by making several turns of the setting nuts on each fancy bracket. Next, mark the cylinder edge with chalk dots at the point of

contact on each edge, as shown in Fig. 14(a). Open the poppet bearings and remove the fancy from the card.

After you have removed the fancy, draw the chalk straight across the cylinder, connecting the contact-point dots on each side. Make a mark approximately 5 in. in width, as shown in sketch (b). When you have made the chalk mark, put the fancy back in position. Rotate it swiftly by hand in its normal direction for a few seconds. The chalk on the cylinder will be brushed off by the fancy wire at the points of contact, as shown in sketch (c).

30. You now have a chalk mark across the cylinder, with a blank contact band running across it. You can easily measure the width of the blank strip with a flexible steel ruler or with calipers. Make sure that the width of the blank strip is equal all the way across the card; otherwise you must equalize the settings on both sides before you go further.

Because of the endless variety of stocks used, no general rule can be given for determining the proper width of the contact strip. However, as a base for tests, you might try a contact mark $\frac{3}{4}$ in. wide for coarse stock, $1\frac{1}{4}$ in. wide for medium stock, and $1\frac{3}{4}$ in. for very fine stock. The finer the stock, the more deeply must the fancy penetrate the cylinder wire. The contact-mark widths just given correspond to penetrations of approximately 0.012, 0.034, and 0.068 in. respectively.

You can prove the relationship between the width of the contact strip and the depth of penetration by applying a formula.

$$\text{FORMULA: } P = R_c - \sqrt{R_c^2 - \frac{C^2}{4}} + R_f - \sqrt{R_f^2 - \frac{C^2}{4}}$$

in which P = penetration depth of fancy wire into cylinder wire, in inches;

R_c = radius of cylinder, or $\frac{1}{2}$ cylinder diameter, in inches;

R_f = radius of fancy, or $\frac{1}{2}$ fancy diameter, in inches;

C = width of contact strip, in inches.

If you can't understand this formula, don't grow any gray hair about it. In practice, simply start with the contact widths given and see how the fancy works. When you have found a setting that works well on a certain stock, make a note of it. Then you can use the same setting again when running similar stock.

Speed of Fancy

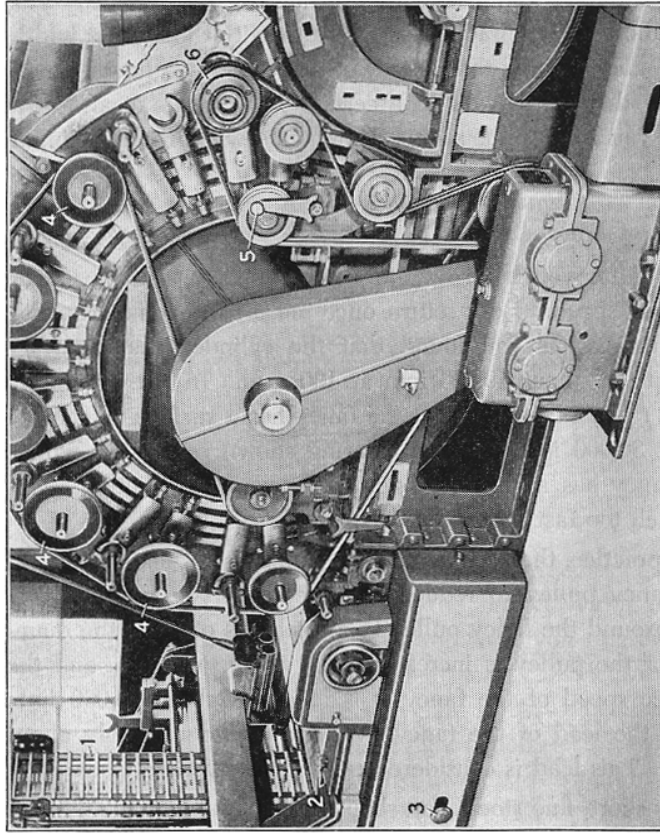
31. After you have set the fancy properly, you must consider its speed. Let's return once more to our diagram, Fig. 12. In Art. 22 you found that the cylinder has a surface velocity of about 19,000 ipm at 100 rpm. In Art. 25 (problem 3) you calculated that the fancy has a surface velocity of about 30,000 ipm with the gearing shown. In other words, the fancy has a lead of about 50% over the cylinder. This is much too fast for most purposes.

In practice, the carding overseer puts laps of leather around the fancy pulley to reduce its speed. If you wrap leather laps around the fancy pulley to a thickness of $\frac{1}{2}$ in., the diameter of the pulley is increased from $5\frac{3}{4}$ in. to $6\frac{3}{4}$ in. and the surface speed of the fancy is reduced to about 23,000 ipm. Then the lead of the fancy over the cylinder is only about 20%. This lead is considered normal for average stock.

For short, fine stock, you should remove one or two laps of the leather from the fancy pulley so that you get a lead of about 30%. If the setting is correct, this lead should keep the card from loading up. Add laps, and thereby decrease the fancy lead, when you card coarser stock. Keep notes, as you did with the settings, of the fancy speeds that you find satisfactory for different types of stock. Such records, accumulated over years, will save you much time in the future.

Layout of Finisher Section

32. Now that you have learned how to handle the breaker section, we can go on to the finisher section. Remember that



1. lattice apron
2. feed apron
3. adjusting knob
4. stripper pulleys
5. release handle
6. variable-pitch fancy pulley

FIG. 15. SECOND BREAKER, OR INTERMEDIATE CARD

in a two-card set the finisher card follows right after the intermediate feed. In a three-card set, there are two cards in the finisher section. The first of these is usually called the second breaker but is sometimes known as the intermediate card. The second card in the finisher section is the finisher card.

No matter what the exact arrangement of the finisher section is, you'll have no trouble understanding it. The construction of the finisher card cylinder, with its workers and strippers, is exactly the same as that of the breaker. It is only at the doffer that the finisher card is quite different. We'll come to this delivery end shortly; but first, let's take a brief look at a modern second breaker.

Shown in Fig. 15 is the second breaker of a Davis & Furber three-card set. (Note the upright lattice aprons of the intermediate feed in the background.) A variable-speed drive for the feed apron is encased under the apron and can be adjusted by a hand knob. The strippers and the fancy are driven by V belts which can be quickly disengaged by handles. The fancy is provided with a variable-pitch pulley, to allow for quick and accurate changes in speed.

Actually, you need hardly any specific instructions about variances in design such as these. Cards are carefully engineered to simplify the adjustments to be made by the carder. What you have learned about settings, speed ratios, and so on applies equally well to any make or model of card.

Types of Condensers

33. The condensers at the delivery end of the finisher card are very important in woolen carding. They are characteristic of woolen cards and are not found in any other carding system.

The object of the condenser is to divide the card web into narrow strips and to condense these by a rubbing action to form roving. The roving formed must have enough strength to allow it to be wound upon spools and to be pulled off the spools in spinning.

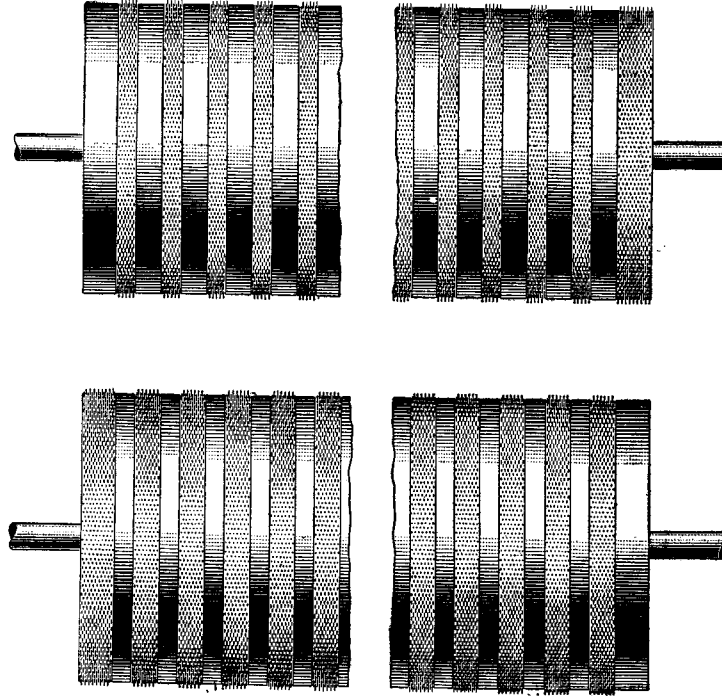


FIG. 16. RING DOFFERS

Over the years different types of condensers have been developed. Today only two types of condensers are important: 1) ring condensers and 2) tape condensers. The ring condenser is the older of these two types. It is simpler in construction than the tape condenser and is particularly suitable for heavy yarns from inexpensive stock. The tape condenser, however, is superior to the ring condenser as far as evenness of the roving is concerned. Most modern woolen cards for high-quality production are equipped with tape condensers.

Actually, the use of the terms ring condenser and tape condenser is somewhat misleading. The two systems differ only in the method used to divide the card web, not in the method used to condense the web into roving. In the ring condenser

the web from the card is divided into strips by ring doffers. A condenser then forms the strips of web into roving. In the tape condenser the web is divided into strips by a tape divider. The strips are then condensed in the same way as they are when a ring doffer is used.

Ring Doffers

34. A card equipped with a ring condenser has two doffers instead of the one doffer found on other cards. These ring doffers, shown in Fig. 16, are not entirely covered with card clothing. Each doffer is divided into strips, and alternate strips are covered with individual rings of clothing. The rings of the two doffers are offset; that is, the rings on the top doffer match the blank spaces on the bottom doffer, and vice versa. You can easily visualize how these doffers act on the cylinder. The top doffer receives strips of card web from the cylinder wherever the doffer is covered. The cylinder continues on its way looking somewhat like a zebra, covered with strips of web at the points where the blank spaces of the top doffer offered no resistance to the web. When the cylinder surface reaches the bottom doffer, the strips of web coincide with the rings on that doffer. Therefore, the bottom doffer completes the transfer of the web from the cylinder.

The rovings from the top doffer tend to be heavier than those from the bottom doffer, because the fibers in the web cling together at the separation points and are therefore unloaded on the first doffer to contact the cylinder. In order to counteract this tendency, the rings on the bottom doffer are made wider than those on the top doffer. The last ring on the right-hand side of the top doffer, and the first ring on the left-hand side of the bottom doffer, are called waste-end rings. They carry the irregular fringes of the card web. These waste strips are returned, usually by means of suction tubes, to the automatic feed and are carded over again.

