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A SERIES OF TEXTBOOKS PREPARED FOR THE STUDENTS OF THE INTERNATIONAL CORRESPONDENCE SCHOOLS AND CONTAINING IN PERMANENT FORM THE INSTRUCTION PAPERS, EXAMINATION QUESTIONS, AND KEYS USED IN THEIR VARIOUS COURSES

WOOL
WOOL SCOURING
WOOL DRYING
BURR PICKING
CARBONIZING
WOOL MIXING
WOOL OILING
WOOLEN CARDING
WOOLEN SPINNING
WOOLEN AND WORSTED WARP PREPARATION

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WOOL

INTRODUCTION

CLASSIFICATION OF TEXTILE FIBERS

1. In order that one may be able to obtain a thorough and comprehensive knowledge of the methods and processes employed in converting any textile fiber into yarn, it is first necessary that the structure of the fiber and its peculiarities shall be thoroughly understood. Especially is this true in regard to wool, which possesses certain peculiarities not shared by any other textile fiber; nor is it sufficient for one engaged in woolen manufacture to understand the wool fiber alone, since cotton, silk, and other fibers are often used in woolen mills in connection with the fiber obtained from the fleece of the sheep.

2. Animal and Vegetable Fibers.—The various fibers used in textile manufacturing are, on account of their origin and the marked difference in their physical and chemical properties, divided into two great classes; viz., **animal** and **vegetable fibers.** To the animal class belong the wool of the sheep and the wool-like hair of certain species of goats and animals of an allied nature, as well as the furs of certain other animals that are used for manufacturing purposes. Another notable member of the animal class of fibers, and one that is second only to wool in importance among the animal fibers, is the silk fiber. The most important member of the vegetable class of textile fibers is the cotton fiber, and then follow, in about the order given, linen, hemp, jute, and china grass, or ramie, fiber, as well as many fibers of minor importance.

3. Mineral Fibers.—A third class of textile fibers is sometimes made under the head of **mineral fibers.** These include such fibers as asbestos, glass wool, etc., but as these are used only for steam packings, and boiler and pipe coverings, etc., and are such an unimportant portion of the textile industry, no further mention will be made of them.

4. Difference Between Animal and Vegetable Fibers.—As previously stated, the difference between animal and vegetable fibers is marked. Generally speaking, the vegetable fibers are smoother and more pliable than the animal fibers, especially wool, which has a rough, curly nature in comparison and a certain elasticity not possessed by any vegetable fiber.

The difference between the two great classes of fibers is even more marked chemically than physically. Vegetable fibers are composed largely of cellulose, and when burned are readily consumed—leaving a very small percentage of white ash and emitting practically no odor during combustion. Animal fibers may be said to have a nitrogenous chemical structure and are burned with some degree of difficulty, emitting during combustion a pungent odor characteristic of burnt horn or feathers, and leaving a charred, globular residue. Vegetable fibers resist the action of alkalies but are readily destroyed by acids, while animal fibers suffer no deterioration from the action of the mild acids but are quickly destroyed by alkalies. The principal animal fiber, wool, has a rough, serrated surface, is curly, or longitudinally wavy, and is disposed on the fleece in locks, technically **staples,** which are composed of a large number of individual fibers. When placed under a microscope and magnified to several hundred diameters, the appearance of various fibers is seen to vary in

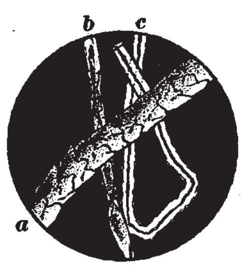


FIG. 1

a marked degree. In Fig. 1, a view is shown of a wool fiber *a*, a cotton fiber *b*, and a silk fiber *c*, as they appear when greatly magnified.

5. Hair.—Not only do animal and vegetable fibers differ in physical and chemical structures, but there is also a marked difference in physical structure between certain of the animal fibers. **Hair** has a smoother surface than wool, is straighter, and is not combined in staples, as each fiber grows individually. Between hair and wool, however, there are many gradations, and certain long hair-like fibers are disposed in staples and are commercially classed under the head of wools when, strictly speaking, they should be included among the hair products. An instance of this kind is the case of *mohair*, which, although often classed as wool, is really the long silky hair of the Angora goat. Another instance is that of the so-called *vicugna* wool, which is the product of the vicugna, an animal native to South America and belonging to the same genus as the llama.

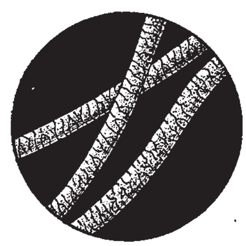


FIG. 2

It is supposed that originally, when wild, all animals were either hair-producing in their nature, or else were covered with fur, which is in reality fine, thick hair. True wool, as typically illustrated by the fleece of the sheep, is the product of breeding and cultivation, the hairy covering of the wild animal gradually becoming more like wool in its nature in direct proportion to the care bestowed on it and the degree to which it is domesticated. Sheep, if neglected and exposed to inclement weather, show a tendency to revert to their supposed former hairy covering, and the fiber becomes shorter, straighter, and coarser, until sometimes, in high latitudes, it very closely resembles hair.

In Fig. 2, a microscopical view of hair fiber is shown, from which it will be seen that the hair fiber is somewhat different in physical structure from the wool fiber shown in Fig. 1.

THE WOOL FIBER

MODE OF GROWTH

6. Wool may be said to be a term that, in its strictest sense, applies only to the fleece or covering of the sheep, but which is often extended, for purely commercial reasons, to include certain other animal fibers that are more properly included under the term *hair*. Wool is an epidermal growth of the sheep, and its character depends on the breed of the sheep, the trueness of the breeding, and the locality in which the wool is grown.

The mode of growth of a wool fiber may be seen by referring to Fig. 3, which is a section of the root of a single fiber. The root of the fiber is enclosed in the *hair follicle*, which is a minute sac formed in the skin of the sheep. The skin itself consists of four layers: an outer, or *scarf*, skin composed mostly of dried or dead cells; the *epidermis*, or true skin; a *papillary layer*, filled with minute blood vessels; and finally the *dermis*, or *corium*.

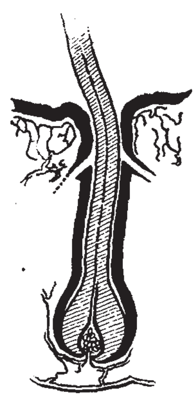


Fig. 3

The wool fiber is formed in the hair follicle and is pushed out through the skin in a somewhat plastic form, which, however, soon hardens into the true fiber. The fiber itself is formed of three distinct portions: In the center is a medullary canal like a pith, which is formed of soft, globular cells; surrounding this is a layer of elongated and somewhat spindle-shaped cells, which form the bulk of the fiber; and surrounding the whole is a layer of flattened, horny scales or cells, which in a healthy sheep have a high luster. These outer scales form a complete covering for the fiber and are fastened near the root ends, the top of each scale, or portion near the tip, being free and projecting somewhat from the body of the fiber. The scales are overlapped, so that the appearance of a typical wool fiber may be compared to an elongated fir cone. The scales form what are known as the **serrations,** or **imbrications,** of the wool fiber, and are one of the prime causes of the great felting or milling power possessed by wool, and by no other fiber to such a marked degree. It is this felting power that enables a woolen cloth composed of suitable wool to be so amalgamated that one fiber joins another fiber, producing a firm, thick fabric, the distinct individuality of the component threads of the fabric being lost.

The scales of the fiber may be readily noticed by drawing it through the fingers from point to root. If the fiber is drawn in the opposite direction, that is from root to point, it will feel perfectly smooth to the touch, since, as previously stated, the scales project from the fiber in the direction of the point. An idea of the appearance of the scales may be obtained by referring to Fig. 1, where the wool fiber shown may be said to be typical of its kind.

PROPERTIES OF WOOL

7. Felting.—On the number of serrations, together with the natural curly, or wavy, nature of the fiber, the value of any wool as a felting wool largely depends. **Felting,** which is a quality possessed in a marked degree by wool only, may be said to be the amalgamation or matting of the fibers of wool. The small teeth-like projections of one fiber catch into those of its neighbor and become locked together, this being helped by the curly nature of the fiber inclining it to twist around anything that is near. Under pressure and in the presence of some lubricant, such as soap, warm water, etc., the fibers of wool become matted together and identified with one another. This is exactly what happens when a woolen cloth is milled. The cloth is under pressure and in the presence of warm water and soap. Under these conditions, the dried-up cells that form the scales on the surface of the fiber become softened; the serrations of one fiber become interlocked with those of the next; and the threads of the fabric become amalgamated to such an extent that they can with difficulty be separated. This process of felting, or milling, is accompanied by a shrinkage and the fabric *takes up*.

In order that felting may take place, it is essential that some of the fibers lie in one direction while others point in the opposite; this object is always accomplished during the manufacture of the yarn, by the repeated mixing and blending to which the fibers are subjected. In Fig. 4, a longitudinal section of two wool fibers is shown, which illustrates the method by which the serrations of one fiber become interlocked with those of another. This illustration is, of course, out of proportion, but it will be readily noticed that the fibers must be inclined in opposite directions in order to felt. If they were both arranged side by side with roots and tips together, the serrations of one fiber would readily slide over those of the other fiber, no matter in what direction the fiber was moved.

FIG. 4

Although the serrations of the wool fiber are a prime cause of its felting power, it must be remembered that the curliness and elasticity of the fiber also influence the felting of the wool. Neither the curliness nor the elasticity, however, is the sole cause of felting, as some fibers, like mohair for instance, have a beautiful crimp, or curl, but owing to the lack of sufficient serrations on the fiber, are extremely difficult to felt.

8. The felting value of a wool is largely determined by the number of serrations per inch of the fiber and also by the freedom with which the upper edge of the scale projects from the fiber. The freer the movement of the scale and the more it sticks out from the body of the fiber, the greater is the felting power. For this reason, it has been found that wool fibers that have been treated with acids or other agents (as for instance, in the process known as **carbonization**, or **extraction**) have a greater felting power than the same fibers before being treated. The acid or other agent seems to open out the scales of the wool so that the fibers are more easily felted. For the same reason, what are known as **pulled wools** (that is, wool that is removed from the skin of dead sheep by first soaking the pelts in, or rubbing the back of the skin with, lime or acid) are often better felting wools than the same grade clipped from a live sheep; the lime or acid, instead of injuring the fiber, actually, increases its felting properties by abnormally extending the scales.

Wool rarely felts on the sheep, owing to the fact that the serrations are filled with a natural grease known as **yolk**, and also because, when on the sheep, the scales all point in one direction; that is, from the root toward the point of the fiber, the root of the fiber being fast in the skin of the sheep. Occasionally, however, in the case of a sick sheep, the wool will felt on the sheep's back in patches, which are called **cots**. These are especially apt to occur on old sheep, particularly ewes 6 or 7 years old, and are due to a scanty supply of the animal grease, or yolk, at the places where the cots occur.

Wool, except for the manufacture of hats and felts, is usually felted or milled after it is spun and woven into cloth, but may sometimes become felted accidentally unless great care is taken at other stages of its manufacture, notably in the scouring process. So remarkable are the felting or fulling properties of some wools, that it is only necessary to beat them in order to form a felted fabric. As a rule, short wools are better felting wools than those of longer staple, since they are usually richer in serrations and generally finer in fiber.

9. Serrations.—Enough has been said (in connection with the structure, mode of growth, and felting power) concerning the serrations, or imbrications, of the wool fiber, to give a knowledge of what is meant by the terms.

Nothing has been said, however, in regard to the number of serrations on the wool fiber, except that the more numerous the serrations, the more valuable is the wool for fulling purposes. The number of serrations per inch of various wools vary from a few hundred to several thousand; in a general way it may be said that the longer and coarser the wool, the fewer are the serrations. The Saxony Electoral wool, which has superb fulling qualities, contains as high as 2,800 serrations per inch, while Australian merino, which also possesses excellent felting properties, has 2,400 serrations per inch. Some of the fine full-blooded merino sheep raised in Vermont for breeding purposes only, are said to have as many as 3,000 serrations per inch. The English Southdown has about 2,000 serrations per inch, while Leicester, a wool of acknowledged inferior felting power, has only 1,800 serrations per inch. While it is true that some wools have even fewer serrations than Leicester, their value as fulling wools is very slight.

10. Softness and Fineness.—These are two very important properties that are necessary in a wool for producing the best grades of cloth. The **softness** and **fineness** of wool vary according to the breed of the sheep and to the state of cultivation to which it has been brought. As a rule, short wools are finer and softer than long wools; but this does not hold true in all cases, since some long wools are very fine and soft, while some short wools are harsh, coarse, and wiry. This, however, is not generally the case. The finer the wool fiber is in diameter, the softer is its feeling. No wool can be soft without a plentiful supply of the natural animal grease or yolk, without which it has a harsh, brashy feeling.

The finest wool is known as **lamb's wool** and is clipped when the animal is about 6 months old. The fiber of lamb's wool also gradually tapers to a point, while wool that has been previously shorn has a blunter point. The second clip, or yearling wool, made when the sheep is about 1 year old, is also somewhat finer than the subsequent, or *fleece clips*, although extremely fine-fibered wools are produced among these. There is a great difference in the softness and fineness of wool according to the portion of the fleece from which it is obtained. This subject is properly included under the head of Wool Sorting, and will be taken up later.

There is considerable difficulty in making accurate measurements of the actual diameter of the fiber, on account of its extreme fineness, and also because of the irregular shape of the section, the fibers being round in some instances and elliptical in others. Saxony Electoral wool, one of the finest and best-grown wools in the world, has been found to be about $\frac{1}{2000}$ inch in diameter, varying from this to $\frac{1}{1600}$ inch. Some of the long braid wools are as coarse as $\frac{1}{400}$ inch in diameter, while selected breeding specimens of the Vermont merino are said to run even finer than the Saxony, being known in some instances to approximate $\frac{1}{3000}$ inch, although it is doubtful if this is not an exceptional case. The Australian merino is said to average from $\frac{1}{1400}$ to $\frac{1}{1200}$ inch in diameter, while the breed of sheep known as Southdowns produce a slightly coarser fiber, being about $\frac{1}{1100}$ inch in diameter.

11. Strength and Elasticity.—Wool, in order to produce cloth of the highest grade, must possess **strength** and **elasticity**. Wool is one of the most elastic fibers known to the textile industry, and for this reason is unrivaled in the production of cloth with a *lofty feel*; that is, cloth having that full, soft, elastic *handle* so much desired by the commission house and buyer. The elasticity of wool is no doubt due in some degree to the curly, wavy nature of the fiber, as well as to its natural structure.

To illustrate the elasticity of wool, as compared with other fibers, take a handful of clean, dry, Australian merino, or other high-grade wool, in one hand and compress it into as small a space as possible; then release the pressure, and the wool will resume its original shape. Try this same experiment with a handful of cotton, and it will be seen that the cotton, after being compressed, will remain in a more or less inert lump, and will not spring back like the wool. When a wool fiber is subjected to tension instead of compression, it is found that the elastic limit, after which it will not return to its original length, is reached after the fiber has stretched from .3 to .5 per cent. of its length. A single wool fiber will support from .5 to 1.25 ounces, depending of course on the fineness of the fiber. Both the breaking weight and the elastic limit, however, will be found to vary greatly with different samples of wool. The strength and elasticity greatly aid in the manufacture of woolen cloth, especially in the spinning of the yarn. That they play an important part in the quality of a fabric is shown by the superior strength and feeling of a piece of pure woolen goods as compared with a fabric manufactured from, or adulterated with, either cotton or cheap wool substitutes.

12. Crimp.—The crimp, or curliness, of the wool is another important factor in its value, since this quality of the fiber aids not only its elasticity but, to a certain degree, the felting power of the fiber. A curly fiber is a great aid in spinning the wool, since it can be drawn finer and a more compact and rounded thread formed. By reason of the curly nature of wool, it is possible to spin a thread containing a very few fibers in its cross-section. Generally speaking, it may be said that the more crimps per inch there are in the fiber, the finer is the wool; that is, the diameter of the fiber. This is not a universal rule as is supposed by some, but serves, however, in the majority of cases as an indication of the diameter of the fiber.

The number of crimps per inch in the wool fiber vary from twenty-eight or thirty in fine wool, as for instance Saxony and merino, to only one or two in coarse carpet wools. While the crimp of the wool fiber is permanent, it is altered somewhat by the amount of moisture in the fiber, and may be taken entirely out by stretching the fiber in hot water. After drying, however, the crimp usually returns, and the fiber assumes its former shape.

13. Soundness.—Perhaps one of the qualities of a wool most desirable to the manufacturer is **soundness** of the fiber. If the sheep have been ill-kept, neglected, exposed to inclement weather, or pastured on ranges where the feed is insufficient, the growth of the wool is stunted and its quality deteriorated. Such a flock will often produce what the buyer terms **tender staple;** that is, the fibers are weakened and are not so strong as the average wool. If a sheep is neglected and starved, even for a few days, there will be a corresponding thin, weak place in the wool, where its growth was stunted during the neglected period. This weak place will remain in the fiber even after the wool has continued to grow. It is said that the most expert buyers can, if there is a weak place in the staple of a lot of wool, tell the month in which the drought that caused it occurred.

It is a well-known fact that alkalies are detrimental to wool; and when a flock of sheep habitually range on an alkaline soil, the fiber will be somewhat weaker than the average. The wool fiber should taper slightly from the root to the tip; but sometimes where sheep are exposed to rough weather, the fiber will thicken up at the tip where it is exposed, and still remain fine near the root, where it is protected from the weather.

Wool being somewhat fibrous and porous, the fiber is easily split; indeed, when the sheep is sick, the fibers often split from the tip toward the root. If the wool is very dull in appearance it is apt to be tender. Sound wool is bright, lustrous, and moderately greasy, or yolked. After a sheep has passed a certain age, say 6 or 7 years, the wool produced is apt to be tender, as well as somewhat deficient as regards yolk.

In testing wool for tenderness, a small lock or staple is taken and its strength tried. It can easily be seen if the wool is weak to any great extent, as it will always break in about the same place.

14. Kemps.—In fleeces from neglected or poorly bred sheep there occur certain bright, shining, straight hairs called

kemps. These hairs are wool fibers that appear to be diseased or dead. They are straighter than the ordinary healthy fiber, and when viewed under the microscope do not show the characteristic scales or serrations of the wool fiber to such a marked extent. Kemps are more or less opaque, while the ordinary wool fiber is somewhat translucent. They occur even in highly bred wool, such as Saxony and merino, but are much more frequently met with among the lower-grade and cross-bred wools. They generally occur about the neck and legs, where the wool gradually merges into hair.

Kemps vary in length, being in some sheep 2 inches long, or even more in some cases. In brown or dark-colored sheep the kemps are black, but in most cases they are white. They never unite with the other wool in forming a thread, but are simply held in place by the other fibers, and on the surface of the cloth will be seen as straight, shining hairs pinioned down by these fibers. In the dye bath, kemps will not dye the same shade as the other fibers, owing to the fact that they do not absorb the dyestuff as readily. This causes them to show up prominently in the finished goods, thus greatly deteriorating the fabric. By careful breeding and care in housing the sheep in cold and stormy weather, the condition of kempy sheep may be greatly improved.

15. Color.—In regard to **color** it may be said that, generally speaking, the whiter the wool, the more highly it is prized, although there are certain shades of natural browns and black wools that are often sought after. The color is not of so much importance as other qualities, unless white or delicately colored goods are to be produced. The majority of wools are white, but there are produced in small quantities brown, black, red, gray, and yellow. The color of the wool is sometimes influenced by the character of the soil on which the sheep ranges.

16. Luster.—Luster may be defined as the bright, or shining, quality possessed by wool in a marked degree. While wool is not as lustrous as silk, it is far more so than cotton. The luster of the wool fiber appears to be due to the reflection of light from the horny scales that surround the fiber. As a rule, long and coarse wools are more lustrous than the finer and shorter wools. This is due to the fact that the scales of the fiber are larger and flatter and thus form a larger reflecting surface for the light. It may be said that the luster is directly dependent on the size, flatness, and polished condition of the scales, and that any cause that tends to injure the scales will injure the luster of the wool. The luster of wool is often injured in the scouring and drying by the use of too strong or unsuitable detergents and the application of too much heat. The wool of a healthy sheep is lustrous, while that of a sick sheep appears dull and dead. A lustrous wool adds a certain brightness and fresh appearance to the fabric that is manufactured from it.

17. Staple.—By the term **staple,** or **length of staple,** the length of the fiber is meant. Wools are classified as long- and short-stapled wools. Long-stapled wools are known as **combing wools,** and are combed for coarse worsted yarns. Short-stapled wools are known as **clothing wools,** and are carded for the production of woolen yarns and fabrics.

There is a class of wools between the long- and short-stapled wools which has a medium length of staple, and is known as **fine combing wools.** They are first carded and then combed for the production of fine worsted yarns for ladies' dress goods, worsted suitings, etc.; these wools are sometimes classified as **delaine wools,** and in this country may be said to include all combing wools that contain merino blood. The term, therefore, has come to be somewhat synonymous with Ohio wools.

The length of staple varies greatly with the breed of sheep, and it may also be said that, generally, the longer the staple, the coarser and more lustrous is the fiber. The long Scotch "braid" combing wool has a staple of from 14 to 18 inches, and some specimens have been known with a fiber over 20 inches in length. On the other hand, some of the short clothing wools are hardly more than 2 or 3 inches in length at the most. It is erroneous to suppose that all long-stapled wools are made into worsted, and all short-stapled wools into woolen yarns. Quite short-stapled wool is now made into the fine grades of worsted yarn by means of the French system of mule-spun worsteds.

18. Hygroscopicity.—The hygroscopic property of wool, or its avidity for moisture, is one of its most marked physical properties. Under normal atmospheric conditions, wool will be found to contain about 14 per cent. of its weight of moisture, but if the atmosphere in which the wool is stored is very damp, it may be found to contain as high as from 30 to 50 per cent. of water. Wool brought from a damp storehouse, therefore, into a warm, dry mill will lose in weight. Sometimes the wool in the mill will become so dry as to contain not more than 6 or 8 per cent. of moisture. In this condition it becomes hard to work and is easily electrified, which leads to the necessity of providing some method of artificially regulating the humidity of woolen card, spinning, and weave rooms.

The moisture seems to be contained in the wool fiber in two conditions: first, in a purely mechanical state as a sponge would absorb water; and second, in a somewhat chemical state as a water of hydration. When dried at 100° (centigrade), wool loses on an average 18.25 per cent. in weight. This percentage is allowed as the standard by conditioning houses.

19. Conditioning.—On the continent of Europe and in England so-called **conditioning houses** are established, where the buyer can determine the amount of moisture in given samples of wool. This is a very great convenience and puts the buying and selling of wool on a sound basis. In this country but very little has been done in this direction, but there should be an understanding between the buyer and seller as to the amount of moisture contained not only in loose wools, but also in yarn and tops. This, with official conditioning houses where the exact percentage of moisture could be determined, would be of mutual advantage to both buyer and seller.

The method of determining the amount of moisture in a sample of wool is first to weigh it carefully, and then to place it in an oven until the moisture is driven off and the sample ceases to become lighter. The amount of loss in weight and the percentage of moisture that the sample contained is then readily determined.

WOOL SUBSTITUTES

20. In manufacturing certain cheap grades of cloth, it is not always possible to use pure wool even of a cheap grade. This leads, therefore, to the use of **recovered fibers,** or wool that has previously been manufactured into cloth and perhaps worn until the garment is no longer serviceable. Under the head of **wool substitutes,** there are three different grades of recovered fibers, each of which is recovered from certain classes of goods and has a distinctive name and character.

21. Shoddy.—The best of the wool substitutes is known under the name of **shoddy,** and consists of the wool fiber recovered from soft woolen rags that have not been milled, or felted; such as flannels, stockings, and knit goods. Shoddy is also made from the hard waste of woolen mills, although this is often used by the mill in connection with their soft waste and new wool. While shoddy is really pure wool, the fiber loses much of its characteristic wool nature in the manufacturing and pulling apart again to regain the fiber.

When viewed under the microscope, the shoddy fiber is seen to differ greatly from the original wool fiber. The distinctive scales or serrations will be seen to have been more or less injured, and may be entirely wanting in places, while the fiber as a whole may appear to have been stretched.

In the process of obtaining shoddy the woolen rags are torn into a fibrous mass or ground up. Although the rags are first oiled and the rag picker is so designed as to perform this office with the least possible injury to the fiber itself, still the process of reducing the rags to a fibrous condition necessarily injures the fiber and breaks it until it may be but a fraction of its original length. The loss in the length and the destruction of the regular structure of the fiber make shoddy only fit for mixing with new wool for the production of low-class goods. White shoddy is very rare, since the material from which shoddy is made has usually been dyed previously.

FIG. 5

The appearance of a fiber of shoddy greatly magnified is shown in Fig. 5, and it will be noticed that the characteristic structure of the wool fiber is almost entirely destroyed.

22. Mungo.—Mungo is a wool substitute that is even poorer in fiber structure than shoddy. Mungo is the fiber recovered from hard-spun and milled, or felted, woolen and worsted goods. Owing to the hard milling and felting that the fibers have previously undergone, when recovered they are almost destitute of the serrated, or imbricated, structure of a pure wool fiber. There are two varieties of mungo. The better quality is obtained from new rags that accumulate as clippings in tailor shops. The inferior quality is obtained from worn and cast-off broadcloths, suitings, etc. Mungo is used for low-quality woolen goods in connection with a small proportion of new wool to give strength to the yarn.

23. Extract.—Extract is the wool fiber recovered from union goods; that is, cloths that contain wool and also some percentage of vegetable fiber, usually either cotton or linen. In order to recover the wool alone, and not to have the recovered animal fiber mixed with vegetable fibers, it is necessary to resort to a chemical process. This process for the extraction of the vegetable from the animal fibers is generally known as **carbonization,** but sometimes is spoken of as **extraction.**

The process is as follows: The rags are first carefully dusted and cleaned, and then are immersed in a solution of sulphuric acid of from 4° to 6° (Baumé) strength. The acid solution is usually contained in wooden tanks, and the rags are frequently stirred and moved about so as to insure the thorough mixing of the acid and water. When the rags have become thoroughly saturated with the acid, they are removed and the excess of the solution drained off, after which they are dried at a high temperature, varying from 100° to 110° (centigrade).

This process reduces the vegetable matter to a charred or disintegrated form, while the acid has no effect on the wool. The rags are then crushed and dusted in a carbonizing duster or similar machine, and the vegetable matter removed as dust. The recovered wool fiber may now be treated with a dilute soda bath to neutralize the effects of any traces of acid that may remain in the fiber. This process, with some alterations, is in use to a large extent for removing burrs, chaff, shives, and other vegetable matter from pure wool, superseding the older methods of mechanical burr extraction. It will be thoroughly explained later.

SHEEP

24. Classification.—Having dealt somewhat exhaustively with the structure of the wool fiber, it will perhaps be of advantage to consider the different varieties of **sheep** from which wool for textile purposes is obtained. Some naturalists recognize but three varieties of sheep: the *Ovis ammon*, or wild sheep, of Asia and America; the *Ovis musmon*, inhabiting the southern parts of Europe and northern portions of Africa; and the *Ovis aries*, or domestic sheep. These naturalists claim that all other sheep are but varieties of the above, being obtained by crossing and breeding.

The best classification of the sheep of the world is that made by Professor Archer in cooperation with noted manufacturers and naturalists. He divides the sheep that are useful to man into thirty-two distinct varieties, and groups them geographically as follows:

EUROPE

1. Spanish, or merino, sheep
2. Common sheep
3. Wallachian sheep
4. Crimean sheep

ASIA

1. Hooniah, or black-faced, Tibet sheep
2. Cago
3. Nepal sheep
4. Curumbar, or Mysore, sheep
5. Gārār, or Indian, sheep
6. Dukhun, or Deccan, sheep
7. Morvant de la Chine, or Chinese sheep
8. Shaymbliar sheep
9. Broad-tailed sheep
10. Many-horned sheep
11. Pucha, or Hindustan, sheep
12. Tartary sheep
13. Javanese sheep
14. Barwell sheep
15. Short-tailed sheep of Northern Russia

AFRICA

1. Smooth-haired sheep
2. African sheep
3. Guinea sheep
4. Ceylon sheep
5. Fezzan sheep
6. Congo sheep
7. Angola sheep
8. Yenu, or Goitered, sheep
9. Madagascar sheep
10. Bearded sheep of West Africa
11. Morocco sheep

AMERICA

1. West Indian sheep as found in Jamaica
2. Brazilian sheep

This classification includes all the known varieties of domesticated sheep, the fleeces of many of which are never used in American mills but which are nevertheless interesting from the student's point of view.

25. Spanish Merino.—The Spanish merino, of which large flocks formerly ranged on the mountain slopes of Spain, were in times past acknowledged to produce the best wool in the world, but were imported into Germany by the Elector of Saxony, who by careful breeding improved on the original Spanish merino and produced the Saxony wool, which took its name from the Elector of Saxony, and is often known as the Saxony Electoral wool. These sheep were also crossed with the native Silesian sheep, producing another extremely fine breed, the fleeces of which even surpass the Spanish merino in fineness and weight.

The Spanish merino sheep were introduced into Australia and South Africa and flourished there, until at the present time the wool from these two places is famous. They were crossed with the various English breeds of sheep, and in many instances the qualities and weights of the fleeces improved. Fig. 6 shows the appearance of a fiber of Spanish merino wool greatly magnified.

26. American Sheep.—Regarding American sheep, it may be said that all of the American breeds of sheep were originally imported. Numerous importations of sheep were made from time to time, including such famous breeds as the Spanish merino, Saxony, and Silesian merino, and also many English breeds, as the Lincoln, Leicester, Cotswold, Southdowns, Oxforddowns, etc.

FIG. 6

FIG. 7

America seems to be well adapted for the raising of sheep, and many fine flocks are to be found on this continent. The full-blooded American merino produces a fleece that is superior in regard to fineness of fiber, serrations per inch, and other desirable qualities. The merino has been crossed in this country with the common sheep, and in many states, notably Ohio, very desirable cross-bred wools are produced. Fig. 7 shows a view of the fiber of a full-blooded American merino, and the numerous serrations should be noticed.

27. Long-Wool and Short-Wool Sheep.—It should be remembered that many of the long-wool sheep, such as the Lincoln, Cotswold, etc., do not produce such fine and well-imbricated fibers as are shown in the previous illustrations. In fact, it is customary among some naturalists to make two distinct divisions of sheep; namely, **long-wool** and **short-wool sheep.** The long-wool sheep are larger and have heavier bodies and white faces. The fleeces are heavier, and the staple longer and less curly. The serrations per inch are less, and the fiber is more lustrous and less heavily yolked.

Short-wool sheep have smaller bodies and lighter fleeces. Their faces are black, and their legs are generally shorter than those of the long-wool sheep. The staple of the wool is shorter and more curly, while the fiber is more imbricated and the fleece more heavily yolked. Fig. 8 shows the fiber of a long-wool sheep greatly magnified. The fibers are those of a Lincoln sheep.

FIG. 8

28. Weight of Fleeces.—In regard to the **weight of fleeces,** it may be said that the weight varies greatly with the breed of sheep and, generally speaking, the long-wool sheep produce heavier fleeces than the short-wool sheep. Fleeces vary in weight from 1 or 2 pounds to 11 or 12 pounds in exceptional cases. An average fleece may be said to weigh from 4 to 6 pounds. Some sheep are bred to heavy fleeces more or less at the expense of the fineness of the fiber, while others are bred for quality alone.

The following table gives the weights of the fleeces of various breeds of sheep, together with other valuable information.

WOOL CONSUMPTION OF AMERICAN MILLS

29. Domestic Wools.—In the United States, the principal wools used are the so-called **territory wools,** which include the wools raised in the states of North and South Dakota, Montana, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Idaho, Washington, Oregon, and California. These wools are largely used in American woolen mills and are generally considered as a good grade of wool. The fleeces of the territory sheep vary from 4 to 7 pounds in weight when in an unwashed state, and lose from 60 to 70 per cent. of their weight in scouring.

Breed	Cross	Quality	Staple	Color	Weight of Fleece Pounds	Kind of Yarn Suited for
Spanish merino		Very fine	Short	White	Ram 8, Ewe 5	Woolen
Saxony	Merino and native	Finest	Short	White	5 to 8	Worsted and woolen
Silesian	Merino and native	Finest	Short	White	5 to 8	Worsted and woolen
New South Wales	Merino and Southdown	Fine		White	$2\frac{1}{2}$	Worsted and woolen
Southdown		Fine	Short	White and gray	3 to 4	Woolen and worsted
Lincoln		Good	Long	White	8 to 9	Worsted
Persian		Medium	Long	White, gray, black, yellow, and brown		Worsted
Donskoi		Coarse	Medium	White and gray		Worsted
Hooniah		Soft and fine	Long			Worsted
Curumbar			Short	White, yellow, gray, brown, and black		Woolen and worsted
Gārār			Short			
Deccan		Coarse	Short			
West Indian		Fine and soft but mixed with hair	Short			Woolen
Morvant de la Chine		Coarse but soft and silky	Short	Yellow		Woolen

The state of Texas also produces a large amount of the so-called **Texas wool.** The Ohio, Pennsylvania, and West Virginia merino and cross-bred wools are largely used in the production of fine worsted yarns. The average weight of American unwashed fleeces is about $6\frac{1}{2}$ pounds.

30. Imported Wools.—Of the imported wools, the principal varieties used are the Australian and Cape Merino and cross-bred wools for the fine worsted and woolen trade, and such wools as Persian, Donskoi, China, and braid wool for the carpet trade. Large amounts of mohair are also used of both the imported and the domestic fleeces.

31. World's Wool Supply.—Of the world's wool supply, it may be said that the largest amount of wool concentrated and shipped is obtained from a few ports in Australasia, which is without doubt the most important wool-producing region in the world. The world's wool production per annum by continents is approximately as follows:

Country	Pounds	Country	Pounds
Europe	950,000,000	Australasia	510,000,000
North America	316,000,000	Africa	135,000,000
South America	510,000,000	Central America and	
Asia	274,000,000	West Indies	5,000,000

MOHAIR

32. Although strictly speaking mohair is not wool, yet it is largely used in American mills, and therefore should be mentioned. Mohair is the fleece of the Angora goat, which is indigenous to the mountainous districts of Asia Minor. The hair of this goat more closely approaches sheep's wool in structure than that of any other animal; it is disposed in long, silky staples and possesses a luster that almost rivals that of silk. The staple averages from 6 to 8 inches in length; the fiber is fine and has a very good development of serrations.

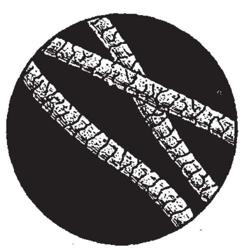


FIG. 9

The Angora goat has been introduced into America, and there are now in this country several very successful flocks, notably in California. The fleece is used for ladies' dress goods and plushes. For pile fabrics, mohair is largely used, as the pile obtained is of great durability. Fig. 9 is an illustration of the mohair fiber greatly magnified.

33. Among other animals, the hair or fleeces of which are used for textile purposes, may be mentioned the Cashmere, or Tibet, goat, which furnishes the material for the famous cashmere shawls, the camel, the kangaroo, the ibex, the llama, the vicugna, from which the vicugna wool is obtained, and the alpaca. The three last-mentioned animals are all varieties of the same species.