The width of the rings on the ring doffers varies according

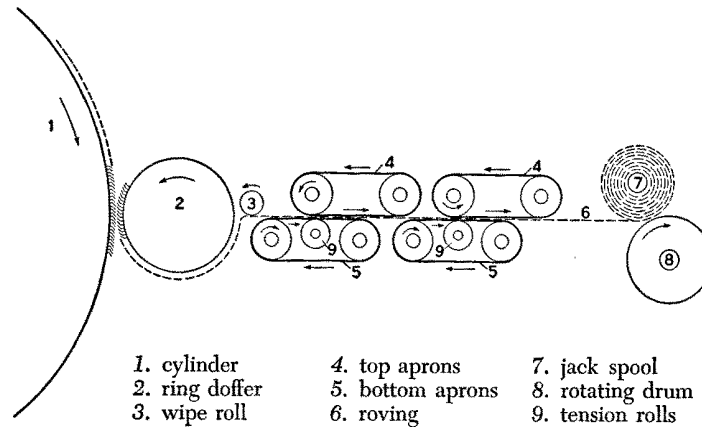


FIG. 17. CONDENSER ACTION

to the width of the card and the number of rovings taken from the card. The usual number of rovings for a 48-in. card is 48 plus the 2 waste ends. On a 60-in. card there are usually 60 rovings plus the 2 waste ends. When a card is running on fine work, doffers with a greater number of rings may be used; sometimes as many as 80 rovings are taken from a 60-in. card.

Principles of Condensing

35. The strips of card web are carried from the cylinder by the rings of the ring doffer. The web is indicated by the dotted line in the simplified diagram, Fig. 17. Only the top ring doffer is shown in the illustration. The bottom doffer would look exactly the same in the diagram; you should have no trouble visualizing it below the one shown. A wipe roll, which is a small roller usually covered with corduroy, wipes the strips of web off the rings of the condenser. The strips can then be pulled off the wipe roll and condensed into roving.

Various devices, such as rotating tubes and series of rollers, were developed to condense the strips of web into roving. Today, rub aprons are generally used. These aprons work on

the same principle whether you use ring doffers or tape dividers. To visualize the action of the rub aprons, take some moist cotton batting or some modeling clay and hold it between the palms of your hands. Rub your hands gently back and forth. Note how the substance between your hands is formed into a thin, round roll. Exactly the same thing happens to the strips of card web between the top and the bottom aprons of the condenser.

The rub aprons move in the direction shown by the arrows. They also have a reciprocating, or traverse, motion. This is given to them by means of eccentrics located at one side of the condenser. The leather aprons, being a slight distance apart, rub the flat strips of web taken from the doffer rings into a round roving. There is no twist put into the roving. The aprons simply rub the flat strips into a round form, the bottom rub apron traversing to the right while the top apron moves to the left, and vice versa.

There is usually a slight draft between the two pairs of aprons in the condenser; that is, the aprons farthest from the doffer are driven slightly faster than the other pair. This draws out the rovings to a slight extent and makes them smoother and more even. Tension rolls inside the aprons permit you to put the roving under more or less pressure, as needed. After being condensed, the rovings are wound on a jack spool, which is driven by surface contact with a rotating drum on the spool stand.

Now that you have an idea of the principles involved, let's go into details about ring doffers and apron condensers. These are important because they largely influence the quality of the roving.

Covering Ring Doffers

36. When you studied card clothing you learned how to cover all ordinary card rolls. Covering ring doffers is a little different. The rings have a slightly smaller diameter than the

doffer, in order to fit it tightly. The first step in covering a doffer is to take it out of the card and place it on end on a suitable stand. A box with a hole in top to fit the doffer shaft will do fine for this purpose. To help in getting the rings on use a wooden cone about 6 in. long, with its lower end of the same diameter as the doffer. The cone must have a hole through its center so you can put it on the doffer shaft. Then put the rings over the cone and push them down over the doffer. To get the rings into place, use a square board 3 or 4 in. wider than the diameter of the doffer, with a round hole slightly larger than the diameter of the doffer cut in it. This can be slipped over the doffer, and with it you can push the rings into place without bruising their foundation by pounding.

After all the rings are on the doffer, take it to the grinder stand and adjust the rings with a screw driver. With the doffer revolving toward you but against the back of the teeth, press the screw driver against the side of the foundation of the ring, which can thus be slid in any desired direction.

To put the rings in their proper places, you need a gage. You can make one from a stick that is as long as the doffer is wide. The usual length is 60 in. On a stick of this length, first mark off $1\frac{1}{2}$ in. on each side for the waste rings. That leaves you with $60-3=57$ in. for the 60 ends to be taken off, or $57\div 60=0.95$ in. for each ring. Now, remember that you want the rings on the top doffer narrower than on the bottom doffer. You may make the gage for the top doffer with 0.9-in. rings and 1-in. spaces and the gage for the bottom doffer with 1-in. rings and 0.9-in. spaces. Of course, you can use the same gage for both doffers, simply by turning the stick end for end. Fasten the gage stick to the grinder stand and adjust the rings with a screw driver as explained. With 48-in. cards, you can use $\frac{7}{8}$ -in. rings for the top doffer and 1-in. rings for the bottom one.

In order to hold the rings in place, put strips of leather or clothing foundation in the spaces between the rings. Tack

the ends of the strips together so they'll stay in place. Another method is to fill the empty spaces by winding them full of layers of cotton twine and saturating these with glue. Once the rings are set in place, grind them carefully and the doffer is ready. Put the doffer in its stand and set it to the cylinder with a No. 28 gage.

Now, having studied the ring doffer in some detail, let's take a close look at the condenser.

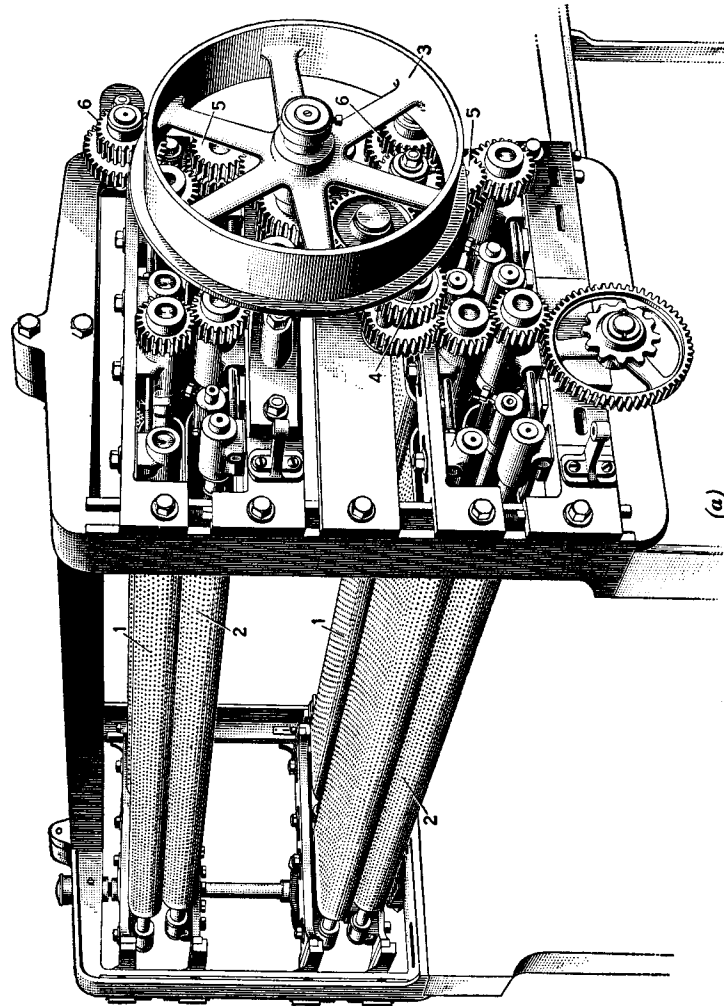
Apron Condenser

37. The gear end of a characteristic two-bank double-apron condenser is shown in Fig. 18(*a*). This is the side with the gears that give the aprons their forward motion. View (*b*) of the same condenser shows the eccentric end, with the eccentrics, or cams, that give the aprons their reciprocating motion. The condenser shown was built about fifty years ago. Modern versions have a few refinements in the drive but are otherwise the same.

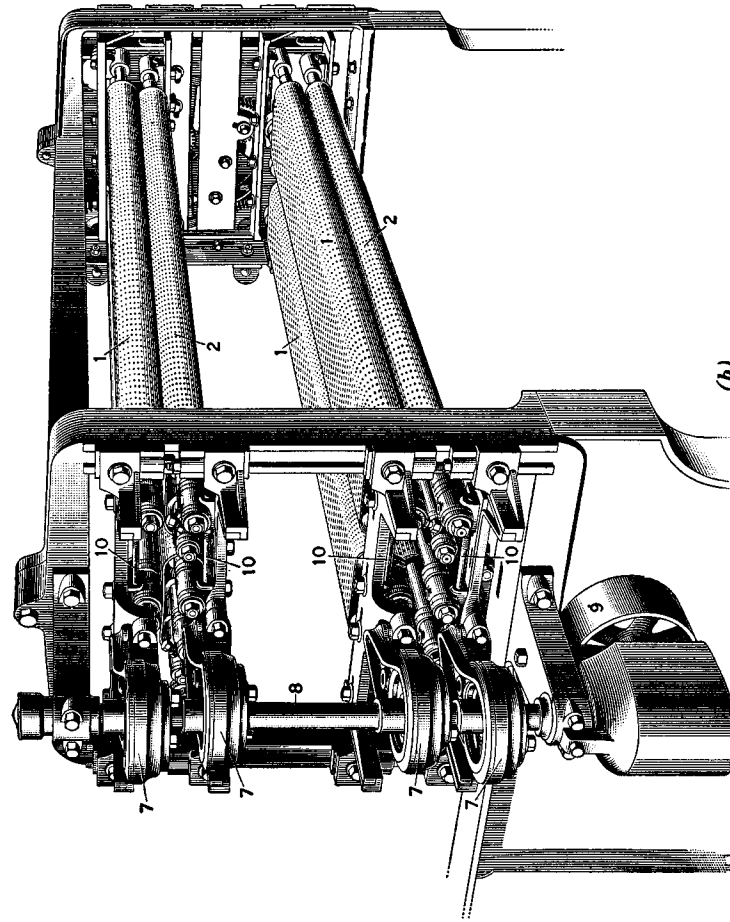
The condenser has a total of 8 aprons: 2 upper aprons and 2 lower aprons in each of the 2 banks. The aprons are of leather or another suitable material. They are honeycombed with perforations, or covered with grooves arranged in a stripe or diamond pattern, to give them a better grip on the fibers.

The condenser is designed to rest against the end of the finisher-card frame, next to the wipe rolls which take the ribbons of card web from the ring doffers.

Two belts are required for driving the condenser. One of them drives the gears that impart the forward motion to the rub aprons and wipe rolls, while the other drives the eccentrics on the opposite end of the machine. The first belt connects a pulley on the cylinder shaft of the finisher with the gear-drive pulley shown in view (*a*) of Fig. 18. The ends of the rub-apron shafts are cross-shaped in section. The driving gears have cross-shaped holes to fit the shafts. Thus, the shafts are driven by the gears and yet are allowed to move



(a)
FIG. 18. TWO-BANK DOUBLE-APRON CONDENSER



(b)

FIG. 18—Continued

1. top apron
2. bottom apron
3. gear-drive pulley
4. draft change gear
5. wipe-roll change gears
6. doffer change gears
7. eccentrics
8. vertical shaft
9. eccentric-drive pulley
10. adjusting screws

sidewise with the traversing motion imparted by the eccentrics located on the other side of the condenser.

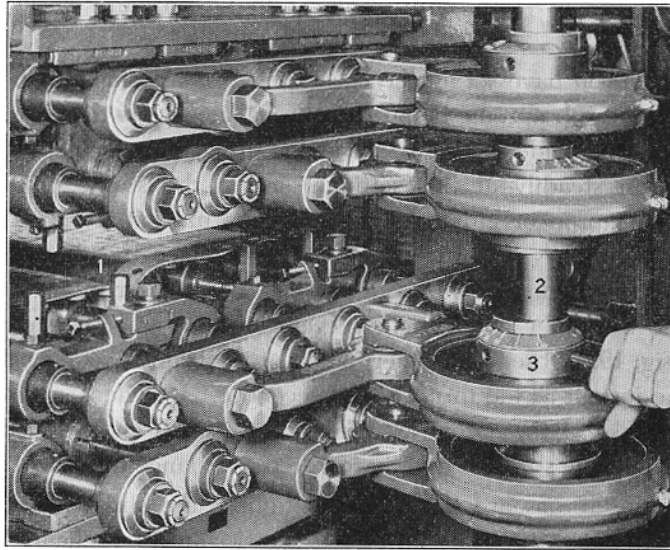
The driving gears on the apron shafts are recessed in order to retain the oil and to keep the machine clean. There are two draft change gears on the aprons nearest the doffers; the one on the lower bank is shown, while the one on the top bank is hidden behind the drive pulley. These gears have 1 to 4 teeth more than the gears on the aprons farther from the doffers and are thus driven slower. This causes a slight draft between the two pairs of aprons on each bank. With low stock, use no more than a 1-tooth or 2-tooth draft between the aprons, or the roving may be strained and twits will result. Fine stock will stand a 3-tooth draft, because it is more elastic and the fibers are generally longer.

38. The adjustments for taking up the slack of the rub aprons when they stretch are placed on the bearings of the binder rolls, or back rolls, of the aprons. Only the front roll of each apron is driven by gears and the apron itself drives the binder roll at the rear. The adjusting screws shown in Fig. 18 move only the binding rolls; so you can tighten the aprons without disturbing the drive gearing.

The wipe rolls and the doffers are both driven from the condenser. The wipe rolls have change gears that are made of the same diameter, but with a difference of one or two teeth. You can change the speed of the wipe rolls to remove different kinds of stock from the ring doffers without disturbing the setting between the wipe rolls and the doffers.

The two doffers are driven from the shafts of the front top aprons of the two banks of rub aprons. Change gears permit adjustment of the doffer speed.

39. The eccentric end of the double-apron condenser, Fig. 18(*b*), shows the method of imparting the traverse motion to the aprons. The eccentrics are fastened to a vertical shaft



1. apron 2. upright shaft 3. eccentric hub

FIG. 19. ECCENTRIC-HUB ATTACHMENT

that is driven from the cylinder shaft of the finisher card through a pulley on a short shaft and a pair of bevel gears. (The bevel gears are protected by a guard and so cannot be seen in the illustration.) On the model shown, the eccentric shaft is driven from the opposite side of the machine from the gear end, but on other models the shaft is continued under the rub aprons and the pulley is placed on the other side, so that both driving belts of the condenser are on one side of the machine. With either arrangement the eccentrics work in much the same manner.

Now turn to Fig. 19, which shows the eccentric side of a modern Davis & Furber condenser. This will show you how to adjust the stroke of the eccentrics. On the top side of each eccentric is a pin working past a dial. When the pin is opposite the outside mark, the stroke is about $\frac{1}{8}$ in. For each mark the pin is moved, the stroke becomes $\frac{1}{4}$ in. longer, in-

creasing from $\frac{11}{16}$ to $\frac{15}{16}$ in., from $\frac{15}{16}$ to $1\frac{3}{16}$ in., and so on to $1\frac{15}{16}$ in.

After you have set all the eccentrics as nearly alike as possible, the rub aprons should then be balanced. If the bottom ring is 1 in. wide, set the stroke at $1\frac{1}{16}$ in. If the machine does not run steadily at this setting, shorten the stroke on the bottom apron of either or both sections until it does. The exact setting is a matter of experiment. Place the thumb of one of your hands against the top of the condenser frame, and place the other hand on the eccentric adjustment as shown in Fig. 19. Observe whether the jar of the frame occurs at the same instant as the thrust of the eccentric. If it does, shorten the stroke of the eccentric. Only a very small change in the length of the stroke is usually required to balance the machine.

If the aprons are stretched too tightly, the stroke will be thrown off. To remedy this, the eccentrics must be rebalanced or the aprons must be relaxed. If you use care when tightening the aprons, this trouble will not occur.

40. The setting of the aprons to each other was formerly accomplished by means of adjusting screws. It was a difficult task, because the aprons must be set the same distance from each other on both sides of the machine.

The setting on the modern condenser sketched in Fig. 20 is accomplished by means of small slotted disks of sheet iron. The method of setting the machine is described in the following paragraphs.

First, drop the tension rolls until they are clear of the aprons, as shown in sketch (*a*). Draw the aprons to a proper tension by turning the side adjusting screws previously described until the aprons present a flat surface. Do not overdraw them, or you'll spoil the aprons and strain the rolls.

Now raise the tension rolls, as shown in (*b*). Test by putting your hand inside the top apron and pressing down. You should feel no sag. If you have made the adjustment prop-

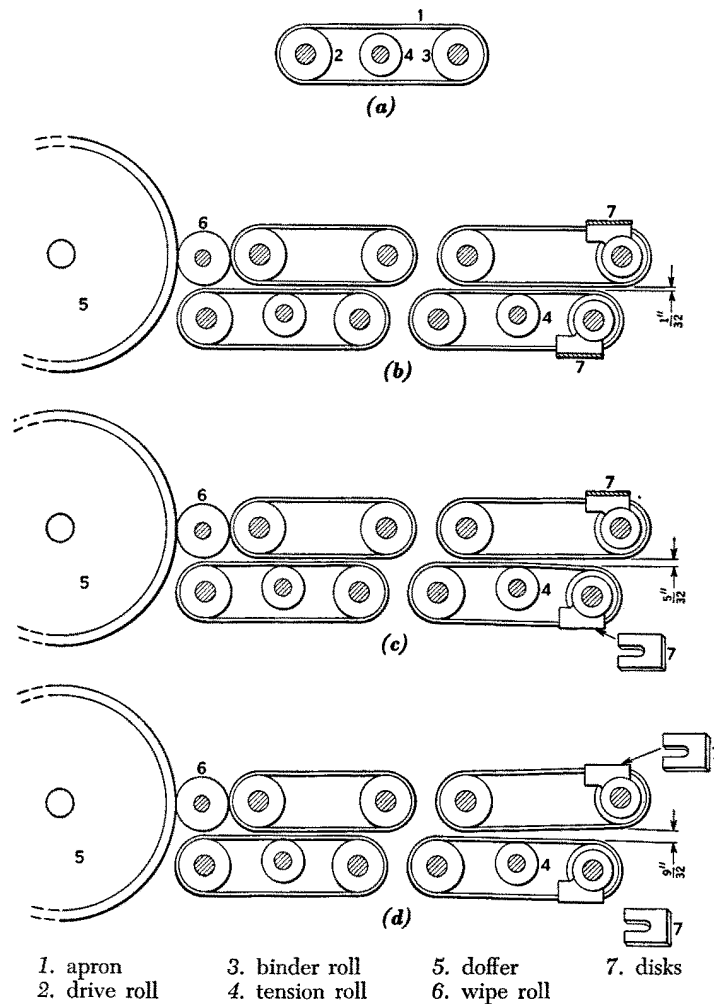


FIG. 20. SETTING THE APRONS

erly, the machine is set for the condensing of coarse numbers of wool or of very fine all-cotton stock. You can increase the degree of condensing by evenly raising the tension rolls.