WOOL SORTING

INTRODUCTION

34. Not only does the wool vary in regard to quality, staple, fineness, etc. in different breeds of sheep, as has been demonstrated, but it also differs widely in these respects when taken from different parts of a single fleece. Thus arises the necessity of separating the various qualities of wool found on the fleece, in order that they may be used for different grades of cloth. The operation of grading the wool found on the fleece into the different qualities and lengths of staple is called **wool sorting,** while the person who performs the operation is known as a **wool sorter.**

Wool sorting constitutes practically the first operation in the manufacture of a piece of woolen or worsted cloth. It may be said that the wool is sorted into as many different qualities as the mill may require, as fourteen distinct qualities of wool are found on a single fleece by an expert sorter. Ordinarily, there is no necessity for making such a large number of sorts, and in some mills running on low-grade goods, perhaps only two sorts may be made, the edges of the fleeces only being thrown out; while another mill may sort its fleeces into three or four grades, a first, second, and third quality, with perhaps a little of the coarse breech in a fourth quality. On the other hand, a mill that is running on fine goods and making several grades of cloth may make as many as six or eight sorts from each fleece. It is rarely that more than eight sorts are made, and the general tendency each year is to do less and less wool sorting, since the operation is slow and expensive. However, the coarse, rough breech, or britch, and the skirtings, or edges, of the fleece should always be thrown out, since the yarn spun will be rough and uneven if a mixture of coarse and rough, and fine and soft fibers is used.

35. Wool sorting is a trade learned only by long experience. After working at his trade year after year, the wool sorter acquires a sensitiveness of touch and judgment of the grade of a handful of wool that seems to be instinctive. It is said that an experienced wool sorter is able to sort a fleece with which he is familiar in the dark, telling the different qualities of wool by the feeling alone. The wool sorter learns to judge wool by its **feel**, or **handle**, and by this means alone can tell the degree of softness, fineness, and loftiness of a sample of wool, although he is also guided by the appearance of the staple. In separating the different qualities of wool in a fleece, the sorter is guided by this sense of feeling together with his knowledge of the positions of the different qualities on the fleece.

The tools required by a wool sorter are few, and consist first of all of a wire-covered bench on which he may spread out the fleece and through which loose particles of dirt and any other foreign matter, such as straws, sticks, dust, etc., may fall. He also requires a pair of shears to clip off paint and tarry marks with which the fleece is often marked and as many baskets or boxes as there are sorts to be made.

METHOD OF SORTING

36. The fleece as it comes to the sorter is rolled in a tight bundle and is tied up with either a twisted portion of itself or a string or small rope. In the latter case great care must be taken to remove every portion of the rope, as any particle of vegetable matter in the wool will show a different color when the cloth is dyed. In the winter, when the weather is cold, the fleece may have to be warmed before it can be opened, because the cold weather solidifies the natural grease, or yolk, in the fleece and renders it stiff and hard. As soon as the fleece is warmed, the yolk is started and the fleece becomes soft and pliable. After the fleece is opened, the sorter throws it on the wire bench and proceeds to shake and pick out the vegetable matter, such as burrs, straws, sticks, etc. The back of the sheep forms an indefinite boundary that divides the fleece into two parts. The sorter first separates the fleece along this line into two sections. The next operation is to clip off all paint and tarry marks. In countries where the flocks of sheep run more or less together, it is the custom of some herders to mark their sheep with paint or tar, to distinguish them from sheep of other flocks. This fact accounts for the great number of paint and tarry marks found on fleeces.

The sorter now commences to sort the fleece, being guided by his sense of touch and by the appearance and position of the wool. All coarse, harsh-feeling wool is separated from the fine, soft, and elastic portions, and cast into separate baskets. The finest fiber is that grown on the shoulders and sides, while that of the flanks and lower portions of the animal is of a coarse quality. As a rule, all black or dark-colored locks of wool are separated from the white and placed in one lot, which is usually dyed black. If mixed with the white, the dark-colored wool will, even if in very small quantities, make a *bloom* on white yarns; that is, the yarn will not be pure white, but will have a tinge of color.

It must be understood that there are no definite boundary lines between the different qualities of fiber, but that one quality merges into another, and a sorter may make three or four, or seven or eight, sorts from the same pile of fleeces according to the needs of the fabrics that are to be made. The poor qualities, which must be separated from the good, include all coarse and harsh-feeling wool, those portions of the fleece that are inclined to be very kempy, tender and ill-grown staples, and also all cotted, or felted, portions, as well as the hard lumps of dirty wool, and the paint and tar marks.

QUALITIES OF WOOL

37. As previously stated, there are fourteen distinct qualities of wool that may be obtained from a single fleece, if carefully sorted. These, according to one authority, are as follows (see Fig. 10):

No. *1* is the shoulder, where the wool is long and fine and grows in close, even staples.

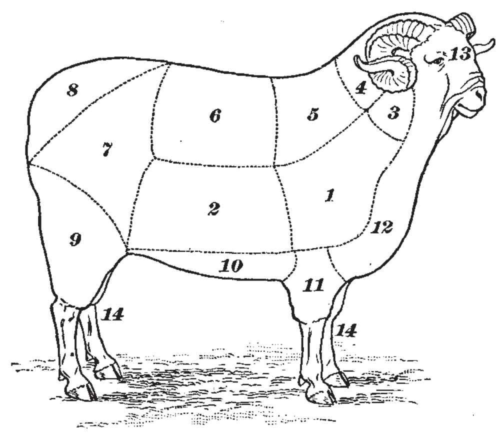


FIG. 10

No. *2* is equally good, but if anything, is inclined to be slightly stronger and the fiber a trifle coarser. The best wool of the fleece is found on these two parts.

No. *3* is the wool that grows on the neck of the sheep, and while the fiber is fine, it is short and liable to contain black or gray hair if the sheep is disposed to their production.

Nos. *4* and *5* produce wool that is somewhat faulty, and the length of the staple is also found to be short.

No. *6*, which covers the loin and back, is still coarser and shorter.

No. *7* produces a wool that is long and strong and hangs in long locks, or staples. It is apt to be very coarse on cross-bred sheep and much resembles the britch.

No. *8* is the britch, or breech, which is the coarsest part of the fleece and is often called *cow-tail* from its resemblance to the coarse tuft of hair on the end of a cow's tail.

No. *9* produces a strong, coarse wool.

No. *10* grows a wool that is short and often dirty from the dirt accumulated when the sheep lies down. It is apt to be finer near the front legs and is commonly known as **brokes.**

No. *11* produces a short and fine wool.

No. *12* is short and fine; the wool is somewhat damaged by rubbing.

No. *13* is the forehead, where the wool is short and coarse and of very little value.

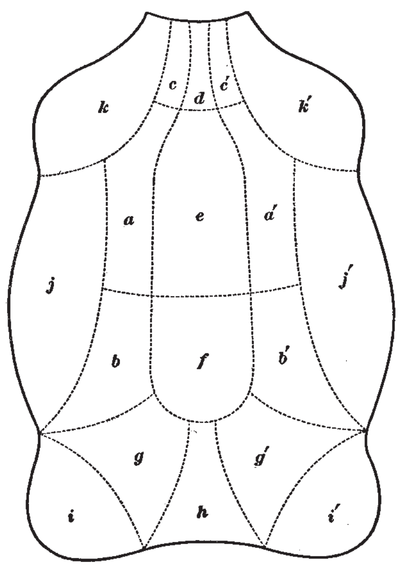


FIG. 11

No. *14* is the legs where the wool is even worse and has no practical value.

When kemps occur in fleeces, they are most liable to be found in Nos. *12* and *8*, although those found on the britch are much longer and stronger.

38. Another excellent division of the qualities of wool in a single fleece is as follows (see Fig. 11): The finest and most evenly grown wool is always found on the shoulders *a*, *a'*.

In some fleeces, this quality extends into *e*, *b*, *b'*, *f* and the quality of the wool at *b* and *b'* is not much inferior, although rather stronger and coarser. These two qualities in the woolen trade would be called **picklock,** and **prime,** or **choice.**

The wool found in position *d* is frequently finer in the staple, but shorter than *a*, *a'* or *b*, *b'* and apt to be defaced by irregular or colored hairs. When free from these defects, it forms a superquality. The qualities *c*, *c'* shade into those on each side of them, and as they form the apex of the shoulders are shorter and less closely grown than *a*, *a'*. The quality of *f* closely resembles that of *b*, *b'*, into which it shades. For many purposes *a*, *a'*, *b*, *b'*, *e*, and *f* are frequently used as one quality.

After passing beyond *f* and back to the flanks of the sheep, the wool becomes long and coarse, the best being found at *g* and *g'*.

At *i*, *i'*, and *h*, the coarsest part of the fleece is reached, where the wool grows in large locks of coarse hair. The former are called the breech, or britch, locks and can only be used for coarse yarns.

39. Perhaps the best division of the different qualities on a fleece is that which separates the varieties of wool as follows:

The Shoulders and Sides.—The wool grown on these parts is remarkable for length and strength of staple, softness of feeling, uniformity of character. It is usually the choicest wool in the fleece.

Lower Part of Back.—This also is wool of a good, sound quality, resembling in staple that obtained from the shoulders and sides, but not so soft and fine in fiber.

Loin and Back.—The staple here is comparatively shorter, the fiber is not so fine, but the wool on the whole is of a true character. In some cases, however, it is liable to be a trifle tender.

Upper Parts of the Legs.—Wool from these parts is of a moderate length, but coarse in fiber and possessing a disposition to hang in loose, open locks. It is generally sound, but liable to contain vegetable matter.

Upper Portion of the Neck.—The staple of wool clipped from this part of the neck is of an inferior quality, being frequently faulty and irregular in growth as well as full of thorns, twigs, etc.

Central Part of the Back.—This wool is nearly like that obtained from the loins and back, and is rather tender in staple.

The Belly.—This is the wool that runs quite under the sheep between the fore and hind legs. It is short, dirty, poor in quality, and frequently very tender.

Root of Tail.—The fiber is coarse, short, and glossy and the wool often runs with kemps or bright dead hairs.

Lower Parts of the Legs.—This is principally a dirty and greasy wool in which the staple lacks curliness and the fiber fineness. Usually it is burry and contains much vegetable matter.

The Head, Throat, and Chest.—The wools from these parts are classed together, all having the same characteristics. The fiber is stiff, straight, coarse, and covered with fodder. The wool is also apt to be kempy.

The Shins.—This is another short, thick, straight-fibered wool, commonly called **shank.**

WOOL-SORTERS' DISEASE

40. This disease, which frequently attacks wool sorters engaged in sorting dusty wool, especially the Eastern or Asiatic wools, first appears as an ordinary cold accompanied with oppression of the chest, severe headache, and profuse perspiration. The temperature of the patient rises and a cough appears. The respiration becomes harder and the pulse weaker and weaker until in three or four days the man dies. **Wool-sorters' disease** seems to originate in the dust of certain infected wools, which when drawn into the lungs of a person produces a disease that is evidently due to the presence of bacilli.

The worst wool for producing wool-sorters' disease has been found to be what is known as Van mohair. Other wools that are liable to be infected are Turkey mohair, Persian wool, alpaca, camel's hair, and the wool of the Cashmere, or Tibet, goat.

GLOSSARY OF TRADE TERMS USED IN CONNECTION WITH WOOLS

41. **Alpaca.**—The wool of the Peruvian sheep, or alpaca, which is related to the llama, both belonging to the same genus as the camel.

Angora.—A district in Asia Minor which gives its name to the Angora goat, from which mohair is obtained.

Anthrax.—The scientific name for wool sorters' disease.

Braid Wool.—The fleeces of lustrous- and bright-haired sheep; such as Lincoln, Leicester, Cotswold, etc.

Britch.—Coarse wool from the breech of the sheep.

Brokes.—Short, dirty wool.

Buck Fleece.—The fleece of a ram.

Carbonization.—The chemical process of destroying any vegetable matter found in wool.

Cast.—The fleece of a rough, badly bred sheep.

Classification.—American wools are classified according to condition, staple, and quality.

Clothing Wool.—Clothing wool is the wool of short-haired sheep, which is commonly carded for the production of woolen yarns and fabrics.

Combing Wool.—Long-stapled wools that are combed for producing worsted yarns.

Condition.—This is the state of the fleece as it comes to the market after the first washing. The sheep are driven into the water courses and part of the dirt and grease washed out before the shearing.

Cots.—Bunches of wool that have felted on the sheep's back, due to an absence of yolk, or grease, at the place where the cot occurs.

Delaine Wool.—Delaine wools are those of merino blood prepared for combing by first being carded, and are used for the production of fine and medium worsted yarns. Delaine wools comprise practically all combing wools with a trace of merino blood. In America the term is practically synonymous with Ohio merino and cross-bred wools.

Elasticity.—The lofty, or springy, nature of certain fibers, notably wool.

Extract.—Wool derived from waste woolen materials that have been mixed with vegetable materials, as cotton, linen, etc., either in weaving or otherwise.

Extraction.—This term is synonymous with the term carbonization.

Felting.—A property of wool that enables a number of fibers to join and interlock with one another until they form a compact whole and the fibers cannot be separated. In America, the semiannual clip of portions of Texas and California is sometimes known as felting wool.

Flocks.—The waste of finishing machines in cloth mills, which is again used as a wool substitute to cheapen yarn and make it bulky.

Fulling.—See Felting.

Grease Wool.—Wools that have not been scoured are known as grease wools or are said to be in the grease.

Hog, Hogget, or Teg Fleece.—The first fleece of a sheep that had not been shorn as a lamb, taken when the animal is about 1 year old.

Imbrications.—A word that is practically synonymous with serrations and indicates the serrated, or imbricated, structure of a wool fiber.

Kemp.—A solid, glazed, dead, horny hair found on badly bred fleeces, rarely over $1\frac{1}{2}$ or 2 inches long, which cannot be twisted into the thread in spinning and will not dye the same shade as the rest of the wool.

Lamb's Wool.—The fleece of a sheep taken when the animal is about 6 months old.

Luster.—The glossy, shiny, or bright appearance of certain fibers due largely to the reflection of light from their surfaces, more particularly noticeable in long and coarse wools, and especially noticeable in alpaca and mohair.

Mohair.—The hair or wool of the Angora goat.

Mungo.—A wool substitute derived from hard-spun and felted woolen and worsted goods.

Noils.—The refuse or short fibers of combing wools that are removed from the longer fiber by the comb during the combing process and which are often used as a wool substitute in connection with pure wool for the production of woolen yarns.

Pulled, or Skin, Wool.—This is the wool of slaughtered or dead sheep. Generally speaking, pulled wool is considered inferior in quality to the wool or fleeces removed from live sheep. This class of wool is not clipped or sheared from the sheep but the skin is plunged in lime water or rubbed with acid, which loosens the roots of the wool, whereupon it can be easily pulled away from the skin. Some varieties of pulled wool felt very easily owing to the fact that the serrations of the fiber are somewhat opened out.

One advantage of pulled wool is that the fibers are whole, whereas in wool that is sheared, unless the process is performed skilfully, there are liable to be short fibers that are cut twice; that is, the shearer in making two successive cuts will cut off the root ends of fibers that were cut from the skin at the preceding time. The sorting of pulled wool is a difficult task, as the wool does not come away from the skin as a whole fleece but in detached portions. The wool is often impregnated with dust and lime and is apt to give rise to wool-sorters' disease.

Quality.—This term denotes the fineness of the fiber and other desirable attributes of first-class wool. In the American worsted trade the qualities are as follows: Picklock; XXX; XX; X; No. 1, or $\frac{1}{2}$-blood; No. 2, or $\frac{3}{8}$-blood; No. 3, or $\frac{1}{4}$-blood; coarse; and common.

Picklock is the finest quality of wool and is supposed to be the wool of the pure-bred Saxony sheep. *XXX* is the first cross of the merino and Saxony. *XX* is the quality of the full-blooded merino. *X* is the three-quarters blooded merino.

Nos. 1, 2, and 3 indicate the variations in purity of blood from the merino and the common sheep.

Scouring.—Wool washing by mechanical and chemical processes.

Scoured Wool.—Wool from which the yolk, or animal grease, has been removed by the process of scouring.

Serrations, or Serratures.—The fine scales, or points, that project from the surface of wool fibers and that interlock with each other in the process of felting.

Skirting.—Separation of the inferior portions of the fleece generally found around the edges and known as skirts, or skirtings.

Shoddy.—The worked-up waste of unmilled, soft woolen and worsted goods.

Shurled Hogget.—The first fleece from a sheep after it has been shorn as a lamb; that is, the fleece of a yearling sheep that had the lamb's wool removed.

Shearlings.—This is a short wool obtained from the skins of sheep shorn just before slaughtering and is largely used by hatters.

Staple.—A lock of wool formed naturally on the sheep's back by a number of fibers clinging together. Wools are classified, according to length of staple, into clothing and combing wools.

Tags.—Short dung locks that are found on fleeces and which are due to improper care and housing of sheep.

Toppings.—These are hard lumps of matted fibers and dirt that must be cut off by the sorter. They are present only to a small extent in well-bred sheep.

Unmerchantable Wool.—Wool poorly washed is known as unmerchantable.

Unwashed Wool.—Unwashed wool is that which comes to the market without a preliminary washing.

Wether Fleeces.—All fleeces shorn from a sheep after the hogget fleece has been removed are known under the general term of wether fleeces.

Yearlings.—The fleeces of 1-year-old sheep.

Yolk.—The natural grease found in the wool of sheep.

WOOL SCOURING

DUSTING

1. Objects of Dusting.—Previous to scouring, the wool as it comes from the sorter is in the majority of cases passed through a machine known as a **duster**. The object of dusting grease wools is, as far as possible, to remove, before scouring such foreign impurities as lumps of dirt, dust, shives, etc. The reason for this is that, as all such impurities are detrimental not only to the finished goods but to the facility with which the processes of manufacture are accomplished, it is advantageous to commence to remove them at as early a period as possible. The wool sorter is supposed to remove burrs and large particles of dirt from the wool during the process of separating the fleece into different qualities, but it is impossible for all impurities to be removed at any one time; and, in fact, they are not all removed until the wool is practically ready for spinning. It is of particular importance to have the wool as free from foreign matter as possible before it is scoured, as the saving in soap and scouring liquor when the wool is dusted and freed from sand, chaff, etc., is very apparent.