To change the setting for medium work, remove the disk on the bottom roll, as shown in (c). To change the setting for

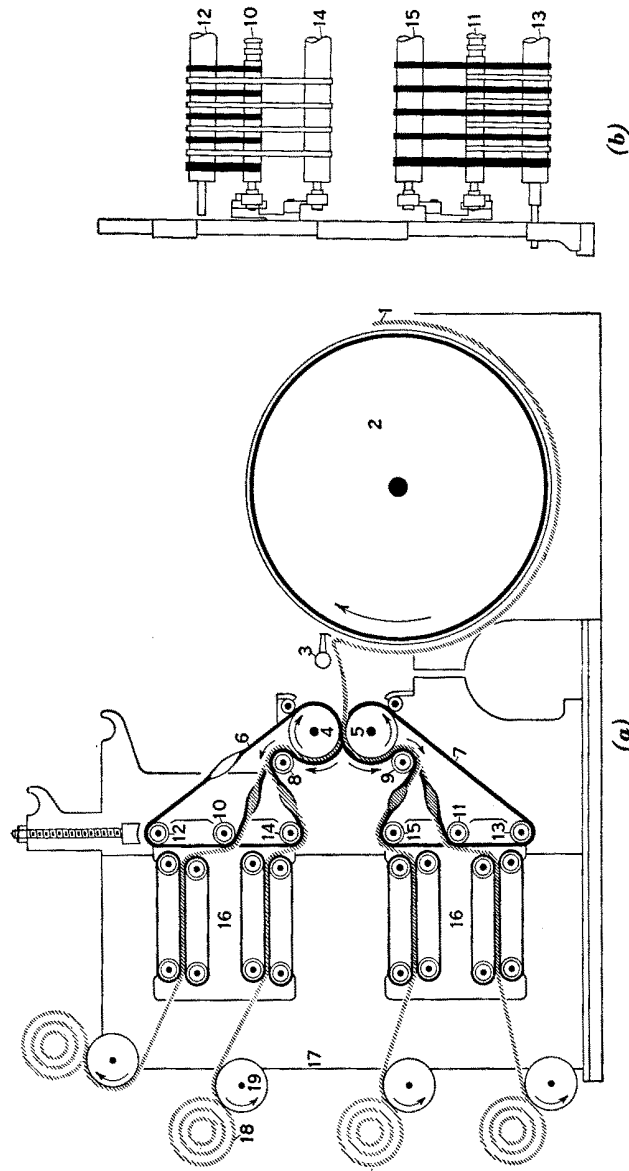


FIG. 21. DIAGRAM OF TAPE CONDENSER

LEGEND FOR FIG. 21

- | | |
|------------------------|------------------------|
| 1. card web | 10. upper grooved roll |
| 2. doffer | 11. lower grooved roll |
| 3. doffer comb | 12. upper tension roll |
| 4. upper divider roll | 13. lower tension roll |
| 5. lower divider roll | 14. upper idler roll |
| 6. tape to upper banks | 15. lower idler roll |
| 7. tape to lower banks | 16. apron condenser |
| 8. upper tape roll | 17. spool stand |
| 9. lower tape roll | 18. jack spool |
| | 19. rotating drum |

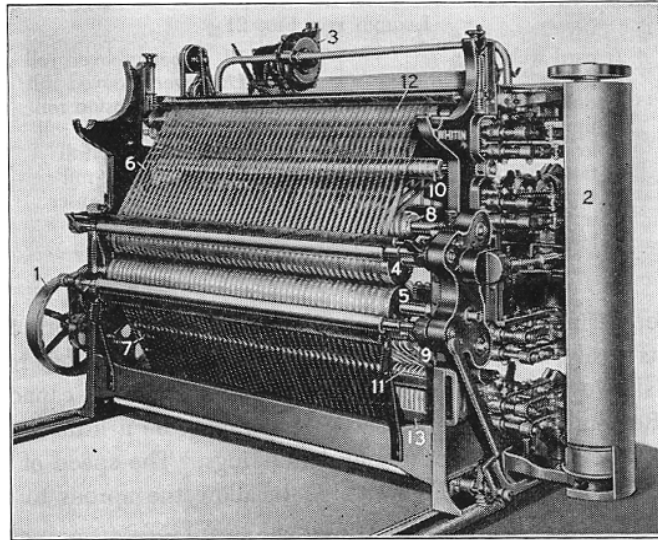
fine merinos, flannels, cashmeres, or any kind of work that felts easily, take out the disks on both top and bottom rolls, as shown in (*d*). This will reduce the condensing capacity.

Remember that the eccentric stroke must be a little longer than the width of the bottom doffer rings. The speed of the eccentric should be high enough to allow the aprons to roll the web into round, compact roving.

Tape Condenser

41. If you don't work on a woolen card equipped with a tape condenser, this attachment may not be easy to understand. However, if you follow the text closely, you'll get a good idea of how it works. The operation of the tape attachment is based on the fact that a web of fibers tends to cling to a leather surface—just as lint tends to cling to your blue serge suit. Now, suppose you mark off the surfaces of a pair of rollers in strips and cover alternate strips with leather tapes, say $\frac{1}{2}$ in. wide. Then you lead the card web between the rollers and have the tapes take off in different directions. The web will cling to the tapes, divide into strips as wide as the tapes, and generally follow the tapes around as closely as the little lamb followed Mary, in the nursery rhyme.

In Fig. 21 are diagrams of a four-bank, single-apron Davis & Furber tape condenser. In Fig. 22 is the photograph of a similar Whitin tape condenser. Compare the equivalent parts on both illustrations; this will give you a clearer picture of the



- | | |
|---|-------------------------|
| 1. drive pulley | 7. tapes to lower banks |
| 2. housing of vertical shaft
(apron drive) | 8. upper tape roll |
| 3. waste-end conveyer | 9. lower tape roll |
| 4. upper divider roll | 10. upper grooved roll |
| 5. lower divider roll | 11. lower grooved roll |
| 6. tapes to upper banks | 12. upper tension roll |
| | 13. lower tension roll |

FIG. 22. TAPE CONDENSER

construction of a condenser. The card web is taken from the finisher by a single large doffer just like the doffer on the breaker. As shown in sketch (a), Fig. 21, the web is combed from the doffer by the doffer comb and drawn between two large divider rolls. These rolls are covered with tapes, and the web is split into ribbons which are as wide as the tapes. Alternate tapes across the face of the divider rolls are in separate groups: one group runs upward and the other group runs downward.

Let's first follow the tapes that run upward. These all pass around the tape roll 8. Alternate tapes of this group lead directly from the tape roll 8 to the grooved roll 10. These

deliver their ribbons of stock to the top bank of rub aprons. The other tapes first pass around the idler roll *14* and deliver their ribbons of stock to the second bank of rub aprons before moving over the grooved roll *10*. All tapes in the upper group then continue over the tension roll *12* and back to the divider roll *4*.

42. The rear view, Fig. 21(*b*), will help you to understand the arrangement of tapes shown in view (*a*). Beginning at the left, the first ribbon of card web will be delivered to the top bank by the tape shown in black, connecting rolls *12* and *10*. The second ribbon will be delivered to the third bank from the top by the tape shown in black, connecting rolls *15* and *13*. The third ribbon will be delivered to the second bank from the top by the tape shown in white, connecting rolls *12* and *14*. The fourth ribbon will be delivered to the bottom bank by the tape shown in white, connecting rolls *11* and *13*. The tapes follow in this order across the width of the condenser.

Note, in sketch (*b*), that the spacing of the grooves in grooved roll *11* is the same as in grooved roll *10*, but that the grooves in roll *11* correspond to the shoulders in roll *10*, and vice versa. This arrangement makes it possible to have the tapes pick up the whole card web, from one side of the card to the other.

The tapes are endless. A complete cycle of travel for one tape is upward over the top series of rolls and downward over the bottom series of rolls. In a complete cycle, each tape carries two ribbons of stock for two roving ends, one on its travel upward and the other on its travel downward. You'll understand this better when you learn how the tapes are put on.

43. Once you understand the dividing action of the tape condenser shown in Fig. 21, you are over the worst. The rub

aprons work in exactly the same way as those you have already studied in connection with the ring condenser. You may have noticed that the condenser illustrated has only one pair of aprons in each bank. This is unusual; double-apron condensers are much more common. The spool stand, also, requires no further explanation.

You can, with a tape condenser, take different numbers of roving ends off a card. All that is needed is to use different numbers and widths of tapes. On a 60-in. card, 96 ends are usually taken off for ordinary woolen yarns up to 3-run yarns. For fine work, say 3-run to 6-run yarns, 120 ends are taken off. The number of roving ends from 72-in. cards is 120 for ordinary yarns and 160 for fine work; and the number from 84-in. cards is 160 for ordinary yarns and 192 for fine work. If you compare these figures with those for ring doffers, you can readily see why tape condensers are installed with most modern woolen cards.

Arranging the Tapes

44. From time to time it becomes necessary to replace tapes on the tape condenser. It is a simple matter to separate the tape frame from the apron condenser; you can do this simply by removing the bolts that hold them together. Then you can take the rolls out. But when you remove the rolls, be sure to mark them so you don't get them mixed up.

The following instructions, and the illustrations in Fig. 23, were adapted from Davis & Furber material, but they apply to other modern tape condensers as well. The numbers of the rolls are the same as those used in Fig. 21; so you can refer back and forth if you are not sure about the location of a roll. At each step, *a* to *p*, refer to the diagram in Fig. 23 marked with the same letter. Now, let's suppose you have taken the rolls out and are ready to put in the new set of tapes.

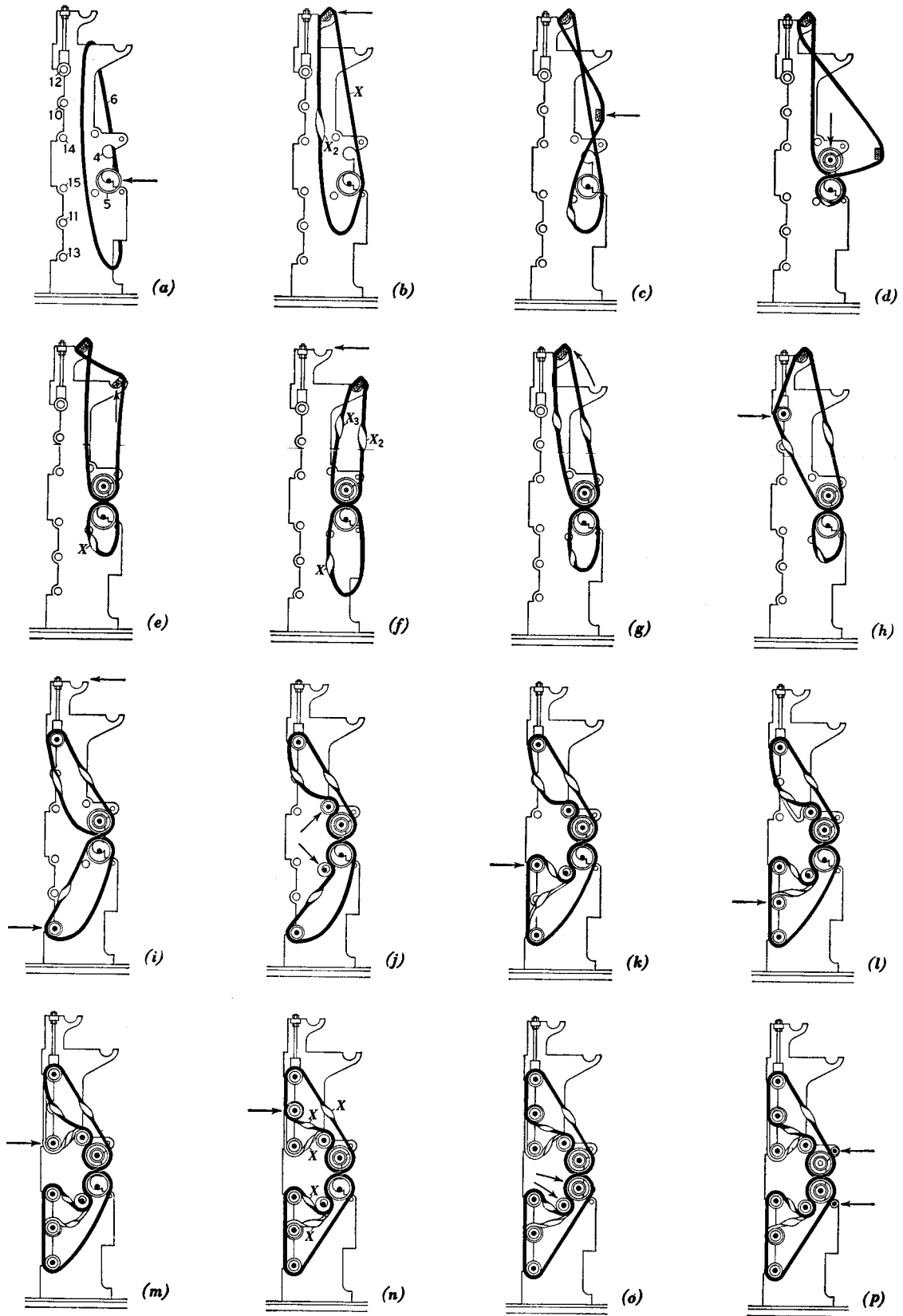


FIG. 23. PLACING THE TAPES

- a) With your back turned to the doffer, hang the new set of tapes over the right-hand tape frame. Lift the bottom divider roll 5 into the frame, leading it through the tapes. Do not replace the bushings of the divider roll.
- b) Push a wooden bar through the tapes and place it across the machine in the upper frame arm, as shown by the arrow. Distribute the tapes over the width of the machine, putting one of the wide, waste-end tapes on each side. Then, still facing the tapes, hold the first tape on the extreme right with your right hand at the point marked X. Find the same tape behind the dividing roll and grasp it with your left hand at the point marked X_2 .
- c) Bring the tape in your left hand forward, so that the tape is crossed. Have a helper insert a second wooden bar at the point indicated in the illustration by an arrow. Continue from right to left until second bar is inserted in all tapes.
- d) Get the top divider roll 4 ready. Let your helper pull the tapes as far forward as he can, and lift the top divider roll through the tapes into the frame, as shown by the arrow. Replace the bushings and bearings of the roll.
- e) Rest the second wooden bar in the lower frame arm, as shown by the arrow. Straighten out the tapes. Bring the original twist behind the bottom divider roll at the point marked X. Each tape has a half twist, or turn, to insure smooth wearing on both sides and constant cleaning from grease and lint, the cleaning being done automatically by the rub aprons.
- f) As shown by the arrow, pull the first wooden bar completely out of the tapes. Let the tapes drop onto the second wooden bar. A new full twist of the tapes results from this move. Bring half of this new twist to the front of the wooden bar at the point marked X_2 and the other half to the back of the bar at the point marked X_3 .
- g) Raise the bar into the upper frame arm, as shown by the arrow, without disturbing the twist of the tapes.
- h) Insert the upper tension roll 12 as indicated by the arrow.
- i) Remove the wooden bar, as indicated by the top arrow in the illustration. Then insert the lower tension roll 13, as indicated by the lower arrow in the illustration. Be sure to keep the twists of the tape in the places indicated.

- j)* Place the upper tape roll 8 and the lower tape roll 9 into the frame, as indicated by the arrows. Don't replace bushings and bearings.
- k)* Go between the tape frame and the apron frame and face the apron frame. Starting with the waste-end tape at the left, pull every other tape down and insert the lower idler roll 15, as shown by the arrow. Note that the first tape is shown in black, and the second tape (as much of it as is visible) in white. These correspond to the black and white tapes in Fig. 21(*b*). Actually, all the tapes are alike. The odd tapes are shown black and the even tapes white only to clarify the illustrations.
- l)* Put the lower grooved roll 11 through all tapes, as shown by the arrow.
- m)* Pass the upper idler roll 14 through the loose tapes, as indicated by the arrow. These tapes, shown in white, are the ones you did not touch in step (*k*).
- n)* Insert the upper grooved roll 10 through all tapes, as shown by the arrow. Now is the time to relax and take a little break. When you feel fit again, check all tapes. Each tape should have a twist in the three places indicated by X's and nowhere else. If all the tapes are in place, your job is almost done.
- o)* Replace the bearings of the lower divider roll 5 and of the lower tape roll 9, as indicated by the arrows. Now set the upper and lower dividing rolls to each other. A loose fit with a No. 24 card gage will be about right.
- p)* Replace the small compression rolls, as indicated by the arrows. This finishes the job, and you can put the tape condenser back into place.

Production of Woolen Cards

45. Now that you have become acquainted with the woolen card from one end to the other, it is time to look at the result of all the bother: the production. Of course, there are so many types of woolen cards, and so many different kinds of stock, that we can only give you a very general idea of card production. For instance, a 48-in. card set making high-quality fine roving may produce as little as 25 lb per hr. On the other hand, an 84-in. card set making coarse roving from

strong stock may produce as much as 150 lb per hr. As you see, the production varies greatly. Nevertheless, it is very important for the overseer of carding to be able to make reasonably accurate estimates of the production. After all, the card production must be considered with the spinning capacity of the mill.

Yarn and Roving Numbering

46. To find the production you must know, first of all, the size of the roving to be produced. The roving that comes off the card is taken to the spinning frame or the woolen mule and spun into yarn. The yarn number is commonly given in woolen runs. The standard is 1 run of 1,600 yd per lb. There are, for instance, 1,600 yd in 1 lb of 1-run yarn; 2,400 yd in 1 lb of 1½-run yarn; 4,800 yd in 1 lb of 3-run yarn, and so on. We'll confine our study here to runs. Perhaps you work with woolen cuts, cotton hanks, asbestos cuts, or another yarn numbering system. In that case you can, later on, study or review the text *Yarn Calculations*. You'll then be able to convert the formulas to other systems without trouble.

There are a few weights and measures, besides those of the woolen run, you must keep in mind. Remember that 36 in. equals 1 yd and that 7,000 grains equals 1 lb. The weight of the roving is often given in grains per 50-yd reeling. With the rule and formula given below, you can convert grain weights to yarn numbers.

RULE: Multiply the number of yards weighed by 7,000. Divide the result by the standard number multiplied by the weight in grains.

FORMULA:
$$N = \frac{R \times 7,000}{S \times W}$$

in which N = yarn number;

R = length of reeling, in yards;

S = standard number;

W = weight of reeling, in grains.

EXAMPLE. You have reeled off 50 yd of roving and found that this reeling weighs 140 grains. What is the yarn number, in the woolen-run system?

$$\text{SOLUTION. } N = \frac{50 \times 7,000}{1,600 \times 140} = 1.56 \text{ run. Ans.}$$

Draft in Woolen Spinning

47. In estimating woolen-card production, you must also consider the draft to be applied during spinning. Because woolen yarn is fundamentally a condensed yarn rather than a drafted yarn, the draft is relatively small. While more and more woolen yarn is spun on frames, let's first visualize the draft as applied to woolen mules, since this is the easier system to understand.

During the spinning action, the mule carriage with the spindles runs away from the rolls that deliver the roving. The distance the carriage runs is usually 72 in. Now, suppose that only 36 in. of roving are let off during each run of the carriage. You'll then get yarn twice as long and twice as fine as the roving. If you have, let's say, $1\frac{1}{2}$ -run roving, you'll get 3-run yarn.

The size of roving to be made depends on the size of the yarn to be spun from it and on the draft to be used in spinning. The roving delivery may be given in inches or it may be expressed as a percentage. The formula below can be used to convert roving delivery from inches to a percentage.

$$\text{FORMULA: } D_p = \frac{D_i \times 100}{L}$$

in which D_p = roving delivery percentage;

D_i = roving delivery, in inches;

L = length of carriage run, in inches.

EXAMPLE. The delivery rolls of a mule deliver 40 in. of roving per 72-in. carriage run. What is the delivery expressed as a percentage?

$$\text{SOLUTION. } D_p = \frac{40 \times 100}{72} = 55\% \text{ (approximately). Ans.}$$

The normal delivery for good-grade roving is 50 to 55%; for medium-grade roving, 60 to 70%; and for low-grade roving, 75 to 80%.

Roving delivery for spinning on woolen ring frames may also be expressed as a percentage. To find the percentage of roving delivered, divide the surface velocity of the back roll by that of the front roll and multiply by 100.

Required Size of Roving

48. The amount of draft that can be used in spinning a certain roving is usually determined by the spinner. However, it is up to the carder to produce roving of the proper weight. To do this, he must first determine the weight of a reeling of the yarn wanted.

$$\text{FORMULA 1: } W_y = \frac{R \times 7,000}{N \times S}$$

in which W_y = weight of reeling, in grains;
 R = length of reeling, in yards;
 N = yarn number;
 S = standard number.

EXAMPLE 1. How many grains will a 50-yd reeling of $1\frac{1}{2}$ -run woolen yarn weigh?

$$\text{SOLUTION. } W_y = \frac{50 \times 7,000}{1.5 \times 1,600} = 145 \text{ grains. Ans.}$$

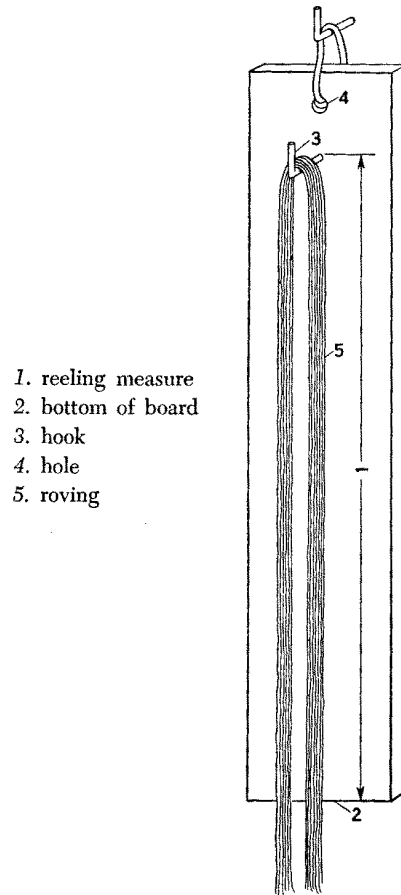
For woolen-run yarns in 50-yd reelings, you can simplify this formula by substituting the known values of R and N .

$$\text{FORMULA 2: } W_y = 219 \div N$$

in which W_y = weight of 50-yd reeling, in grains;
 N = yarn number, in woolen run.