2. Another object, although a subsidiary one, is to deliver the wool to the scouring machine in a more open and *lofty* condition, as it is found that scoured wool which has previously been passed through a duster leaves the washing machine more thoroughly and evenly scoured and brighter looking. The reason for this is that the stock is not only partly cleaned by the dusting, but is also opened up so that the scouring liquor will penetrate every portion of it and thus render the scouring more even and more thorough.

TYPES OF DUSTERS

CONE DUSTER

3. Principle of Construction.—The principle on which the **cone duster** operates is simply that of beating the wool

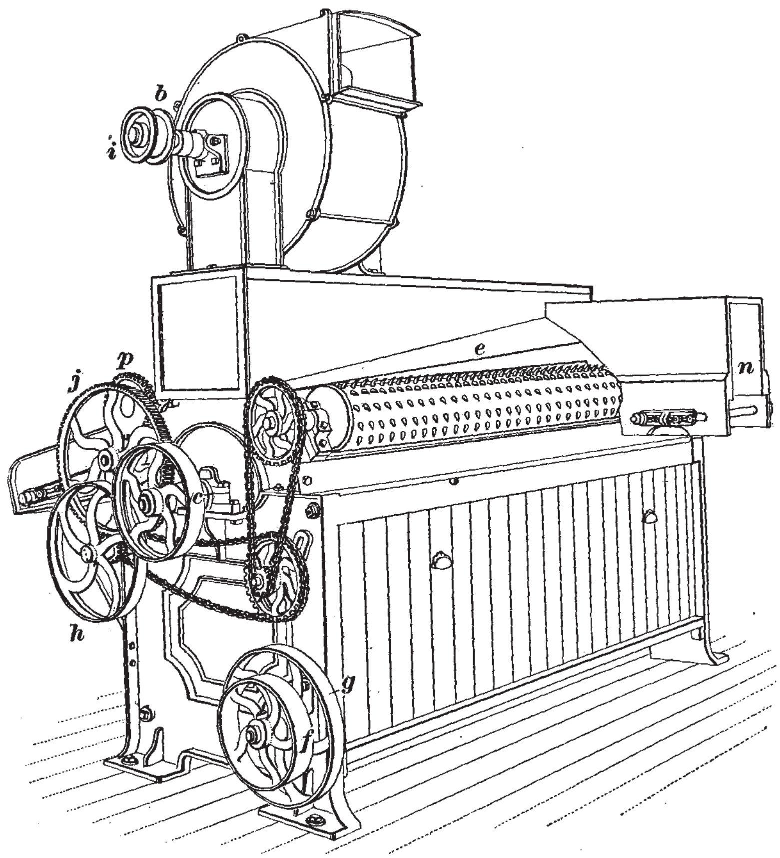


FIG. 1

by means of a rotating cylinder below which is suspended a screen, or grid, that allows the dust and other foreign matter to fall through but retains the stock. The principal features of the cone duster are shown in Fig. 1, while Fig. 2 is a view of the main cylinder of the machine, which cannot be seen in Fig. 1. This cylinder is cone-shaped, the larger end being 4 feet and the smaller end 26 inches in diameter in some

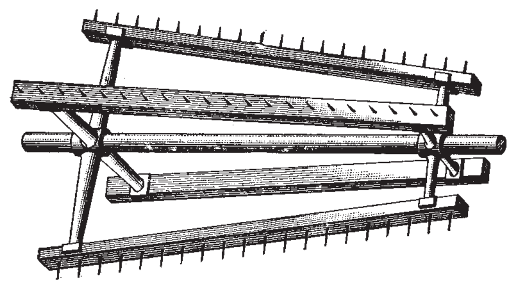


Fig. 2

machines, while the total length is usually about 7 feet. The cylinder is built up on a central shaft with arms, or spiders, to which are attached four wooden lags. Each lag carries iron teeth that project generally about 3 inches from the lag, but in some machines more. Sometimes similar teeth are placed on the frame of the machine so that the teeth lags on the main cylinder will mesh with them.

Below the main cylinder is a grid made in two parts, one of which may be removed from the front of the machine and the other from the rear; the details of one part are shown in Fig. 3. In some machines the grid is so arranged that it may be removed as a whole from one end of the machine. The grid, being removable, is easily accessible for cleaning. Sometimes, instead of a grid, a coarse-meshed screen is used. The dirt that is beaten out by the cylinder falls through the grid into a chamber, from which it can easily be removed.

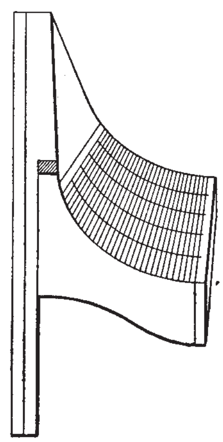


Fig. 3

4. The Fan.—In order to carry off the light foreign matter and dust from the wool, a fan *b* is often used in connection with the duster, which in this case is shown above the machine in Fig. 1. This is a 24-inch fan so connected to the inside of the cover of the cylinder that a current of air carrying away the lighter impurities is constantly passing through the duster and being delivered outside the mill by means of suitable pipes. Beneath the fan is a screen that retains the wool but allows the dust to be removed. The lower part of the machine is made air-tight, so that the air in the space below the screen will be comparatively still; by this means the current generated by the fan will not hinder the fall of the heavy particles of dirt as they are beaten from the wool and drop through the screen.

5. Feed.—Another feature of the machine is the mechanism for feeding, which consists of a traveling feed-apron, or lattice, on which the wool is fed either by hand or by a self-feed. Immediately over the delivery end of the apron is placed a single large cockspur feed-roll, which, working in conjunction with the apron, delivers the wool to the cylinder. Dusters are occasionally built with two cockspur feed-rolls instead of the single roll.

The method of imparting motion to the various parts of the cone duster is as follows, the references being to Fig. 1: The fan is driven from the pulley *c* on the main shaft of the machine, which drives a pulley *i* on the fan shaft. A small pulley fastened on the main shaft behind the pulley *c* drives a pulley *g* on a stud; fast to this pulley and loose on the same stud is a pulley *f*, which drives a pulley *h* with a cross-belt. Compounded with the pulley *h*, is a small pinion gear that drives a large gear *j* on the apron-roll shaft. The single cockspur feed-roll is driven by a gear compounded with the gear *j*, which drives the gear *p* fast to the shaft of the feed-roll. The main cylinder shaft carries tight and loose pulleys on the opposite end of the machine and is driven from the driving shaft of the room. The main cylinder should have a speed of about 400 revolutions per minute, while the fan should make about 1,000 revolutions per minute. It is not necessary to give any speed calculations in regard to a duster as it is a very simple machine and it is seldom that changes are made; if a change is made it is usually in the speed of the whole machine, which necessitates changing only the main driving pulley.

6. Operation.—In operation, the wool is fed on the traveling feed-apron and is delivered to the cockspur feed-roll. The stock is then beaten by the teeth on the lags of the cylinder and all heavy dirt drops by gravity through the screen under the cylinder, while the lighter dust, shives, etc., are drawn off by the fan. The stock travels from the small end of the cone-shaped cylinder toward the large end, and is finally thrown through an opening *n* at the rear of the machine ready for scouring. The wool is now open and lofty and the scouring liquor can penetrate it quite easily; thus more even and more thorough work is assured and there is less need of agitation in the washing machine.

A worker *e* is shown in Fig. 1, which is more particularly used in case of dusting card waste, noils, and similar materials. A duster used for grease wools may be built with or without this roll, which is driven from a sprocket compounded with the pulley *h*. This sprocket drives a compound sprocket on a stud that drives a sprocket on the shaft of the worker. The power required to drive a cone duster may be estimated as $3\frac{1}{2}$ horsepower and the machine should be driven by a $3\frac{1}{2}$-inch or 4-inch belt. The floor space occupied by this machine is 9 feet by 7 feet.

SQUARE DUSTER

7. Object of Square Duster.—Another form of duster for grease wools is shown in Fig. 4, being known as a **square duster.** The object of this machine may be said to be the same as that of the cone duster; namely, to free the wool of dirt before scouring. It is, however, more particularly adapted to the longer-stapled wools, such as are used in the fine worsted trade and do not require such severe treatment. The cone duster has a tendency to roll short stock and make the wool *pilly*, while on long stock the

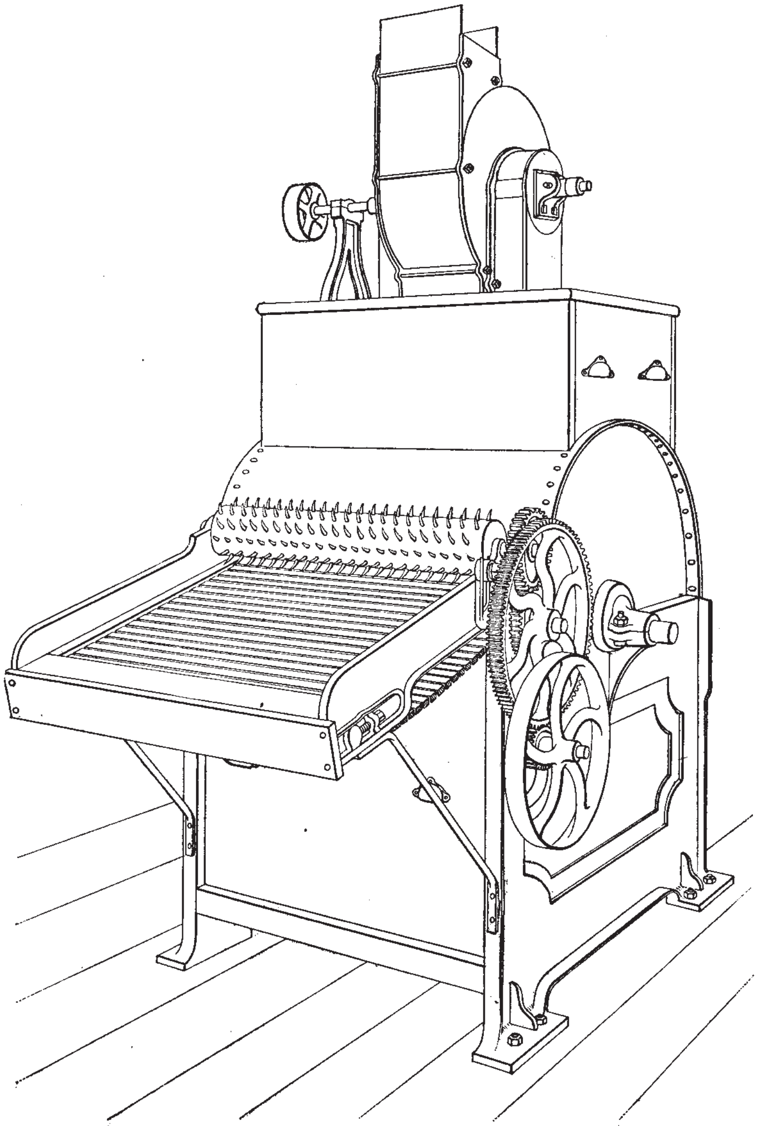


Fig. 4

cone cylinder is apt to make the stock *stringy;* both of these faults are eliminated by the square duster. The principle of the square duster is the same as that of the cone duster, except that in the latter the cylinder is cone-shaped, while in the former the cylinder has the true cylindrical form. The machine is fed by means of a feed-apron, which is made of slats of hardwood, generally maple, as in the cone duster, being fastened on endless belts of leather. The apron runs on cast-iron rolls, which are provided with adjusting screws for tightening the apron when slack. The feed-roll is constructed on the same principle as that in the cone duster and is furnished with cockspur teeth. The advantage of using cockspur teeth for feed-rolls is that when teeth are made curving back from the direction of rotation of the roll they are self-stripping; that is, they clear themselves from wool and the roll does not become matted and choked with stock.

8. **Construction and Operation.**—The square duster is built with or without a fan. In Fig. 4, a fan is shown on the top of the machine. The advantage of a fan is very apparent, as the strong current of air thus generated cleans the wool of all light impurities and conveys them away through suitable pipes. Since the lower part of the duster is made air-tight, the current of air from the fan will not hinder the fall of the heavier particles of foreign matter through the screen, the air being admitted to the fan through suitable openings in the sides of the duster frame.

In operation, the wool is fed to the machine on the traveling apron. It is then taken by the feed-roll and delivered to the rotating cylinder, which in this duster runs downwards, but which in the cone duster runs upwards. The wool in this machine is subjected to the action of the cylinder for about half a revolution and the fleece opened up for the scouring liquor without rolling it or breaking the fibers. The power required to drive a square duster varies with the amount of wool that is being fed to the machine, but may be estimated at 3 horsepower, a $3\frac{1}{2}$-inch belt being sufficient for driving purposes. The machine occupies a floor space of

5 feet by 7 feet. The speed of the square duster is about the same as that of the cone duster.

9. Management.—The management of either duster is a comparatively simple matter and its success depends largely on the manner in which the duster is attended to in regard to cleaning. Dusters, if not properly cared for, soon choke up and in this condition are useless, so far as dusting the wool is concerned. The dust box under the screen, or grid, should be frequently cleaned out, and care should be taken to clean the grid at the same time, because if it is choked up the dirt cannot fall through into the dust box, even if the latter is empty. In putting up the dust pipes for the fan, care should be taken to have as few angles or bends as possible, so as to obtain a good current of air and also to avoid sharp curves or bends. Round elbows with a full sweep and round piping should be used for conveying dust or stock from a duster, or in fact any machine requiring to be thus connected. Sharp angles in dust pipes destroy the force of the air-current and are liable to become choked with refuse. The dust pipes should be as large as the opening of the fan casing and preferably of galvanized iron.

OPEN, OR CAGE, DUSTER

10. A duster occasionally used in small mills is shown in Fig. 5; it is of so simple a type as to require only a brief description. This is sometimes known as an **open, or cage, duster.** The machine consists of a large rotating horizontal cylinder covered with heavy wire screening. Inside the cylinder is a central shaft on which are fixed eight iron cross-bars about 5 feet long, these cross-bars being fixed to the shaft at different angles to one another. The cylinder is provided with a door through which the stock may be entered and removed.

In operation, the wool is placed in the duster and the iron cross-bars, which rotate, beat out all the dust and dirt from the wool and force it through the screen-covered cylinder. The great objection to this machine is that all the dust and dirt is discharged into the room, where the workmen must breathe the air. Another fault is that the operation is not continuous, the wool being placed in the machine in small lots, dusted, and removed, when another lot is introduced.

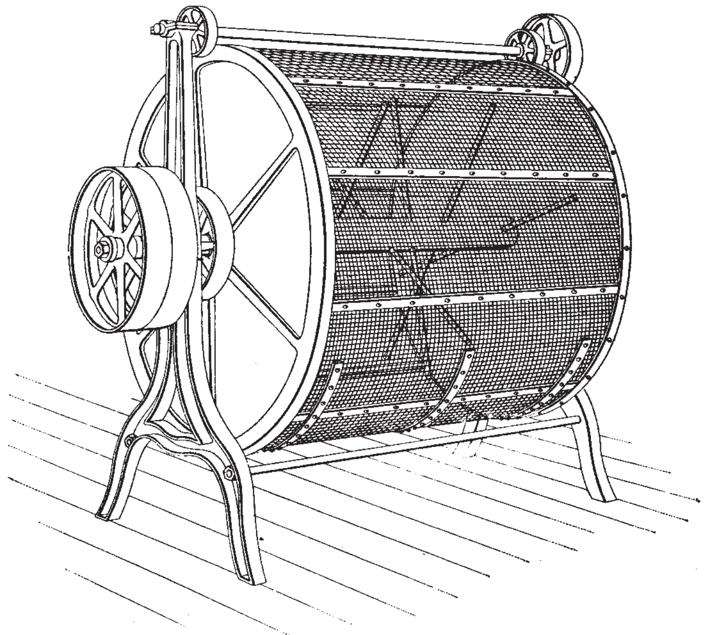


FIG. 5

The open duster does good work so far as the stock is concerned, but the slowness and expense of the operation, together with the unhealthy conditions caused by the dust, are fatal to its general adoption.

In England, a duster is known as a **willow** and this term is used to a limited extent in American mills.

SCOURING

11. Object of Scouring.—The operation that follows the dusting of the wool is known as **wool scouring,** or **washing,** and has for its object the cleansing of the wool from the natural and foreign impurities that, if not removed, would effectually prevent the wool from being worked in the after processes of manufacture. In the dyeing, particularly, great trouble is caused by imperfectly scoured wool and it has been found impossible to fasten the colors on such stock. The primary objects of wool scouring, therefore, are to cleanse the wool of the yolk, or natural preservative, a greasy matter that covers the outside of the fiber, and at the same time to remove such mechanically adhering impurities as dirt, pieces of manure, etc., that have not been loosened in dusting. The proportions of the different components of unwashed, or grease, wool vary greatly, but are usually included within the following limits:

	Per Cent.
Moisture	4 to 24
Yolk	12 to 47
Dirt	3 to 24
Wool fiber	15 to 72

From the above list, it will be seen that wool, as it is clipped from the sheep's back, is a very impure article and contains from 18 to 85 per cent. of impurities, the general average being in the vicinity of 60 or 65 per cent. These impurities may be classified in general under three heads: yolk; suint; matter mechanically fixed on the fiber by the yolk and suint.

IMPURITIES IN WOOL

12. Yolk.—In treating of the structure of the wool fiber, reference has been made to the greasy matter with which the wool of sheep is impregnated. This substance is termed **yolk** and is of great service during the growth of the wool in protecting the physical structure of the fiber from injury. While it is true that the wool grease is commonly termed yolk, it really consists of two distinct parts—the *yolk proper*, which consists of substances that require the use of soaps or solvents for their removal, and the *suint*, or portion that may be readily removed by the application of water only.

13. The **yolk proper,** or **wool fat,** as it is sometimes called, has a composite structure, and is composed of substances known as cholesterine and isocholesterine, both in an uncombined state and as salts of oleic and other fatty acids, the latter mainly stearic and palmitic. Wool fat is insoluble in water, but may be dissolved by such solvents as carbon bisulphide, benzine, naphtha, etc.; or it may be removed as an emulsion by the use of alkaline detergents. The removal of the wool fat necessitates the use of strong scouring agents, and were it not for this substance, the wool could easily be washed in pure water. In washing raw wool, therefore, if it contains an excess of this fatty matter it will be more difficult to scour thoroughly, and will require the use of more soap or alkali. Such wools are often termed **pitchy.**

14. Suint.—This is the portion of the wool grease that is soluble in water and is usually included under the general term of *yolk*, which is the common word for wool grease when considered as a whole. **Suint** is really the collected perspiration of the sheep, commonly called wool perspiration, and consists chiefly of potash salts, principally potassium oleate, palmitate, acetate, and other salts of organic acids. Potassium carbonate, chloride, sulphate, and phosphate (carbonate of potash, chloride of potash, etc.) are also present, as well as a small amount of ammonia (about .5 per cent.); these form the inorganic constituents of wool perspiration. From this it will be seen that the suint, or portion of the yolk soluble in water, is a valuable source of potash salts.

15. Yolk Ash.—In France and Belgium, it is customary to steep wool in tanks before scouring, in order to dissolve the wool perspiration. The dirty brownish water thus obtained is then evaporated in specially constructed furnaces, and a product procured, known as **yolk ash,** from which the potash salts can be recovered. It is said that certain heavily yolked wools will yield, when steeped in warm water, from 70 to 90 pounds of carbonate of potash, and from 5 to 6 pounds of potassium chloride and sulphate per 1,000 pounds of wool. The value of the potash salts obtained in this manner in France alone exceeds $500,000 per annum. In England and America, it is not customary to make any distinction between the wool fat, or true yolk, and the wool perspiration, or suint, the whole being removed in the one operation of scouring, and the waste water allowed to run away in the drains and rivers. Many thousands of dollars are wasted in this manner by American woolen mills, although of late some mills have been taking steps toward retaining these valuable by-products.

16. Analysis of Yolk Ash.—The yolk ash obtained from the water in which the wool is steeped consists of about 60 per cent. of organic matter and 40 per cent. of mineral, or inorganic, substances, these latter consisting largely of potassium carbonate. An analysis of the inorganic matter contained in the yolk ash gave the following results:

	Per Cent.
Carbonate of potash	86.78
Sulphate of potash	6.18
Chloride of potash	2.83
Other metallic elements, as lime, iron, phosphorus, alumina, etc.	4.21
	100.00

Whether wool is steeped for obtaining the potash salts or not, it is always necessary to scour it, since the steeping only dissolves the suint, or wool perspiration, and does not remove the wool fat, or true yolk. The preliminary steeping of the wool, however, is an aid in turning out the stock bright and lofty.

17. Earthy Matter.—The mechanically adhering impurities of wool consist mainly of **earthy material,** such as sand and dirt, which are held on the fiber by means of the greasy, sticky nature of the yolk and suint, to which they adhere or in which they are enveloped. The mechanical impurities are all foreign, and vary greatly with the character of the soil on which the sheep range, in some fleeces being gritty, and in others consisting of a loamy dirt. The percentage of these foreign substances varies greatly, being sometimes as low as 3 or 4 per cent., and in other cases as high as 20 or 25 per cent., of the total weight of the fleece.

In regard to the amount of weight lost by removing the yolk, suint, and dirt from wool in scouring, or in other words the shrinkage from a grease to a scoured basis, it may be said that there is considerable variation. Long luster wools do not contain as much yolk as those of shorter staple. Merino fleeces average only about 35 per cent. of clean fiber, 40 per cent. of yolk and 25 per cent. of dirt being removed during the preparatory processes of manufacturing. The average shrinkage of American wools may be said to be about 60 per cent., but it is in many seasons a little more than this.

SCOURING MATERIALS

18. The scouring agents in most common use for cleaning wools are soda ash, carbonate of soda, soda, or hard, soaps, potash, or soft, soaps, and ammonia.

19. Soda Ash.—This substance is really an impure form of carbonate of potash, as it contains from 65 to 95 per cent. of the pure carbonate. One of the great dangers in the use of **soda ash** as a scouring agent occurs, not from the carbonate of soda itself, but from the impurities found in connection with it. One of the impurities most likely to occur is caustic soda, which is injurious to wool even when present in only small quantities. A caustic alkali should not be used on wool or any other animal fiber, since in the presence of hot water free alkali will entirely dissolve the fiber, leaving in the case of wool a milky solution. Tepid water alone will swell the structure of the wool fiber and cause it to lose some of its luster and brilliancy; therefore, the danger of a caustic alkali in the warm (100° to 120° F.) scouring liquor is apparent.

To test soda ash for the presence of caustic soda, first dissolve a small amount in pure water; then add an excess of barium chloride and filter the solution. The filtered solution may now be tried with a piece of litmus paper, the presence of caustic soda being indicated by red litmus paper turning blue; a more delicate test is obtained by the addition of a small amount of phenol-phthalein, the slightest amount of caustic soda immediately turning the solution pink, while its absence will be indicated by the solution remaining colorless.

20. Carbonate of Soda.—This substance, which is the main constituent of soda ash, may be obtained in a very pure form and is the soda crystals, or washing soda, of commerce. It may, however, be tested for caustic soda in the same manner as soda ash, although it is usually free from any such impurity. The ordinary soda crystals contain 63 per cent. of water, but there are several other forms of sodium carbonate (one of which is known commercially as *crystal carbonate*) that are not open to this objection. **Carbonate of soda** is largely employed for scouring the coarser grades of wool, especially those that are very dirty.

21. Soda Soaps.—**Hard soaps** have soda as a base and are quite frequently used for scouring wool. Soda in any form, however, is not to be recommended for the very finest grades of wool. Soda soaps are made by treating caustic soda with any fatty acid; as, for instance, oleic acid, in which case sodium oleate, which is a hard soap, is formed.

22. Potash Soaps.—These soaps are made with potash as a base and are commonly called **soft soaps. Potash soaps** are made in the same manner as soda soaps, that is, by combining caustic potash with some fatty acid, in which case a soluble soap is obtained. It is commonly supposed that soft soap contains more water than hard soap, but such is not always the case. Soda soaps are hard and potash soaps soft because it is the nature of these two substances when used as the base of a soap to form hard and soft soaps, respectively. A soda soap may contain a much larger percentage of water than a potash soap and yet remain hard and firm. When proper precautions are not taken in manufacturing, any soap may be found to contain caustic alkali in a free, or uncombined, state. Potash soaps, contrary to the general opinion, may very frequently contain caustic potash. When this is the case, the soap may have a more severe action on the wool fiber than a soda soap or than even carbonate of soda. A quick test, and one often employed to test soaps for caustic alkalies, is to place a drop of phenol-phthalein on the soap, when a pink color will immediately indicate any free caustic alkali present.

23. Ammonia.—**Ammonia** is frequently added to carbonate and soap scouring liquors and aids in the removal of the yolk. Carbonate of ammonia, which may be obtained in commercial form, is rarely used. The liquid ammonia of commerce, which is added to the scouring bath in small quantities, contains only about one-third pure ammonia, the other two-thirds being water. Formerly it was the custom to scour wool with stale urine, or **lant.** This substance owes its detergent properties to the presence of ammonium carbonate. The wool was placed in tanks containing equal proportions of lant and water and poled around until the yolk and dirt were removed, when it was taken out and carefully drained and rinsed. This process gave results in many ways superior to the present methods. The action of the lant was mild and, when dry, the wool had that soft, *kind* feeling that it should be the aim of every scourer to obtain.

IMPURE SCOURING MATERIALS

24. Great care should be taken in purchasing scouring materials not only because of the necessity of obtaining an agent that will not injure the wool, but also because of the danger of obtaining an article of inferior scouring properties. There are many so-called patent soaps and scouring materials on the market, but they should, as a rule, be avoided, since they are usually expensive and are all based on the ordinary scouring agents with which every scourer is familiar. Soap is one of the easiest articles to adulterate and also one that is rarely tested unless poor results are traced directly to it. Soda soaps will contain a large percentage of water without any noticeable effect on the soap. For this reason, the manufacturer of the soap is liable to allow a large amount of water to be retained for the purpose of adding weight. To determine the amount of water in a sample of soap, weigh it carefully and then reduce to parings and dry in an oven until the sample ceases to lose weight. Then find the loss in weight, and the percentage of water is easily determined. There is a great loss of scouring power besides the inferior work done, if a soap contains resin, potato starch, or other impurities; in some cases earthy matter is added to a soap for the purpose of increasing its weight. Cases are on record where a potash soap has been analyzed and found to contain 40 per cent. of common salt, a substance of no value as a scouring agent.

A simple recipe for testing soap for impurities is to dissolve a small quantity in water and then add a little sulphuric acid to the solution. The acid breaks up the structure of the soap and all earthy and heavy adulterations fall to the bottom of the solution, while grease and resin, being lighter, float on the surface. The presence of resin in a soap is a disadvantage, especially in the soda soaps, where it most frequently occurs. Resin has a tendency to make the wool yellow; in fact, wool is very apt to have a more or less well-defined yellow tinge if scoured with soda in any form unless great care is taken.

THE SCOURING LIQUOR

25. It may be said that for the finest grades of wool, a fine quality of soap should be used, a well-made potash soap absolutely free from caustic alkali being preferred. The use of soda as an agent for scouring wools that are to be stored for some time before using, invariably results in the yellowing of the fiber and gives the wool a harsh feel. Especially is this true in regard to Australian and other fine wools. For medium and coarse grades of wool, where the strength of the fiber is such that it will resist the action of a stronger scouring agent, soda soap, carbonate of soda, or even soda ash may be used; but in all cases the scouring agent should be free from caustic alkali.

The amount of soap or other scouring agent used should be so regulated that no more than is actually necessary to remove the yolk and dirt is used, and the temperature of the liquor should also be as low as is consistent with the results desired. A potash soap for scouring fine wools should be neutral, and from 3 to 5 pounds should be used to each 100 gallons of water. Ammonia may be added to the liquor in small quantities, or part of the soap may be substituted with ammonia. The water used for the scouring should be soft, as hard water is detrimental, as will be explained later.

For coarse wool, the scouring bath should be made up with from 15 to 20 pounds of sodium carbonate to 100 gallons of water; and for medium grades, soap and carbonate of soda in combination may be used to advantage. Some scourers test the scouring liquor for strength by means of the hydrometer, using a carbonate-of-soda liquor of from 1° to 2° Twaddle, depending on the class of the wool to be treated.

26. Preparation of Scouring Liquor.—The scouring liquor may be prepared by first dissolving the detergent to be used in a pail of boiling water, which is constantly stirred. This makes a stock solution and is added to the heated water (100° to 120° F.) in the washer until an emulsion is formed of the right strength, that is soft and smooth to the fingers when dipped into it and rubbed together. A sample of wool may now be washed, by hand, in the liquor and the liquor squeezed out; if it springs with elasticity on being released and has parted with its grease and dirt, though its natural feeling has not been injured, the liquor is in good condition for scouring.

27. Strength of Liquor.—In scouring wool, the fineness and strength of the fiber should always govern the strength of the liquor used, not the amount of dirt and yolk in the wool, since the finer wools are often the heavier yolked and the fiber would be injured by a severe scouring agent.

In America, the suint is not removed from the wool by steeping before scouring, as in Continental Europe; thus the carbonate of potash that it contains will aid in the scouring of the wool and a smaller amount of scouring material will be necessary.

28. Temperature of Liquor.—In regard to the proper temperature of the scouring liquor, it may be said that a temperature that the hand can just comfortably bear is sufficient, from 100° to 120° F. being the heat generally allowed. The temperature should never be more than 120°, as under the most favorable conditions the natural qualities of the wool are liable to suffer, the luster especially being liable to be diminished. However, many scourers if working on very dirty clothing wools use a temperature as high as 130°, this being done, however, only because of the difficulty in scouring such stock clean. For scouring alpaca and mohair, the heat should be considerably less and should never be more than 100° F., since the luster of these fibers is of prime importance.

HARD WATER

29. As has been stated, **hard water** is detrimental to wool scouring, this being especially true if soap is used as a scouring agent. The substances that are usually found in hard water are various compounds of lime (calcium), iron, and magnesium, the most common substances being the various lime compounds. If water containing these substances is used for the scouring liquor, the soap is decomposed and the tallow and fat in it unite with the acids contained in the lime, iron, or magnesium compounds, which are also broken up, thus forming a lime soap. The disadvantage of this is that while ordinary soap is soluble and forms an emulsion, the lime soap is insoluble in water and is deposited on the wool in the liquor. This lime soap is a sticky, pasty substance and completely envelops the fiber, being almost impossible to remove; yet if the fiber is not cleansed, subsequent dyeing of the wool is attended with great difficulty and is liable to be uneven. Two kinds of hardness are liable to occur; namely, *temporary* and *permanent*.

30. Temporary Hardness.—Water that contains in solution bicarbonates of lime, iron, or magnesium is said to possess **temporary hardness,** since the water may be softened by simply boiling. The effect of the boiling is to drive off one-half of the carbonic acid, thus changing the soluble bicarbonates to insoluble monocarbonates, which are precipitated, allowing the softened water to be drawn off. This method of softening water, however, is too expensive for commercial purposes, since the softening takes place only gradually, and it is therefore necessary to boil the water for at least one-half hour.

31. Permanent Hardness.—Water that contains in solution chlorides or sulphates of lime, iron, or magnesium is said to be **permanently hard.** Boiling simply concentrates the hardness of permanently hard water.

If the water available for scouring is hard, means should be taken to soften it before using; otherwise, much of the valuable scouring materials will be wasted in neutralizing or softening the water, and even then there is danger of the results being impaired, owing to the insoluble lime soap being deposited on the fiber and not being thoroughly removed. Some mills arrange a system of pipes and tanks to catch, for scouring purposes, the rain water that falls on the roof. Rain water is always soft and an excellent water for this purpose. This method is not reliable, however, as during the dry season the mill is apt to suffer from a lack of water of this kind and other means must be used.

32. Softening Hard Water.—There are several methods of softening hard water and there is apparatus especially designed for this purpose; but for wool scouring the cheapest method is to precipitate the lime or other compounds with caustic soda. From 3 to 5 pounds of powdered caustic soda should be added to each 1,000 gallons of hard water, the amount added depending, of course, on the degree of hardness of the water. This will remove both temporary and permanent hardness and works as well with cold as with warm water. The caustic soda precipitates all the lime magnesium and iron salts as insoluble compounds, leaving the water soft and ready for use in washing wool.

EFFECT OF IMPROPER SCOURING

33. Wool properly scoured should be open and lofty and of a clear color; the luster of the fiber should not be impaired. Wool improperly scoured, with too high temperature, too strong liquor, or a liquor in which free caustic alkali is present, has a *harsh*, rough feeling. The fiber is also rendered stiff and brittle, is apt to be yellow in color, and much of the natural elasticity of the wool is injured. The serrations on the surface of the fiber are also injured and the value of the spinning and felting properties of the wool deteriorated.

a *b*

FIG. 6

Fig. 6 shows the appearance of two fibers of wool under the microscope; *a* is a fiber carefully scoured at a mild temperature and with a suitable detergent, while *b* is a fiber that has been injured by excessive heat or alkali. The appearance of the serrations on the fiber marked *b* shows why wool improperly scoured feels rough and harsh.

34. Effect of Soda.—It is contended by many persons that the use of soda in any form as a scouring agent will produce the results shown at *b*, Fig. 6, it being claimed that soda destroys the nature of the wool and renders it brashy and brittle. To a certain extent this is true, that is, when either soda soap or carbonate of soda is improperly used. It must be remembered that soda in any form is a much more powerful scouring agent than potash and therefore must be used in correspondingly smaller quantities. Potash being milder in its action and present in the wool itself, may be said to be a natural scouring agent; but on the other hand, many scourers, if working on a medium or coarse grade of wool, use carbonate of soda as a scouring agent, and the results obtained by proper treatment justify its use.

SUMMARY

35. The following rules for wool scouring are a summary of what has been previously stated and should be followed in all cases where the quality of the work is an object.

1. A fundamental rule is to use as weak a scouring liquor and as low a temperature as is possible to thoroughly remove the yolk.

2. Nothing but perfectly neutral soaps should be used for the best results, at any rate when the yolk is easily started from the fiber. A potash soap, free from caustic alkali, is to be preferred. When the wool is very dirty and the grease stiff and hard, a slightly alkaline liquor will cut the grease from the fiber more quickly; but the greatest care should be taken to prevent injury to the surface structure of the fiber.

3. The less the stock is agitated, the better will be the results, provided that the dirt is thoroughly removed. When the cellular structure of the fibers is swelled by the action of the warm scouring liquor, the wool is more liable to become felted than when in a dry state and, especially when worsted stock is being scoured, the greatest care should be taken to avoid felting and matting.

4. As the higher-lustered fibers, such as mohair and alpaca, are even more sensitive to heat and free alkali than wool, the greatest care should be taken in washing all fibers of this description where luster is important, both the temperature and strength of the scouring liquor being reduced with advantageous results.

5. The water for the scouring liquor should be soft and should not contain either organic or inorganic impurities, although the former do not occasion as much trouble as the latter.

THE SCOURING PROCESS

36. Introductory.—The old method of scouring wool, which was accomplished by means of kettles or tanks in which the wool was worked in the scouring liquor and rinse boxes in which the stock was rinsed, has given way to scouring by means of scouring, or washing, machines. The method of immersing the wool in solutions of lant, while it gave excellent results owing to the mild action of the lant, was apt to roll and mat the stock by the excessive poling to which it was subjected during the process.

The old process of wool scouring is frequently used today in small concerns, with the exception that potash and soda soaps or carbonate of soda have entirely replaced lant as scouring agents. The stock to be scoured is thrown into tanks that contain the scouring liquor, and worked with poles for 15 or 20 minutes in order to remove thoroughly the yolk and dirt from the wool, which is then forked out and allowed to drain on wooden racks and is afterwards rinsed with pure water in another tank. The great disadvantage of this method is that, in the poling and forking, the stock becomes more or less rolled and felted, causing the fibers to be broken when the wool is burr picked and carded, thus reducing its value proportionately. Modern scouring machines have been constructed, therefore, with a regard to keeping the stock in an open and lofty condition as well as cleansing it of its yolk, or natural grease, and are so arranged as to agitate the wool as little as possible consistently with removing the impurities; and since this is the case the stock should come from the washer open and lofty, free from grease and dirt, and having a bright, natural color with the luster but little impaired.