When the carder knows the weight of a 50-yd reeling of the spun yarn, he can calculate how heavy the roving from the card should be.

$$\text{FORMULA 3: } W_r = \frac{W_y \times 100}{D_p}$$



1. reeling measure
2. bottom of board
3. hook
4. hole
5. roving

FIG. 24. REELING BOARD

in which W_r = weight of 50 yd of roving, in grains;

W_y = weight of 50 yd of yarn, in grains;

D_p = delivery percentage.

EXAMPLE 2. A card is to make roving for $1\frac{1}{2}$ -run yarn (145 grains per 50 yd). The desired delivery is 65%, or 47 in. What should be the weight of a 50-yd reeling off the card?

SOLUTION. $W_r = \frac{145 \times 100}{65} = 223$ grains. Ans.

Reeling Board

49. At this point you may wonder how a 50-yd reeling of roving is obtained. After all, there are a great number of ends on each spool, and you can't run them off on a little yarn reel as you would with yarn on bobbins. Fortunately, you can solve this problem by means of a reeling board, which is very easy to make.

The reeling board is made from a plank of wood about 8 in. wide. The length of the board depends on the reeling measure you want to use and on the number of ends on a roving spool. A reeling board like the one shown in Fig. 24 may be easily made by following a simple rule.

RULE: Multiply 36 in. by the reeling measure and divide by the number of ends on the spool. Divide your answer by 2, to allow for the doubling on the board.

FORMULA:
$$L = \frac{36 \times R}{2 \times E}$$

in which L = length of measuring board, in inches;

R = reeling measure to be used;

E = number of ends on jack spool.

EXAMPLE. It is desired to make a reeling board for measuring 50 yd of roving from a 24-end jack spool. How long should the reeling board be?

SOLUTION. $L = \frac{36 \times 50}{2 \times 24} = 37\frac{1}{2}$ in. Ans.

Take the plank of wood and measure $37\frac{1}{2}$ in. from the bottom. Put a sturdy hook at this point, as shown in Fig. 24. A few inches further up on the plank, bore a hole so you can hang the board on the wall. Cut off the rest of the plank above the hole, and your reeling board is ready for business.

To make a reeling, grasp all the 24 ends on the spool, pull off about 3 yd, and cut this strand of roving off. Take the strand near the center and hang it over the hook of your

reeling board as shown. Pull the two ends of the strands down gently—you want to straighten, but not stretch, the roving. Cut the roving off exactly flush with the bottom of the reeling board.

You now have 24 ends of roving extending from the bottom of the board up to the hook and down to the bottom again. Therefore, you have $2 \times 37\frac{1}{2} \times 24 = 1,800$ in., or 50 yd, of roving. Your reeling is ready to be weighed. You can weigh it on a grain scale, to get the weight in grains; or you can use a special balance scale, called a run scale, which gives you the run number of the roving. Then you can adjust the card, if necessary, to give you the exact roving weight needed for spinning. When the card is adjusted, you are ready to calculate the production of the card.

Production Constants

50. To calculate the production, you must know the diameter and the speed of the rotating drums on the winding frame, shown in Figs. 17 and 19. Also, you must know the weight of the roving you are producing. Finally, you must keep records to estimate the efficiency of your cards, that is, the time they are actually running. For instance, if your cards are stopped for repairs, stripping, or other maintenance operations for 6 hr in every 120-hr week, the efficiency is $(120 - 6) \div 120 = 95\%$. If you know the factors mentioned, you can use a basic rule or formula to calculate a production constant.

RULE: Multiply the diameter of the rotating drums by 3.14 by 60 (minutes per hour), by the number of ends per jack spool, by the number of jack spools on the winding stand, and by the efficiency percentage. Divide by the number of yards per reeling, by 36 (inches per yard), and by 7,000 (grains per pound).

$$\text{FORMULA: } C = \frac{D \times 3.14 \times 60 \times E \times N \times F}{R \times 36 \times 7,000}$$

in which C = production constant;

D = diameter of rotating drums, in inches;

E = number of ends per jack spool;

N = number of jack spools on winding stand;

F = efficiency percentage;

R = number of yards per reeling.

EXAMPLE 1. The winding frame on a card equipped with ring doffers holds 2 jack spools driven by rotating drums 10-in. in diameter. There are 40 ends of roving on each jack spool. You make 50-yd reelings, and the efficiency of your card room averages 94%. What is the production constant for the card?

$$\text{SOLUTION. } C = \frac{10 \times 3.14 \times 60 \times 40 \times 2 \times 0.94}{50 \times 36 \times 7,000} = 0.01124, \text{ production}$$

constant. Ans.

EXAMPLE 2. The winding frame on a card equipped with tape condensers holds 4 jack spools of 24 ends each driven by 6.5-in. rotating drums. You make 50-yd reelings. What is the production constant at 95% efficiency?

$$\text{SOLUTION. } C = \frac{6.5 \times 3.14 \times 60 \times 24 \times 4 \times 0.95}{50 \times 36 \times 7,000} = 0.00886, \text{ produc-}$$

tion constant.

Remember that you have to find the production constant all over again if you change any of the factors involved. The production constant changes, for example, when you change the number of tapes on a tape condenser or the number of rings on ring doffers.

Production Calculations

51. When you know the production constant, it is a simple matter to calculate the production of a card. You have only to multiply the constant by the two factors that are most often changed, that is, the weight of the reeling and the speed of the drums on the winding frame.

$$\text{FORMULA: } P = C \times W \times S$$

in which P = production of card, in pounds per hour;

C = production constant;

W = weight of reeling, in grains;

S = speed of revolving drums, in revolutions per minute.

EXAMPLE. The production constant of a card is 0.01124. The rotating drums on the winding frame make 32 rpm. What is the production per hour of the card if a reeling weighs 223 grains?

SOLUTION. $P = 0.01124 \times 32 \times 223 = 80.2$ lb per hr. Ans.

To change the weight of the roving, you must change the speed of the doffer. On some cards you must stop the cards and change gears to do this, but on others there are variable speed units that allow you to adjust the roving weight without stopping the card. Remember that when you change the weight of the roving, the card production will also change.

Now that we have our woolen card in production, let's turn to worsted carding. However, we'll not repeat what you have already learned; so keep it in mind. The instructions on cardroom management that will follow apply equally well to any cardroom. Even though you may be interested in only one type of carding, study the whole text in order to learn as much as you can.

Worsted and Synthetic Carding

Comparison of Cards

52. Throughout your study, you should keep in mind that worsted carding differs from woolen carding chiefly in the purpose for which the cards are used. The mechanical differences in the cards are not so important. The main difference is that the woolen cards produce roving, to be spun directly into yarn. The worsted cards produce slivers, to be combed, doubled, and drafted before spinning.

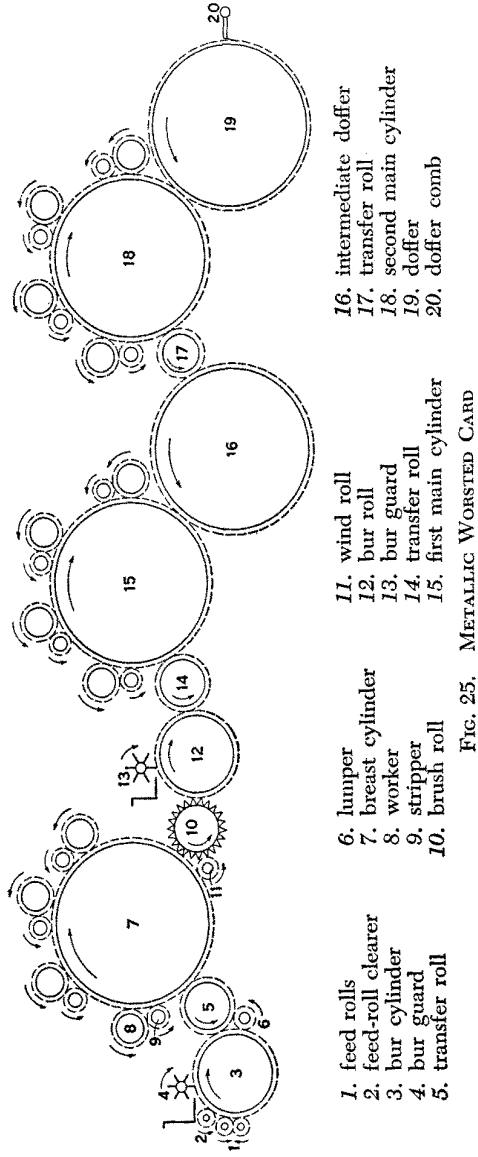
There is a vast difference in the stocks to be processed by the different types of cards. Woolen cards must handle all types of wool, from the longest and strongest wools for tweeds to the finest noils for downy fleeces. Also, woolen cards handle all types of recovered fibers—shoddy made of anything from cashmere sweaters to shredded nylon hosiery and rags. Adaptations of woolen cards are used to card cotton waste for mop yarns and blankets; asbestos for insulating materials; wool and cotton bats for comforters; wool and hair fibers for hatmaker's felts. Worsted cards, on the other hand, process nothing but worsted wool and long-staple synthetics.

The question may be in your mind, Why use worsted cards for synthetics? Haven't I just learned that synthetics can be processed on cotton cards, especially roller-top cards? You are right. However, worsted cards, being much larger, have several times the production capacity of a cotton card. Also, a two-card set specially adapted for synthetics, with a Scotch intermediate feed, does an excellent job of blending. Of course, a cotton mill that makes only an occasional run of synthetics is better off with cotton-type cards. But a mill that specializes in synthetics, especially worsted-type wool-synthetic blends, will probably find worsted-type cards a good investment.

Major Types of Worsted and Synthetic Cards

53. Like woolen cards, all worsted cards begin with an automatic feed. This may be followed by one or several lickerins or by a metallic bur-removal breast. The worsted cards may then have one to three cylinders. As a rule, one-cylinder cards are used only for rayon staple and for long, coarse wools. Two-cylinder cards, the most common type, are used for average wool, for synthetics, and for wool-synthetic blends.