The essential parts of a scouring machine are a long bowl, or tank, which contains the liquor; a mechanism for propelling the stock through the bowl; at one end a feed-apron, and at the other a pair of heavy squeeze rolls equipped with weights for the purpose of squeezing the liquor from the stock and returning it to the bowl. The machines should be so constructed that two or more may be coupled together, making a combination of two, three, or four bowls as is desired.

THE RAKE WOOL WASHER

37. A type of washing machine that was formerly used to a great extent is the **rake machine,** which consists of a long bowl *a*, Fig. 7, with the usual feed-apron and squeeze rolls, the stock being propelled through the liquor in the bowl by means of **stirring,** or **stirrer, forks,** or **rakes,** marked *b*, which are actuated by cranks *c*. In Fig. 7, will be noticed the method of operating the rakes by means of the cranks driven by bevel gears from a central shaft *d*.

The wool on entering the bowl that contains the scouring liquor is immersed by the **duckers,** or extra tines, *e* attached to the first rake and then passed along through the scouring liquor by the rakes. A carrier *f* then takes the stock from the liquor and passes it between a pair of heavy press rolls, which remove the excess of liquor from the saturated stock. There is a tendency in this machine to string the stock in long ropes, owing to the action of the forks, which move in the arc of a circle. Many of these washers are in use today, but they are being supplanted by improved machines.

THE PARALLEL RAKE MACHINE

38. Construction.—This machine may be said to be the best type of wool washer in use at the present day and is largely employed in the scouring plants of American

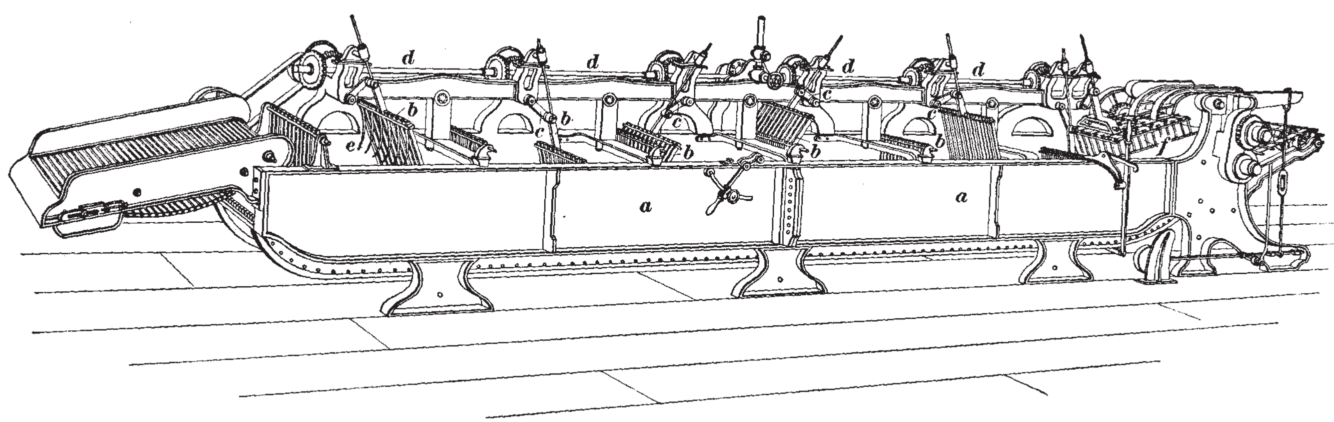


FIG. 7

mills. The main features of this washer are shown in Fig. 8; it will be seen that it consists primarily of a long iron bowl, which is built in different lengths and widths according to the capacity of the machine. The bowl is usually made 16, 21, 27, or 32 feet in length, the sides being made in sections so that any desired length may be obtained. (Fig. 8 illustrates one of the shorter machines.) The width of the bowl varies from 24 to 48 inches.

The bowl is furnished with a suitable exhaust pipe, through which the liquor can be flushed when too dirty for further use, and is made water-tight so as to retain the scouring liquor. Water is supplied by means of suitable pipes, and the bottom of the bowl is fitted with removable perforated brass or copper plates, which allow the sediment

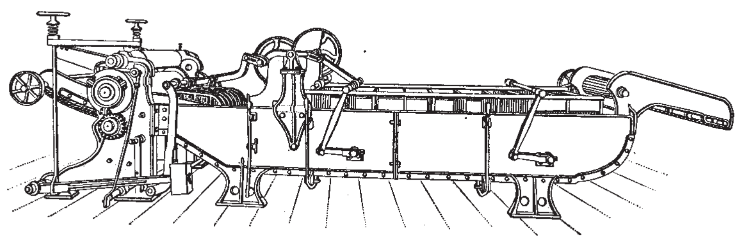


FIG. 8

of the scouring liquor to be deposited underneath them so as to keep the wool from coming in contact with the dirt removed by the scouring. The bowl also has valve and pipe connections for supplying steam to the liquor in order to heat it to the right temperature, and should be filled with liquor to within about 3 inches of the top. In order to save time in replenishing the bowls, a good arrangement is to have a hot-water tank heated by steam from which hot water can be run into each bowl.

39. Rakes.—The most important feature of this machine, and the one that led to its supplanting the old-fashioned rake machine, is the motion of the rakes, which will be explained with reference to Fig. 9, which shows a larger machine of the same type as Fig. 8. At one end of the bowl is a feed-apron, or lattice, *a* of the usual construction, on which the

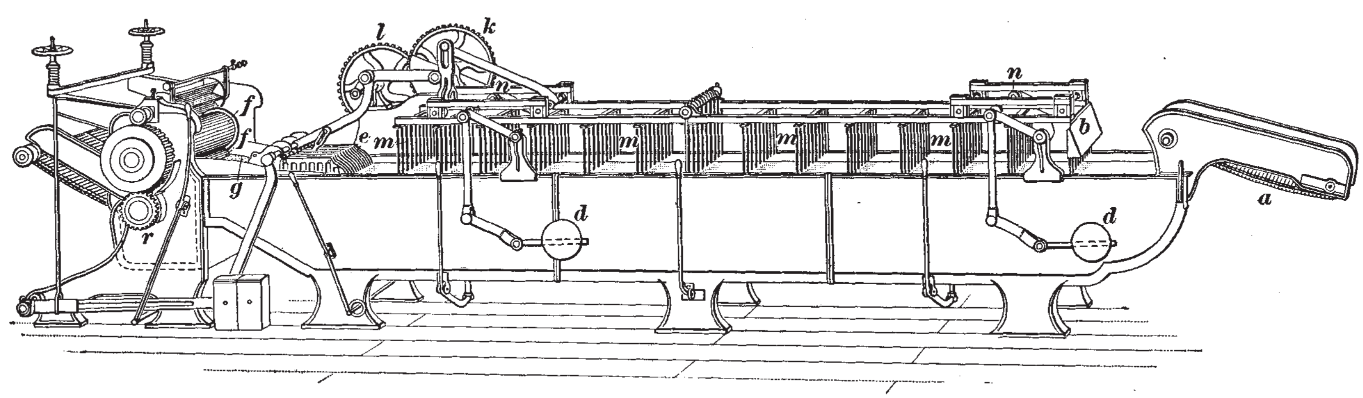


Fig. 9

stock to be fed to the washer is evenly spread. The rakes *m* that propel the stock through the liquor are constructed of brass or forged-iron tines, and are fastened to a frame so that they all move in unison. The weight of the rakes is balanced by means of the weights *d*, which relieve the strain on the working parts of the machine when imparting motion to the rakes.

The motion of the rakes is derived from the main shaft of the washer, which is not shown in Fig. 9, being on the opposite side of the machine. This shaft should run about 56 revolutions per minute, and carries a gear of 18 teeth, which meshes with the gear *k*, shown in Fig. 9, having 144 teeth. This gear actuates the rakes by means of a crank through suitable levers, which are so arranged as to result in a rectangular motion, the whole rake frame when actuated by the crank and levers sliding forwards on small rolls placed at *n*. The forward motion of the rakes is generally arranged so as to be about 14 inches.

The rakes drop into the liquor perpendicularly, and when the points of the rake tines are close to the perforated false bottom of the bowl they move forwards in a straight line, carrying the stock with them. When the end of the motion is reached, the rakes are withdrawn from the liquor in a vertical direction and travel back to their first position with the tines clear of the liquor. By this motion, the wool is carried forwards in practically a continuous film with no danger of stringing or felting. Attached to the end of the rake frame at *b* is a **ducker,** or **immerser,** which plunges the wool under the surface of the liquor as it enters the bowl, thus remedying the fault of the stock's floating on the surface of the liquor for some distance.

40. Carrier.—There is a **carrier** at the end of the bowl for the purpose of taking the stock from the liquor and delivering it to the heavy squeeze rolls; this is shown at *e* and consists of an arrangement of brass fingers, or tines. In its forward motion, it carries the stock over a perforated brass table *g*; in its backward motion it is lifted over the wool and returns to its former position, moving forwards again with a fresh supply of stock. The carrier is operated by means of a crank connected with a gear *l* of 118 teeth, which is driven by a gear of 60 teeth on the main shaft of the machine, on which there are also tight and loose pulleys, 24 inches in diameter, for driving. The speed of the carrier is much faster than that of the rakes, as will be understood by the gearing, the carrier making nearly four motions to one of the rakes; thus there is no chance for the stock to accumulate and roll at the delivery end of the bowl, and the feed to the squeeze rolls is rendered more even.

41. Squeeze Rolls.—The carrier takes the wool to a pair of heavy squeeze rolls *f* that remove the excess of liquor and pass the stock forwards to a traveling apron that drops it on the floor or into a truck. The bottom squeeze roll is sometimes made of brass, but generally a steel roll is used. The great objection to brass for squeeze rolls is that it wears unevenly when in actual operation, and unevenness in squeeze rolls is to be avoided. The top squeeze roll is able to make a slight vertical movement and may be covered with rubber, waste, or cloth, a good rubber-covered roll being preferred, although its expense does not always warrant its adoption. If the top roll is wound with waste, care should be taken to use only pure woolen or worsted waste, because if cotton is used, and the covering wears, the cotton will become mixed with the wool that is being washed, causing specks in the cloth when dyed. Waste- and cloth-covered rolls give excellent service and are inexpensive.

The roll should be springy in order to pass the stock forwards without injury, which is liable to occur owing to the great pressure that is obtained by means of a combination of levers and weights. The weight of the squeeze rolls varies from 1,000 to 1,200 pounds each, and the amount of pressure applied varies from 6 to 8 tons, depending on the amount of stock that is being passed through the washer; the more stock going through the rolls, the greater should be the pressure in order to remove the scouring liquor.

The bite of the rolls is a little above the level of the scouring liquor, which is retained by means of a water-tight partition. The wool in passing to the squeeze rolls does not emerge from the liquor but passes along, actuated by the carrier, in an even sheet. In some machines the bite of the squeeze rolls is at least 6 inches above the level of the liquor in the bowl instead of nearly level as it should be. The consequence is that the carrier pushes the stock up the inclined perforated plate until a considerable quantity accumulates, when it is caught by the rolls and passes through in a bunch, being imperfectly squeezed and often breaking the gear on the end of the squeeze-roll shaft. A receptacle is shown, by dotted lines, at *r* into which the liquor squeezed from the stock by the squeeze rolls falls, and from which it is removed by a small pump on the floor, which discharges through suitable pipes into the bowl near the feed-end of the machine. In operation, the stock is fed to the machine on the feed-apron by hand, or by a self-feed, in which case the apron is dispensed with, the feed dropping the stock directly into the scouring liquor. Occasionally, the wool is discharged from the duster directly into the washer.

42. The wool, being open and lofty, has a tendency to float on the surface of the liquor but is immediately immersed by the copper ducker *b*. The rakes, descending perpendicularly into the stock and then moving forwards in a direction parallel to the bottom of the bowl, convey it without any unnecessary agitation toward the delivery end of the machine, where it is acted on by the carrier *e*. In its passage through the bowl, the impurities are removed by the action of the liquor, and the particles of sand and dirt are loosened from the grease that previously held them to the fiber and drop through the perforated false bottom of the bowl. The carrier then takes the stock from the bowl in an even web and carries it over the perforated table to the squeeze rolls *f*, where the liquor is extracted and the wool passed to the delivery apron, from which it falls either to the floor or into a truck. The wool is now taken to a rinsing tank, through which there is a strong current of water passing. The water used for rinsing should be soft and free from alkali; otherwise, an insoluble lime compound will be formed with any soap that remains on the fiber; and this being a pasty, sticky substance removed only with difficulty, the subsequent dyeing of the stock will be uneven.

HYDRAULIC WASHER

43. A type of scouring machine known as the **hydraulic washer** is sometimes, although not frequently, met with in American mills. This machine, as its name indicates, carries the wool through the bowl by means of a current of liquor without the use of rakes. The liquor pours from a long inlet extending across the machine at the feed-end, and is supplied by a pump that takes it from a compartment under an inclined carrier table at the delivery end. The wool, as it enters the bowl, is submerged by a revolving drum, and is then carried along by the current of warm liquor to the inclined table and carrier and is delivered in an unbroken web, or film, to the squeeze rolls. As the web passes through the machine in the liquor, it is operated on by duckers that tilt without breaking or otherwise disturbing it. This aids the scouring liquor to remove the larger particles of dirt, which fall through a perforated false bottom.

44. Combinations of Washers.—The description so far given has dealt with a single-bowl machine, but it should be remembered that these washers are built so that they may be arranged in combinations of two or more bowls. In the case of the two-bowl combination, the first bowl contains the scouring liquor, while the second bowl may contain a weaker scouring liquor or be used as a rinsing bowl, thus doing away with the rinse box and consequent handling of the stock.

Scouring machines are coupled together in this manner in combinations up to four bowls for special stock, such as some kinds of carpet wools. The three-bowl combination is used in many mills for fine stock, especially for combing wools. The first bowl contains a strong scouring liquor;

the stock passes through a pair of squeeze rolls into the second bowl, which contains a weak liquor; and then to the last bowl, which is used as a rinser when scouring stock for woolen yarn, but when scouring combing wools is filled with a weak scouring liquor. Combing wools for worsted yarn are never rinsed. It may be said that the best results are obtained by the use of four bowls in the case of dirty clothing wools, the first three containing scouring materials and the fourth tepid water only. This combination will give better results than the three-bowl combination so often used. When the liquor in the first bowl becomes too dirty to use, it is flushed out and the liquor in the second bowl is then run into the first and raised to the required strength, while fresh liquor is made for the second. The production of such a combination is from 8,000 to 12,000 pounds per day, according to the condition of the stock.

In combinations like those described, an extra function is performed by the squeeze rolls. The wool very often contains hard lumps of manure, dirt, and solidified grease, which cling to the fibers with more or less tenacity, but as they pass through the squeeze rolls from one bowl to the next they are broken up and easily removed by the second immersion. The squeeze rolls between the bowls also prevent the dirty liquor of the first bowl passing into the liquor in the second bowl, etc., thus rendering it dirty more quickly than would otherwise be the case. A single-bowl machine requires about 3 horsepower for driving purposes.

SELF-FEED ATTACHMENTS TO SCOURING MACHINES

45. There are three methods of feeding the stock to wool washers in common practice: (1) Allowing the duster to discharge directly into the bowl of the washer; (2) spreading the stock on a feed-apron, which conveys it to the bowl of the washer and drops it into the scouring liquor; (3) by means of a **self-feed,** of which there are several suitable machines.

The advantages of a self-feed are apparent, one of the greatest being that the machine fed by this means does not require the constant attention of a workman, as all self-feeds are provided with a hopper large enough to hold the stock for 15 or 20 minutes' feeding. In Fig. 10 is shown a self-feed that is built with especial reference to feeding wool

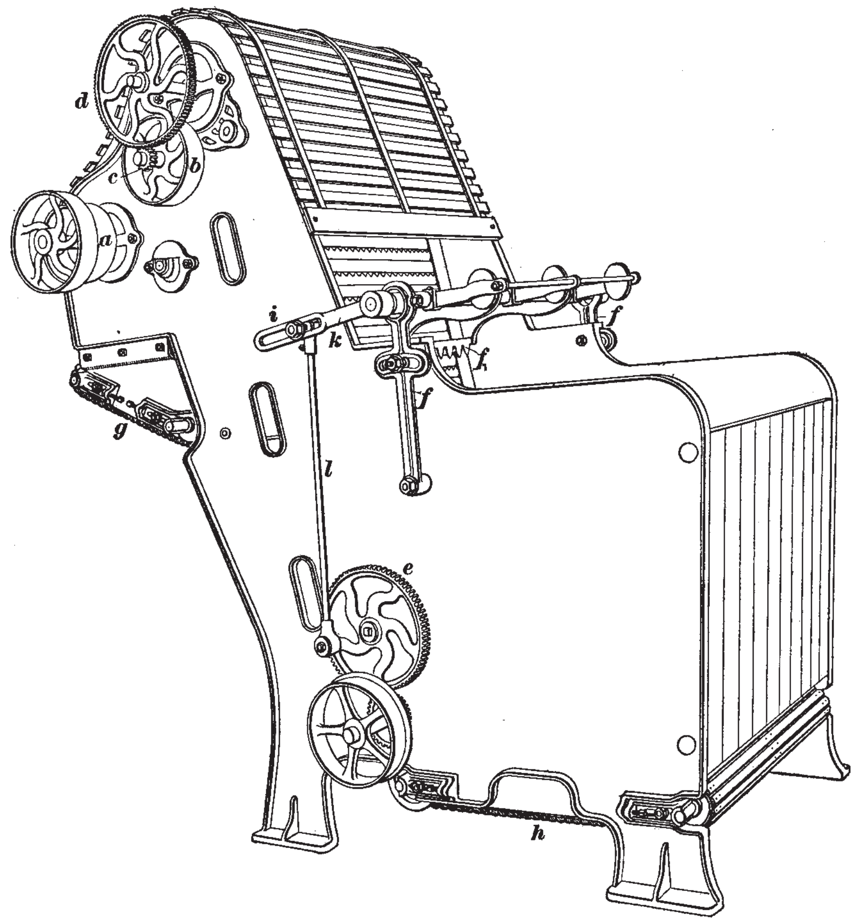


FIG. 10

washers. The main object of this machine is to feed the stock continuously and uniformly to the washer; another object, although a subsidiary one, is that of opening out the stock, rendering it easier for the scouring liquor to penetrate.