Instead of the conventional two-cylinder worsted cards, three-cylinder metallic cards may be used. These cards have



- 1. feed rolls
- 2. feed-roll clearer
- 3. bur cylinder
- 4. bur guard
- 5. transfer roll
- 6. lumper
- 7. breast cylinder
- 8. worker
- 9. stripper
- 10. brush roll
- 11. wind roll
- 12. bur roll
- 13. bur guard
- 14. transfer roll
- 15. first main cylinder
- 16. intermediate doffer
- 17. transfer roll
- 18. second main cylinder
- 19. doffer
- 20. doffer comb

FIG. 25. METALLIC WORSTED CARD

somewhat smaller cylinders, which are covered with metallic clothing throughout. Metallic cards, and metallic clothing for conventional cards, are becoming more and more popular. Another alternative to the conventional worsted card is the two-cylinder card set separated by a Scotch intermediate feed. This is useful for carding blends that are to be spun on the cotton system. They not only blend the stock but also cross the fibers, thus making the resulting yarn more lofty. However, such an arrangement is not advisable when the card sliver is to be combed.

At the delivery end, worsted cards may be equipped with a balling head, to wind the sliver into balls. Sliver packaged in this way, however, presents a problem in materials handling. Consequently, many cards today have a delivery end fitted with a coiler and can. The sliver delivery is just about like that on cotton cards, except that the cans used are generally larger.

Metallic Worsted Card

54. When you studied *Carding Principles*, you saw in Fig. 16 an illustration of a conventional worsted card. Take this instruction text now and compare that illustration with Fig. 25, which shows a metallic worsted card.

Also compare Table 1 of *Carding Principles* with Table 1 of this text, noting the names, diameters, and speeds of the different rolls and cylinders. Remember that these speeds can be varied. They may work on one stock but be all wrong for another. The speeds are merely intended to give you a general idea of the relative velocity of the various card surfaces.

Note in Fig. 25, the bur cylinder and the bur roll, each equipped with a bur guard to knock burs into the bur pans. The metallic cards will not only increase efficiency, but they will also handle burry, tangled wools that could not be processed on conventional cards.

Card Drive

55. Having studied the drive of the woolen card, you should have little trouble with the drive of the worsted card. Of course, the specific drive arrangement differs from one card to another. However, once you understand the general principle, you should have little trouble understanding any card you may come across.

Just as in woolen cards, the drive goes to the main cylinder shaft, whether the card is driven from an overhead shaft or an electric motor. To give you a general idea of the drive of a worsted card, the first main cylinder of a two-cylinder card is shown in Fig. 26, as seen from one side in (*a*), and from the other side in (*b*).

On the cylinder shaft is a 7-in. pulley. As shown in sketch (*a*), this drives a 15-in. pulley on a stud to which the doffer change gear is attached. The speed at which it drives the 250-tooth doffer gear may therefore be varied. The doffer change gears may have from 20 to 30 teeth.

The strippers have 12-in. pulleys and are driven from a large pulley 36 in. in diameter. The same belt that drives the strippers also drives the fancy, by means of a 7-in. fancy pulley. The pulley below the cylinder is a tension pulley, by means of which you can adjust the tension of the belt.

The drive for the workers is shown in sketch (*b*). A sprocket on the doffer shaft drives the worker sprockets by means of a chain. The small sprockets between the doffer and the workers are guide and tension sprockets. The driving arrangements for the workers, strippers, and fancy are similar on all cylinders.

We can skip over the drives for the automatic feed, bur breast, and other rolls, because these are practically the same as for woolen cards. One item that is peculiar to worsted cards, however, is the balling head; so we had better take a look at it.

TABLE I
 CARDING AND STRIPPING ACTION
 (For Worsted Card, Fig. 25, Set for 58s Wool)

Name of Part	Diameter (Inches)	RPM
Feed rolls	$2\frac{1}{2}$	5
Feed-roll clearer	4	6
Bur cylinder	16	30
Bur guard	4	933
Transfer roll	8	122
Lumper	4	122
Breast cylinder	30	46
Breast cylinder workers	6	15
Breast cylinder strippers	4	146
Brush roll	11	220
Wind roll	3	14
Bur roll	16	215
Bur guard	4	1,200
Transfer roll	8	444
First main cylinder	30	250
Workers	7	36
Strippers	4	476
Doffer	30	16
Transfer roll	8	156
Second main cylinder	30	250
Workers	7	44
Strippers	4	476
Doffer	30	16

Balling Head

56. Various types of balling heads are in use. A common type, which gathers the card web at the center of the doffer, is shown in Fig. 27. Sketch (*a*) shows the balling head as seen from the front, sketch (*b*) as seen from the top, and sketch (*c*) as seen from the driving side.

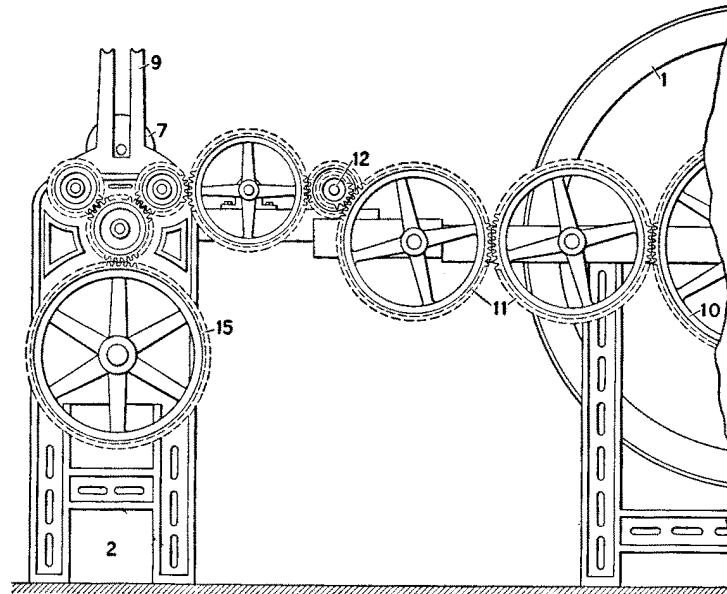
The card web is doffed from the doffer by the doffer comb. After passing through a stationary trumpet and a pair of calender rolls, the web is condensed into a sliver, which is given

a little false twist by a revolving trumpet. After leaving the revolving trumpet, the sliver is wound on the cone-shaped bobbin, which is rotated by a pair of positively-driven, cone-shaped, fluted rolls. To keep the bobbin in contact with the fluted rolls and to produce a tightly wound ball, sliding weights press on the ends of the bobbin shaft. The bobbin shaft rests between uprights, which allow it to rise as the ball builds up.

The whole balling-head mechanism is driven from the doffer by the doffer gear, which, in the installation shown, has 290 teeth. This gear, through intermediate gears, drives the change gear fixed to the shaft of the bottom calender roll. The bottom calender roll is slightly fluted and drives the top one by frictional contact. In the head shown, the diameter of the roll is $3\frac{1}{2}$ in. Remember this, because it is important for production calculations: the change gear is used to regulate the sliver tension between the doffer and the calender rolls.

The other gearing may interest you, but it does not enter into production calculations. A gear on the shaft of the bottom calender roll drives the fluted rolls through intermediate gears. The two fluted rolls revolve in the same direction.

The bobbin on which the sliver is wound is cone-shaped so the ball can readily be removed. To form a ball that can be easily unwound at the next process, the fluted rolls and the bobbin are traversed from side to side so that the sliver will be wound spirally, with each layer binding the one beneath it. The mechanism to accomplish this traversing motion can best be seen in sketch (a) of Fig. 27. A gear train, including bevel gears, drives a short vertical shaft, at the upper end of which is attached a crank plate carrying a stud near the rim. This stud fits into a part of the carriage that carries the fluted rolls and the bobbin stand. The rolls are fitted with keys that fit into grooves in the roll shafts, thus permitting a traverse



(c)

- | | |
|-------------------------|-----------------------------|
| 1. doffer | 10. doffer gear |
| 2. balling head | 11. intermediate gears |
| 3. doffer comb | 12. change gear |
| 4. stationary trumpet | 13. calender-roll shaft |
| 5. bottom calender roll | 14. gearing to fluted rolls |
| 6. revolving trumpet | 15. traverse-drive gearing |
| 7. bobbin | 16. bevel gears |
| 8. fluted rolls | 17. crank plate |
| 9. uprights | 18. Rope drive for trumpet |

FIG. 27—Continued

motion. The trumpet is driven by a rope from a pulley on one of the roll shafts.

As previously mentioned, many worsted cards are fitted with can coilers. However, you can study these in connection with cotton carding. Whether a balling head or a can coiler is used, the best place to calculate the card production is at the calender rolls that draw the sliver off the doffers. Calculating production at this point reduces the possibility of errors.

Worsted-Sliver Calculations

57. Before we can start calculating sliver weights and production, we have to face an unpleasant fact: almost every mill seems to use a different system of measuring worsted-card sliver. Let's look at a few of the systems used.

The common English system, adopted by many American mills, is to measure card sliver in drams per yard. The dram is seldom used elsewhere. It is equal to $\frac{1}{16}$ oz; that is, 1 oz = 16 dr (drams), and 1 lb = 16 oz = 256 dr.

To get away from this obsolescent measure, some carders prefer to measure the sliver in ounces per 5-yd or 10-yd length. In other words, they prefer to express sliver weights in fifths or tenths of an ounce per yard, rather than in sixteenths.

Still other carders, especially those working with synthetics or blends, use the cotton system; that is, they measure the sliver in grains per yard. As you probably know, 1 lb = 7,000 grains, and 1 oz = 437.5 grains. One dram = 27.34 grains, approximately.

Doffer Speed and Sliver Weight

58. To calculate the doffer speed, you must consider the gearing of the card you are working with. For the card shown in Fig. 26(a), you can set up a formula for calculating the doffer speed when the speed of the main cylinder and the number of teeth on the doffer change gear are known.

$$\text{FORMULA:} \quad D = \frac{M \times P_m \times C}{P_d \times G}$$

in which D = revolutions per minute of doffer;

M = revolutions per minute of main cylinder;

P_m = diameter of pulley on main cylinder (7 in.);

C = number of teeth on doffer change gear;

P_d = diameter of pulley on doffer stud (15 in.);

G = number of teeth on doffer gear (250).

EXAMPLE. What is the speed of the doffer on a card geared as in Fig. 26(a) when you use a 25-tooth doffer change gear and the main cylinder makes 100 rpm?

$$\text{SOLUTION. } D = \frac{100 \times 7 \times 25}{15 \times 250} = 4.67 \text{ rpm. Ans.}$$

59. If you should want to make radical changes in sliver weight, you would probably change the card feed. However, all ordinary changes in sliver weight are taken care of by changing the doffer change gear. The formula for calculating the number of teeth required on the gear is very simple. It applies whether the sliver weight is expressed in ounces, drams, or grains. All you need to know is the weight of the sliver the card is producing, the number of teeth on the change gear you are using, and the weight of the sliver you want.

$$\text{FORMULA: } C_w = \frac{S_p \times C_p}{S_w}$$

in which C_w = number of teeth wanted on change gear;

S_p = sliver weight presently produced;

C_p = number of teeth on change gear presently in use;

S_w = sliver weight wanted.

EXAMPLE. You want to change from 21-dr sliver to 18-dr sliver. You are using a 24-tooth change gear. What change gear do you need?

$$\text{SOLUTION. } C_w = \frac{21 \times 24}{18} = 28. \text{ A 28-tooth change gear. Ans.}$$

Production Calculations

60. If you are a stickler for accuracy, you will probably think it best to calculate the card production from the surface velocity of the calender rolls on the balling head or can coiler. Most carders, however, prefer to calculate the production from the doffer speed, disregarding the inaccuracy introduced by the slight tension draft between the doffer and the calender

rolls. You have already learned how to calculate surface velocity; so there is no need to explain again how it is done. All three of the following formulas can be used to calculate production. The formula to use depends on the way you measure the slivers.

$$\text{FORMULA 1: } P = \frac{D \times 60 \times S_d \times E}{36 \times 256}$$

in which P = production, in pounds per hour;
 D = surface velocity of doffer, in inches per minute;
 S_d = sliver weight, in drams per yard;
 E = efficiency percentage.

$$\text{FORMULA 2: } P = \frac{D \times 60 \times S_o \times E}{36 \times 16}$$

in which P , D , and E = same as in formula 1;
 S_o = sliver weight, in ounces per yd.

$$\text{FORMULA 3: } P = \frac{D \times 60 \times S_g \times E}{36 \times 7,000}$$

in which P , D , and E = same as in formula 1;
 S_g = sliver weight, in grains per yard.

EXAMPLE. You have a card running at 96% efficiency, and the surface velocity of the doffer is 600 ipm. How many lb per hr of 20-dr sliver will the card produce?

$$\text{SOLUTION. } P = \frac{600 \times 60 \times 20 \times 0.96}{36 \times 256} = 75 \text{ lb per hr. Ans.}$$

Cardroom Production

61. There are many points to watch in the management of cardrooms. Always try to attain the following results: *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 in keeping down the expense of wages and supplies; *d*) the maintenance of the machinery in good condition.

You can increase production by limiting as much as possible the time allowed for stripping, grinding, or setting the carding machines. Also, the production may be increased by speeding up the whole card or by increasing the speed of the doffer and the feed rolls. Card speed can be higher if the cards are covered than if they are not. Uncovered cards spread fly, which not only increases the amount of waste but settles on the cards and makes them more difficult to clean. Too much material should not be forced through the card by speeding up the doffer. The quality of the work in carding should not be sacrificed for the sake of production.

Production in carding depends in a large measure on the overseer. Generally speaking, the efficiency of a well-managed plant should reach 90%. In other words, if the theoretical 100% output of a set of cards is calculated at 10,000 lb in a 120-hr week, it should not drop below 9,000 lb. The cardroom overseer should use modern methods and equipment wherever he can. For instance, semiflexible and metallic clothing, which requires little maintenance, should be used wherever possible.

Cardroom Economy

62. When it comes to economy, the best cardroom overseer and the most willing help are no substitute for modern machinery. For example, a survey by Davis & Furber showed that four sets of modern 84-in. woolen cards needed the following help for three-shift operation: 3 fixers or grinders, 3 finisher tenders, 3 feed and alley tenders, and 2 strippers—a total of 11 men. To get the same production with old equipment, twelve 60-in. cards were needed, which required 32 men for their operation. Obviously, a mill with obsolete equipment cannot compete with a modern mill.

Besides labor, the major cost factor is waste. The different types of waste should be kept separate so they can be used again. Grids similar to those used in cotton carding have been used to good advantage on woolen cards to reduce waste.

Static Electricity

63. One of the major sources of trouble in woolen and worsted carding is static electricity. It is bad enough with wool, but even worse with the synthetics. An important factor in controlling static is the relative humidity, which should be about 60 to 70% at 75 to 80 degrees Fahrenheit. Fluctuations in humidity and temperature will cause trouble.

Another factor affecting the amount of static is the lubrication of the stock. Many carders believe that 2 lb of soap per 100 lb of wool should be added to the spinning emulsion. For synthetics, it is best to get the advice of the fiber producer. New antistatic agents are constantly being developed and you might as well try the latest available remedy.

One of the places at which static gives a lot of trouble is at the condenser of the woolen card. Special static eliminators should be used here. One such attachment, the Ionotron static eliminator, built by the United States Radium Corporation, is available from Davis & Furber. The eliminator consists of a bar containing a radioactive source which emits rays. These rays ionize the air and the static bleeds off. You should try using this eliminator or some other eliminator if you have static trouble.

Keep Up to Date

64. If cards are left standing idle for prolonged periods, they deteriorate. The same applies to your mind. You have now learned quite a bit, and you should keep learning. When you come to the end of your course, you might subscribe to a good textile magazine and read it. Join technical associations if you can, and learn what others are doing. No matter what your exact job is, it always pays in the long run to learn as much about it as you can. New developments occur so frequently that you'll never run out of something to learn.

*Answers to Practice Problems
in Article 25*

1. a) $\frac{120 \times 12}{17.625} = 81.7$ rpm, speed of breast cylinder. Ans.
- b) $\frac{120 \times [60 + (0.375 \times 2)] \times 3.14}{12} = 1,886$ fpm, surface velocity of cylinder. Ans.
- c) $\frac{81.7 \times 25 \times 3.14}{12} = 273$ fpm, surface velocity of breast cylinder.
Ans.
2. $\frac{90 \times 12 \times 17.625}{17.625 \times 12} = 90$ rpm, speed of drive shaft of automatic feed.
Ans.
3. a) $\frac{100 \times 46}{5.75} = 800$ rpm, speed of fancy. Ans.
- b) $\frac{800 \times 12 \times 3.14}{12} = 2,512$ fpm, surface velocity of fancy. Ans.

Carding Practices: Wool and Synthetics

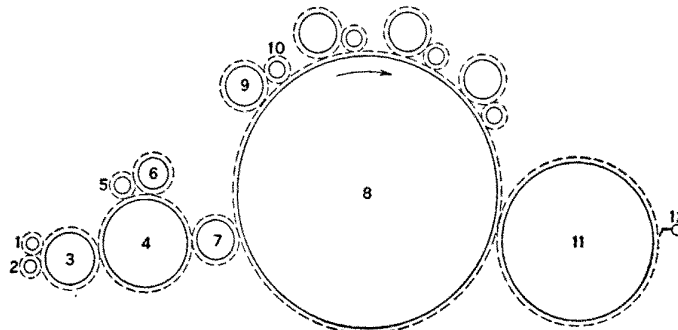
Serial 6203

Edition 1

Examination Questions

Notice to Students.—Study this instruction text thoroughly before you answer the following questions. Read each question carefully and be sure you understand it; then write the best answer you can. If the answer involves a mathematical solution, show enough of your work to indicate how you obtained your answer. We will not accept answers alone. When you complete your work, examine it closely, correct all the errors you can find, and see that every question is answered; then mail your work to us. **DO NOT HOLD IT** until another examination is ready.

1. A single-cylinder card for synthetics and mohair, similar in principle to a two-cylinder card for worsted, is shown in Examination Fig. I. The rolls and cylinders of the card are numbered from 1 to 12. Write these numbers on your answer paper, and after each number write the name of the corresponding part. For example, "8. main cylinder. Ans." (12%)



EXAMINATION I

2 CARDING PRACTICES: WOOL AND SYNTHETICS

2. Copy Examination Fig. I on your answer paper. It doesn't have to be a masterpiece of art; just make the drawing clear enough so that your instructor can see the different parts. Note the arrow on the main cylinder 8, showing the direction in which it turns. Put similar arrows on the other rolls and cylinder to indicate the direction of rotation. (10%)
3. (a) The main cylinder of the card shown in Examination Fig. I has a diameter of $50\frac{1}{4}$ in., including the clothing. What is the surface velocity, in feet per minute, of the cylinder if the cylinder makes 100 rpm? (4%)
(b) The doffer of the card has a diameter of $40\frac{1}{2}$ in., including the clothing. What is the surface velocity, in inches per minute, of the doffer if the doffer makes 7.5 rpm? (4%)
4. The doffer of the card shown in Examination Fig. I has a surface velocity of 955 ipm. What is the production of the card when, at 90% efficiency, it produces sliver that weighs 11 oz per 10 yd? (10%)
5. The surface velocity of the main cylinder of a woolen card is about 20,000 ipm. What should be the approximate surface velocity of the fancy if you are carding stock composed mostly of fine noils? (5%)
6. You have a woolen card geared as shown in Fig. 12. The cylinder makes 70 rpm. You are using a 30-tooth change gear. What is the speed of the doffer? (5%)
7. A worsted card is geared as shown in Fig. 26. You are producing 18-dr sliver with a 28-tooth change gear, and you want to change over to 20-dr sliver. What change gear do you need? (5%)

8. A woolen card has a tape condenser that delivers 40 ends of roving to each of 4 jack spools. The winding drums, making 40 rpm, have a diameter of 6.5 in. A 25-yd reeling of the roving weighs 40 grains. What is the production of the card, in pounds per hour, 92% efficiency? (10%)
9. The spinner in a woolen mill wants to spin 2-run yarn with a roving delivery of 60%. What should be the weight, in grains, of a 50-yard reeling of the roving? (10%)
10. Static electricity is a major source of trouble in carding, especially in the carding of synthetics.
 - (a) What can you do to improve the stock before carding?
 - (b) What can you do to reduce static, especially at the tape condenser? (10%)
11. You have set the workers and strippers on the first main cylinder of a two-card set to a No. 28 gage. What gage would you use on the second main cylinder? (5%)
12. You have been carding synthetic blends on a two-cylinder worsted-type card. You notice that the different fibers in the blend separate and that the yarn produced looks skinny. How could the card be changed to give you better results? (5%)
13. You want to make a reeling board to measure 50-yd reelings off jack spools holding 40 ends of roving. What should be the distance between the hook on which you hang the roving and the bottom of the reeling board? (5%)