46. The principle of the feed is that of a spiked lifting, or elevating, apron, which extracts an amount of stock from the mass in the feed-box, or hopper, in excess of what is needed, the excess being removed by means of an oscillating comb. A stripping, or doffer, beater is so arranged in connection with this apron that the wool which it conveys may be removed from the apron and passed to the machine to be fed. The framework of the feed is of iron, with the exception of the rear of the hopper, which is enclosed with boards. The top of the machine is enclosed with a flexible covering composed of wooden strips, or slats. The elevating apron is made of half-round slats, generally maple, securely riveted to four belts, and is filled with sharp spikes about $1\frac{1}{4}$ inches apart. The apron is driven by means of a pulley *a* on the beater shaft, which drives a pulley *b* on a stud. Attached to this pulley is a gear *c* that drives a gear *d* on the shaft of the top roll of the lifting apron. The gear *c* is the change gear for altering the speed of the apron; an increase in its size drives the elevating apron faster and gives a heavier feed to the washing machine. In the bottom of the hopper is a traveling apron *h* for the purpose of keeping the stock constantly pressed against the elevating apron, thus insuring a constant supply of wool for the lifting apron as long as there is any left in the hopper.

The oscillating comb f_1 is driven by a crank from a gear *e* on the side of the machine. There is a slot *i* in the lever *k* attached to the comb shaft, which allows a change in the position of the connecting-rod *l*, thus increasing or decreasing the throw of the comb. Provision is also made for moving the comb closer to, or farther from, the lifting apron by means of slots in the stands *f* that carry the comb shaft. This allows an alteration in the feed of the machine at this point, as the nearer the comb is placed to the apron, the more stock will be knocked back into the hopper and the lighter will be the feed. The spiked apron on the rear side passes over a binder roll, making an angle with its front side. The doffer beater that strips the stock from the apron is placed at the vertex of this angle, thus helping to prevent the beater from winding with stock. The beater is usually constructed with four blades attached to spiders on the beater shaft. The beater shaft carries the main driving pulley of the machine and should make about 150 revolutions per minute.

Beneath the doffer beater is a doffer apron *g* on which the stock drops and is carried to its edge, from which it drops into the scouring liquor in the washing machine. This apron is not absolutely necessary, as the beater will allow the stock to drop in practically the same manner; the machine is therefore built either with or without the apron, as desired.

47. In operation, the stock, which has been dusted to remove as much of the loose dirt as possible, is placed in the hopper of the feed, the traveling apron at the bottom keeping it pressed against the lifting apron, the spikes of which are inclined upwards and catch the fibers and locks of wool. The stock is thus lifted to the oscillating comb, which is balanced so as to run smoothly and which knocks off large bunches of wool clinging to the apron. This process makes the feed more uniform and the apron is more evenly loaded. After passing the comb, the stock is carried over the top of the elevating apron to the beater, which takes it from the apron and either throws it directly into the scouring liquor or on the traveling apron, which drops it into the washer. When connected to a scouring machine, this feed occupies a space 6 feet 8 inches in length and is adapted to all kinds of grease wools, including long and coarse carpet wools.

SOLVENT PROCESS

48. Mention has been made that certain volatile liquids, as for instance, *naphtha*, *benzine*, and *carbon bisulphide*, will entirely dissolve the yolk of wool. On this fact there is based a new method of scouring wool known as as the **solvent process.** This method of cleansing wool of its natural grease, while not adopted to a universal extent on account of the expense of proper apparatus for treating the wool, has been introduced in a few of the largest mills in the country; and it is claimed that the results fully warrant the expense of the equipment, especially where large amounts of combing wool are to be cleansed. By this process, the stock to be scoured, or rather degreased, instead of being immersed in a soap or carbonate scouring liquor, is treated with naphtha in large tanks, or *keirs*.

49. The wool is stripped of its grease by the naphtha and emerges from the closed compartments without the slightest odor, as the liquid is volatile and does not remain in contact with the fiber. The whole process is carried on in the presence of some inert gas that will not form explosive combinations with naphtha nor with air, carbon dioxide being generally used for this purpose; this gas also acts as an extinguisher of fire. The object of this is to guard against the danger of explosions and fires, which are a constant menace where large quantities of explosive liquids, like naphtha, are used. Not only is the degreasing accomplished in the presence of this gas, but the gas is compressed and serves as a motive power for conveying the naphtha through the various *digesters*, etc., that are necessary in an equipment for scouring by this process.

The plant of one large mill that has introduced this method of scouring is so perfect that, although thousands of gallons of naphtha are in motion, there is not the slightest odor to indicate its presence about the works. After being treated with the naphtha, the stock is carried at once to ordinary washing machines, in which it is passed through tepid water only (sometimes, however, a little soap is used); from these it issues absolutely clean and sweet, brilliantly white, and in a perfect workable condition. The previous treatment requires the minimum mechanical action on the fiber in the washing machines, and no highly heated water nor unnatural soaps and alkalies come in contact with the fiber, the potash that occurs naturally in the wool being of sufficient quantity to remove the dirt completely when the wool is treated with warm water in the washing machine.

None of the staple or fiber is broken by this process; neither is the wool tangled nor matted, as is likely to occur in the ordinary method of washing; and the amount of waste in the succeeding processes is greatly reduced. The wool grease, which is known under the French term of **degras,** is retained by this process and forms a marketable by-product largely used in the manufacture of leather and also in the preparation of oils for use in the manufacture of woolen and worsted yarns.

THERMOMETERS

50. A **thermometer** is an instrument for measuring (in degrees) the temperature, i. e., the amount of heat present either in the air or in any other body. The most common form consists of a glass tube sealed air-tight and containing a small amount of mercury, or, as it is commonly known, *quick-silver*. For its effectiveness, the instrument is dependent on the expansion and contraction of mercury under different conditions of heat and cold, thus causing the column of mercury to rise or fall in the glass tube as the case may be, the reading being obtained by means of a graduated scale that registers the height of the mercury column, in degrees.

51. There are three standard thermometers in use; namely, the *Fahrenheit*, *centigrade*, and *Réaumur*. The **Fahrenheit thermometer** is the one most generally used in America for ordinary purposes. The **centigrade thermometer** is sometimes known as the **metric thermometer** and is generally used for scientific and experimental work. This thermometer is the simplest and will no doubt, in time, come into general use. The **Réaumur thermometer** is of very little importance in America, although it finds a limited use on the continent of Europe.

There are two constant, or standard, temperatures on a thermometer, the freezing and boiling points of water, and the different thermometers vary only in the methods of graduating the degrees of heat or cold. The boiling point of water is indicated on the Fahrenheit thermometer by

212°, on the centigrade by 100°, and on the Réaumur by 80°. The freezing point of water is indicated on the Fahrenheit system by 32°, and on the others by zero. In other words, zero Fahrenheit indicates a lower temperature than zero centigrade, while 100° centigrade indicates a higher temperature than 100° Fahrenheit, etc. Fahrenheit readings are indicated by the letter F. following the indicated number of degrees, centigrade by C., and Réaumur by R.

52. Interchanging Thermometer Readings.—The following rules will enable the student to transpose Fahrenheit and centigrade readings from one system to the other.

Rule I.—*To change Fahrenheit readings to centigrade, subtract 32° from the Fahrenheit reading and multiply the remainder by* $\frac{5}{9}$.

EXAMPLE 1.—Change 140° F. to centigrade.

SOLUTION.— $C. = \frac{5}{9}(140° - 32°) = \frac{5}{9} \times 108° = 60°$. Ans.

Rule II.—*To change centigrade readings to Fahrenheit, multiply the number of centigrade degrees by* $\frac{9}{5}$ *and add 32°.*

EXAMPLE 2.—Change 40° C. to Fahrenheit.

SOLUTION.— $F. = (\frac{9}{5} \times 40°) + 32° = 104°$. Ans.

SPECIFIC GRAVITY

53. Definition.—The **specific gravity** of a body is the ratio between its weight and the weight of a like volume of some other substance taken as a standard, which must be invariable. For solids and liquids the standard adopted is pure, or distilled, water at a temperature of 4° C., or 39.2° F.

Rule.—*The specific gravity of a solid or liquid is equal to its weight divided by the weight of an equal volume of pure water at 4° C.*

EXAMPLE.—If a given volume of olive oil weighs 115 grains and a like volume of water at 4° C. weighs 125 grains, what is the specific gravity of the oil?

SOLUTION.— $115 \div 125 = .92$. Ans.

It will be noticed that in this case the specific gravity of the oil is a fraction; this indicates that the oil is lighter than water for equal volumes.

HYDROMETERS

54. For the more convenient determination of the density of liquids, instruments called **hydrometers** are used. The form of hydrometer generally used in mill work is the constant-weight hydrometer, shown in Fig. 11, which consists of a glass tube near the bottom of which are two bulbs. The lower, or bottom, bulb is loaded with shot or mercury in order to make the instrument float upright, while the upper bulb contains enclosed air, which makes it lighter than water. The point to which the hydrometer sinks when placed in pure water is marked zero and the tube is graduated above and below zero, the graduation being sometimes on a piece of paper placed within the tube. As a long tube would be inconvenient, it is customary to have two instruments, one having the zero near the top for liquids heavier than water (the hydrometer rising according to the density of the liquid) and another having zero near the bottom for liquids lighter than water.

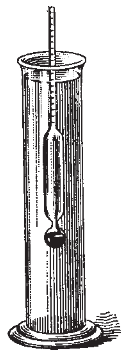


FIG. 11

If any substance is dissolved in water, the liquid becomes heavier and more dense. This density is registered in degrees on the hydrometer. For liquids lighter than water the specific-gravity value is commonly used. Two hydrometers are commonly used as standards; namely, *Baumé's* and *Twaddle's*.

Twaddle's hydrometer is almost exclusively used in England, while in the United States and on the continent of Europe the Baumé hydrometer is more generally in use. Twaddle's hydrometer bears a direct relation to the specific gravity of a body, while the Baumé hydrometer with zero in pure water as a starting point, assumes a density according to the percentage of saturation of pure water with common salt.

The table on the opposite page gives a comparison of Baumé and Twaddle hydrometer degrees.

COMPARISON OF BAUMÉ AND TWADDLE HYDROMETERS

Baumé Degrees	Twaddle Degrees	Baumé Degrees	Twaddle Degrees
1	1.4	18	28.4
2	2.8	19	30.4
3	4.4	20	32.4
4	5.8	21	34.2
5	7.4	22	36.0
6	9.0	23	38.0
7	10.2	24	40.0
8	12.0	25	42.0
9	13.4	26	44.0
10	15.0	27	46.2
11	16.6	28	48.2
12	18.2	29	50.4
13	20.0	30	52.6
14	21.6	31	54.8
15	23.2	32	57.0
16	25.0	33	59.4
17	26.8	34	61.6

WOOL DRYING

INTRODUCTION

1. After wool has been scoured, it is necessary to dry it before passing it on to the next process of manufacturing, except when the wool is to be dyed in the raw state. When this is the case, the stock is taken to the dye house direct from the squeeze rolls of the washer, although a slight extraction of the water may be made in some instances by means of the hydro-extractor, a machine that will be described later.

2. Importance of Proper Drying.—The **drying** of the wool is an important process and one on which the condition of the stock as it is received at succeeding processes largely depends. Wool that is dried quickly with a high temperature, has a harsh, unkind feeling, and the fiber loses its suppleness, becoming stiff and brittle; the elasticity and strength of the stock are materially reduced. It is impossible to spin harsh, brittle stock into fine yarn, so that the value of the stock is deteriorated, as the finer the yarn a wool will spin, the greater is its value. If stock capable of spinning to fine numbers is rendered fit only for low numbers of yarn, because of an improper method of drying, there is always a consequent loss to the mill. Cloth made from wool thus maltreated will not have the desired soft, velvety feeling, but will be harsh and rough, the yarn spun from such wool being uneven and lacking in strength and elasticity, and requiring an excessive twist in order to have strength enough to weave.

Formerly wool was dried by spreading it in the open air and allowing the sun and wind to dry it naturally. This method, although slow and laborious, had many advantages over modern methods, and the stock when thoroughly dried was soft and kind to the touch, none of its natural qualities being injured. The modern process of drying stock with artificial heat, while accomplished with greater speed, is liable if not carefully performed to destroy the life of the wool and render it harsh. Wool that is overheated and baked will also change color and become a dirty yellow shade. The percentage of waste in carding, spinning, and weaving will be increased if the wool is rendered harsh and brittle in the drying, and consequently the cost of the finished product, although it is of inferior quality, will be increased.

From this it will be seen that one of the chief points to be observed when drying wool is to avoid high temperatures; but as it takes longer to dry wool at a low temperature, there is a tendency in some mills to increase the temperature in order to reduce the cost of drying the stock, the fact being ignored that by so doing the saving in time is taken out of the value of the wool, and that the cost of carding, spinning, weaving, and finishing is increased relatively more than the cost of the drying is reduced.

METHODS OF DRYING WOOL

THE COLD-AIR PROCESS

3. There are two general methods of drying wool, the *hot-air* and the *cold-air process*, the former being the modern process largely in use in American mills, while the latter, although a somewhat older process, is sometimes used where the best results are desired, especially for drying fine combing wools.

The cold-air process gives results that are very satisfactory, but is slow, laborious, and expensive, as regards the time required and labor necessary for handling the stock. The wool, however, is left open, lofty, and ready, without any injury to the fiber, for the succeeding operations, not being rendered harsh and brittle by baking as is sometimes the case with stock dried by the hot-air system, nor is there the danger of yellowing the fiber.

TABLE DRYER

4. The **cold-air process** of drying involves the use of a **table, or platform, dryer.** The principle involved in a table dryer is that of either drawing or forcing air, ordinarily at the normal temperature, through the wet wool, which is spread on wire screens. These screens are so arranged that there is an enclosed space underneath them from which the air may be exhausted by means of a fan, thus drawing a current

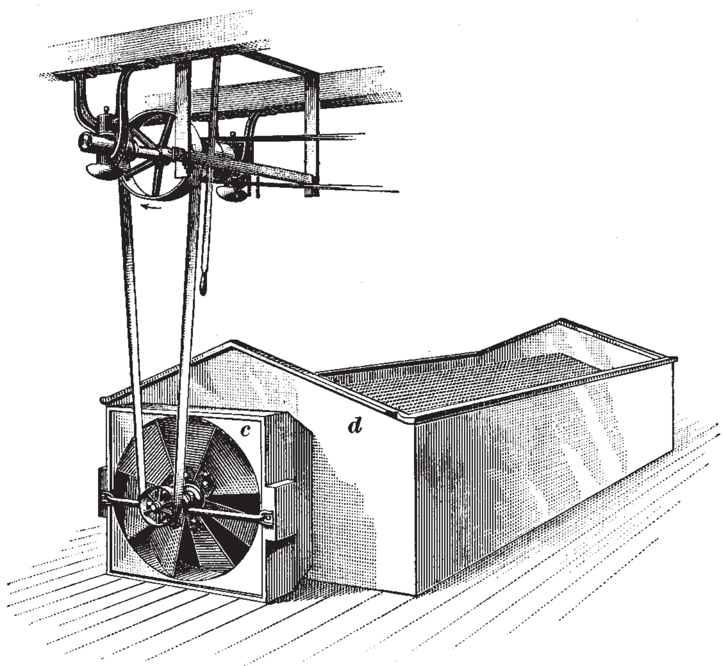


Fig. 1

of cold air through the wool; or the air may be forced by the fan into the enclosed place under the screen and thus blown through the stock spread on the screen. This latter method is to be preferred, since any process of forcing the air through the stock gives better results than by drawing it, because the wool is rendered more lofty and open when it is lifted by the air-current than when pressed against the screen, in which case it tends to dry in matted bunches. An ordinary arrangement of a table dryer is shown in Fig. 1.

The machine consists of a wooden, box-like framework *d*, made air-tight with the exception of the top, which is covered with wire screens. At one end, a paddle-wheel fan *c* is attached, being made with an iron frame having a circular opening in which the bearing of the rotating portion is enclosed.

The fan is of the reversible type and may be used either for blowing or for suction. In this case, as the arrow on the main driving pulley indicates, the fan is creating an induced, or suction, draft. A fan with curved blades has considerably greater efficiency than one with straight blades. A fan of this type, however, cannot be reversed.

Occasionally table dryers are operated with warm air, which is forced through them by a fan placed in a separate compartment containing steam coils. This arrangement is sometimes varied by building the dryer as shown in Fig. 1 and placing steam pipes under the screen, the fan forcing the air through the pipes and screen. The disadvantage of using heat in a table dryer is that the heat is unconfined and the operation of drying is attended with more or less inconvenience to the operator. The speed of a fan for a table dryer should be from about 1,000 to 1,200 revolutions per minute.

The principal objection to a table dryer is the slowness of the operation and the lack of continuous motion, as each lot of stock must be spread wet on the screen of the dryer and when dry removed by hand. Such a dryer as shown in Fig. 1 can easily be constructed by an ordinary carpenter, with the exception of the fan, which must be purchased. Fans suitable for table dryers are usually made in sizes from 30 to 40 inches in diameter.

HOT-AIR PROCESS

5. The general method of drying wet wool from the washing machine is with some form of hot-air dryer, of which there are several of standard manufacture on the market. The drying machines in some mills are fed directly from the washers, while in others the wool is first placed in a hydro-extractor and the excess of moisture removed, after which it is fed to the dryer either by a self-feed or otherwise.

When fed directly from the scouring machine, the wool is transferred to the dryer by means of an endless apron, or lattice. This is a very economical way of manipulating the stock, as there is no handling from the time the greasy stock is placed in the self-feed of the scouring machine until it is deposited, all scoured and in a dry and lofty condition, by the delivery apron of the drying machine.

The wool is dried in a hot-air dryer by means of warm air heated by steam pipes placed either in a separate compartment or in the dryer itself and circulated by means of fans. The circulation of the heated air is a matter of prime importance, since it is generally conceded that two things produce harshness and a yellow color in drying; namely, too high a temperature and a lack of circulation, in other words a baking of the stock.

MULTIPLE-APRON DRYER

6. This type of dryer is used to a considerable extent in woolen mills, and while not so good as some other types, excellent results may be obtained with proper precautions in regard to temperature. These dryers are generally made with three or five carrying, or drying, aprons, hence the name **multiple-apron dryer.**

7. Construction.—A section of a five-apron dryer is shown in Fig. 2; it will be seen that the principle of this machine is simply that of carrying the wool through a heated chamber by means of traveling aprons. This dryer is usually

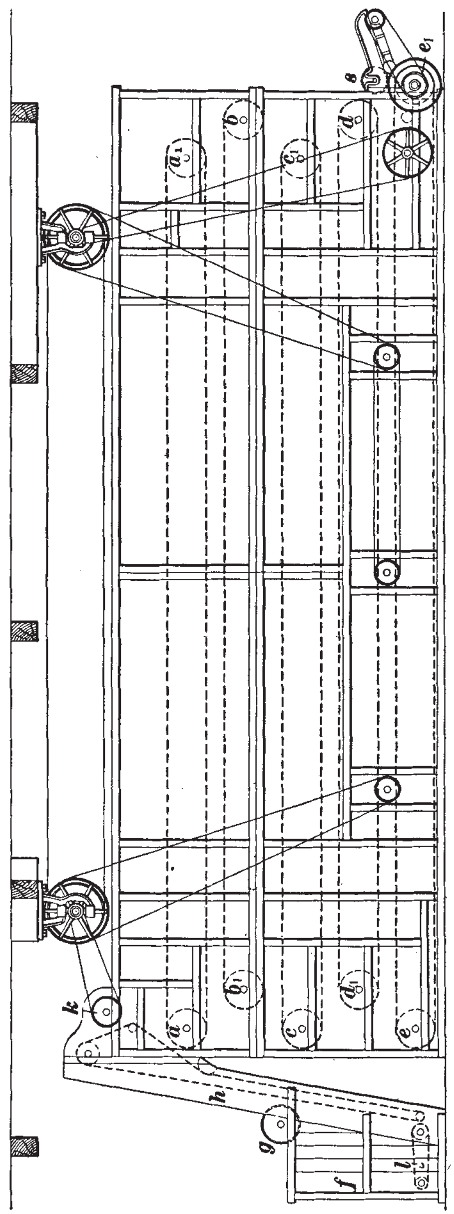


FIG. 2

constructed with a hardwood frame and has the sides enclosed either with wood or sheet-iron panels. A dryer constructed of wood and lined with tin holds the heat better and is more comfortable to work around than one constructed of sheet iron. The wood, however, should be especially kiln-dried; otherwise when the dryer is heated it will, in the course of time, shrink badly. The air is generally heated by steam pipes in a separate chamber running along the side of the machine, and blown into the drying chamber by means of powerful fans. The carrying aprons are often made of wooden slats especially prepared to withstand a heat of at least 250° F. without catching fire, but it is preferred to have them made of woven wire, since the heated air then has a better chance to circulate through the wool, as it reaches it from the under side as well as from the top.

8. Operation.—In operation the wool is placed in the hopper of the self-feed *f*, and is pressed against the lifting apron *h* by the traveling apron *l*. The stock is taken from the mass in the hopper by the lifting apron, and any excess of wool that is taken is knocked off by a revolving comb *g*, thus evening the feed. The wool is deposited by the lifting apron on the top apron $a a_1$ of the drying machine, being stripped from the elevating apron by a beater at *k*. As the wool travels along the apron, it is subjected to currents of heated air from fans located at the sides of the machine, the heated air being supplied by compartments at the side of the machine filled with steam coils.

The wool travels along the apron from a to a_1, and then drops on to the next apron, in so doing being turned over and thus exposing to the heat the portion of the stock that was underneath while on the apron $a a_1$.

The wool travels along from b to b_1, and is then dropped on the apron $c c_1$, and so on. Each time the wool drops to another apron it is turned over, so that all portions are thoroughly exposed to the heat. At the end of the bottom apron, a squeeze roll *s* is shown. This is attached only when the dryer is used for drying carbonized wools. The object of the roll is to pulverize the carbonized vegetable matter and thus render it more easily removed by the carbonizing duster. The steam pipes in a dryer of this description are sometimes placed in tiers between the aprons, thus doing away with the fans; this, however, is quite apt to bake the stock, owing to a lack of circulation of the heated air in the chamber.

9. High temperatures in a dryer of this description should be avoided and it is better for the stock to have the aprons run somewhat slowly and have a lower temperature than to have a high temperature and drive the aprons faster. The temperature in this type of dryer should not be allowed to be higher than 160° F. if the best results are desired.

The speed of the drying aprons should be so arranged that with the proper temperature the stock will remain in the machine just long enough to become dry and no more. It is better to have the stock delivered slightly moist rather than too dry and with a harsh feeling.

SECTIONAL DRYERS

10. With a common, one-compartment, hot-air dryer it is imperative that a uniformly low temperature (about 160° F.) be maintained in order to prevent harshness and yellowing of the fiber, which are the chief dangers to be avoided in successful wool drying; consequently, the capacity of a dryer of this type is small and the expense of drying great. In order to render the drying of the stock more rapid and at the same time preserve the soft, kind feeling, drying machines are now constructed with two compartments, the first being heated to a high temperature and the second only to a medium temperature. It has been found that the wool is able to stand a high degree of heat when it is quite wet, but this same degree of heat would tend to injure it if dry; thus by entering the stock at a high temperature and then reducing the heat, the stock is rapidly dried and at the same time there is no injury, as when partly dry it is transferred to the other compartment where the heat is less intense.

By subjecting the wool to about 180° F. in the first compartment and then reducing the heat to 110° F. in the second compartment, it emerges from the machine in a condition that is practically equal to the results obtained by cold-air drying and has the advantage of being extremely rapid and of drying the stock in large quantities. The grading of the heat produces a soft fiber free from harshness and with its color unimpaired when dry, which is due to the fact that on entering the dryer, the stock contains a maximum amount of moisture which counteracts the bad effects of the high temperature to which it is subjected, the actual temperature of the stock being much lower than that of the heated air with which it is in contact. The greatest amount of moisture is,

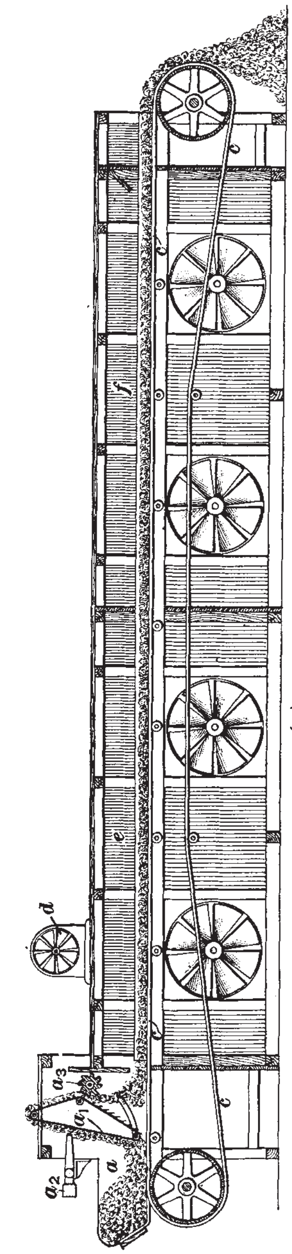


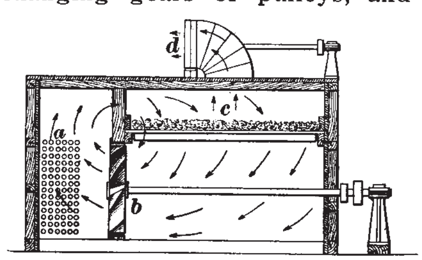
Fig. 3

(a)

of course, evaporated in the first compartment, and as the wool passes to the next compartment the heat is reduced according to the amount of moisture still remaining in the stock, until it finally emerges from the dryer soft and lofty and with its natural feeling uninjured.

11. Construction.—A longitudinal section of a two-compartment dryer is shown in Fig. 3 (*a*). This machine is constructed almost entirely of wood carefully kiln-dried before being put together, in order to prevent any possibility of shrinkage and consequent opening of cracks after the dryer is in operation. A dryer made of wood, if properly constructed, is to be preferred to one made of sheet iron, since the wood holds the heat better and thus makes the machine not only more comfortable to work around, but more economical to operate. It will be noticed that in this machine only one carrying, or drying, apron is used; this is made of wire cloth of $\frac{1}{4}$-inch mesh and runs over large drums at each end of the machine. The drums are carefully trued so as to insure the perfect running of the apron, which should not run over the edges of the drums. The apron varies in width from 4 to 9 feet, according to the size and capacity of the machine.

In three- and five-apron dryers there is considerable annoyance, expense, and delay from the breaking of aprons, due to constant bending around drums of small diameter. This difficulty is almost entirely done away with in the single-apron dryers, owing to the large drums over which the apron passes. The apron is driven by a pair of cone pulleys, the driven one communicating motion to a vertical shaft by means of a pair of bevel gears. To the vertical shaft a worm is attached, which works in connection with a worm-gear on the end of the drum shaft. The apron may be immediately stopped by means of a lever, which when operated withdraws a clutch driving the worm. The three-step cone pulleys allow three speeds of the aprons without changing gears or pulleys, and this is ample range for ordinary work. The more moisture the stock contains, the longer it will have to remain in the dryer and, consequently, the slower the apron will have to be driven, and vice versa.



(b)
FIG. 3

The drying of the wool is accomplished by circulating heated air alternately through the stock and steam coils placed in a compartment at the side of the machine. The air is drawn through the layer of stock on the apron by means of powerful steel-blade fans. In a two-section dryer there are four fans, two in each compartment. A transverse section of the machine is shown in Fig. 3 (*b*), which illustrates the mode of circulating the heated air. As will be seen, the dryer is divided into two compartments laterally as well as transversely; in one section are placed the steam coils *a* that heat the air. A fan *b* draws the heated air through the wool, which is spread on the traveling wire apron *c*. As the heated air comes in contact with the damp wool, the water is driven off in the form of steam and a constant current of moisture-laden air is removed from the dryer by means of a fan placed in the flue *d*.

The large fans for circulating the air are coupled together by belts, and are driven directly from an overhead countershaft, two such shafts being required for driving the machine. From the first countershaft, the apron and fans are driven; the speed should be about 400 revolutions per minute. The second countershaft is driven from the first and drives the self-feed by two belts, one driving the elevating apron through a pulley on a stud, to which is fastened a pinion gear that drives a large gear on the top roll of the apron, and the other driving the stripper, or doffer, beater by a pulley fastened on its shaft. Attached to this shaft is a sprocket gear, which drives a similar sprocket on the feed carrying a crank driving the oscillating comb of the feed through a connecting-rod.

12. Operation of Sectional Dryer.—In operation, the stock is either taken from the scouring machine directly or is first run through a hydro-extractor, which will be described further on, and then placed in the hopper *a* of the self-feed. [See Fig. 3 (*a*).] There is no necessity for a traveling apron in the bottom of the hopper to keep the stock pressed against the lifting apron, as the drying apron is carried outside of the drying chamber and forms the bottom of the self-feed hopper. The elevating apron a_1 takes the stock and carries it to the oscillating comb a_2, where the feed is evened and any large bunches of stock knocked back into the hopper. The moist wool is stripped from the elevating apron a_1 by the beater a_3 and deposited on the traveling wire apron *c* on which the stock passes into the first drying compartment *e*, where the wool is subjected to a strong current of air, heated to about 180° F. and the moisture removed by the fan *d*. The stock then passes to the second compartment *f*, where the heat is reduced to 110° F. and the drying completed, whereupon the wool is delivered onto the floor or into trucks by the drying apron.

The dryer here described is built either for carbonizing or for drying, and when built for the former purpose is arranged to dry the wool completely in the first compartment, and subject it in the second compartment to a dry heat, which effectually carbonizes the previously chemically treated vegetable matter in the stock. The carbonizing dryer may be used for a wool dryer, but the ordinary dryer does not make an efficient carbonizer, although the stock can be carbonized with one. Carbonizing requires a higher heat than is ordinarily used for drying, and the wool must be dry before it is subjected to this heat. The process of carbonizing will be treated of later.

13. Capacities of Sectional Dryers.—The following table shows the capacity of two-compartment dryers of different sizes, both for ordinary drying and for carbonizing. It will be noticed that the capacity for carbonizing is much less than that for drying, owing to the slower speed at which the apron is necessarily driven in order to perform the carbonization efficiently. As the capacity of a dryer depends on the amount of moisture in the stock, the following capacities are based on the assumption that the stock has been well hydro-extracted and does not contain more than 60 pounds of water per 100 pounds of dry wool.

CAPACITY IN POUNDS PER DAY OF 10 HOURS

Drying Pounds	Carbonizing Pounds	Width of Apron Feet	Length, Exclusive of Self-Feed		Horsepower
			Feet	Inches	
4,000	2,000	4	37	6	11
6,000	3,000	6	39	1	12
9,000	4,500	9	39	1	14

14. Another type of sectional dryer is shown in Fig. 4, the steam coils in this machine being placed over the carrying apron instead of in a compartment at one side. In this case the fans are carried in a horizontal instead of a vertical plane. In operation, the stock is fed on the

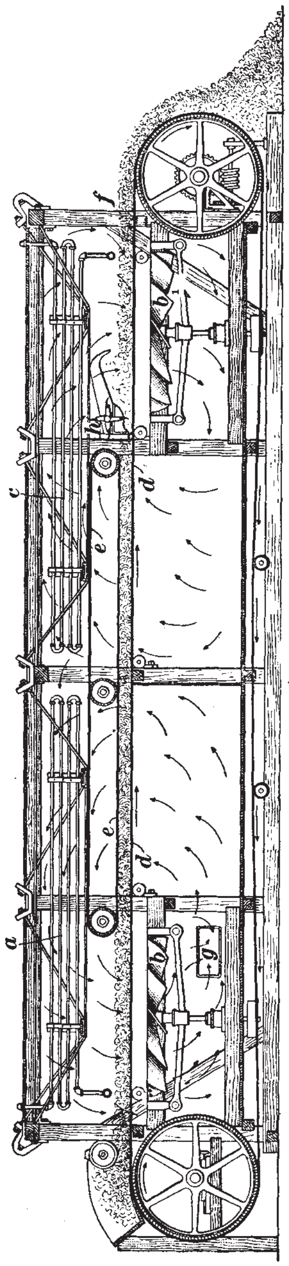


FIG. 4

carrying apron and passes into the first compartment of the machine, where the air heated by the steam coils *a* is drawn through the wool on the apron *d* by the fan *b*, which also forces it through the wool again, as indicated by the arrows showing the circulation of the heated air. The stock then passes into the second compartment of the dryer, where the heat is reduced and the wool is subjected to the air heated by the steam coils *c* and circulated by the fan b_1. Besides the carrying apron, there is another apron *e*, shown in the illustration, the purpose of which is to keep the stock from being blown off the apron at those points where the current of heated air is passing upwards. This apron and also the carrying apron are made of wire screens, those usually employed in dryers being about $\frac{1}{4}$-inch mesh. The inlet of air in this machine is at *f*, while a current of moisture-laden air finds its exit from the machine at *g*; thus it will be seen that the general direction of the air is against the motion of the stock.

At *h*, there is a revolving beater for the purpose of opening up the stock before it leaves the machine, thus making it emerge in an open and lofty condition instead of in the more or less matted condition in which it is received from the washer. Sectional dryers are sometimes built with more than two compartments, although two are sufficient for all ordinary purposes.

HYDRO-EXTRACTORS

15. Hydro-extractors, already referred to in Art. **12** are not designed to dry the stock, but are largely used for removing the bulk of water from wet wool, cloth, yarn, etc., and are indispensable to a dye house or scouring plant. In some mills, the stock is rinsed in a rinsing box instead of in the last bowl of the scouring machine, in which case it is necessary to run the stock through an extractor before drying or sending it to the dye house, unless the rinsing box is provided with a pair of squeeze rolls. In some cases when the stock is fed to the dryer directly from the squeeze rolls of the washer, an extractor is not necessary; but although the squeeze rolls remove a considerable amount of moisture, the production of the dryer is reduced, owing to the excessive amount of moisture that must be dried out and that could be much more rapidly removed by extracting. Stock that is run through a hydro-extractor contains from 6 to 12 per cent. less moisture than stock from the squeeze rolls of the washer. This represents a considerable saving of time and heat in drying the stock, thus making the hydro-extractor an economical machine for the mill.

Hydro-extractors are also used for extracting the acid solution used in carbonizing, before subjecting to heat; in fact, any place where it is desirable to remove rapidly a large percentage of moisture in saturated raw stock, yarn, or cloth, the hydro-extractor is an economical machine. When used for acid work, the basket of an extractor should be galvanized or lead-lined so that the acid will not attack and destroy it.

SELF-BALANCING EXTRACTOR

16. This type of hydro-extractor, shown in Fig. 5, consists of a wrought-iron casing *a* supported by standards *b*. These standards are cupped out to receive the ball-shaped heads of the supporting rods *c*, which lead down to the lower flange of the casing and are there attached by similar ball-and-socket joints. The necessary adjustments for leveling the outer casing and parts carried by it are secured by means of turnbuckles on the supporting rods. These may be securely fastened by means of check-nuts.

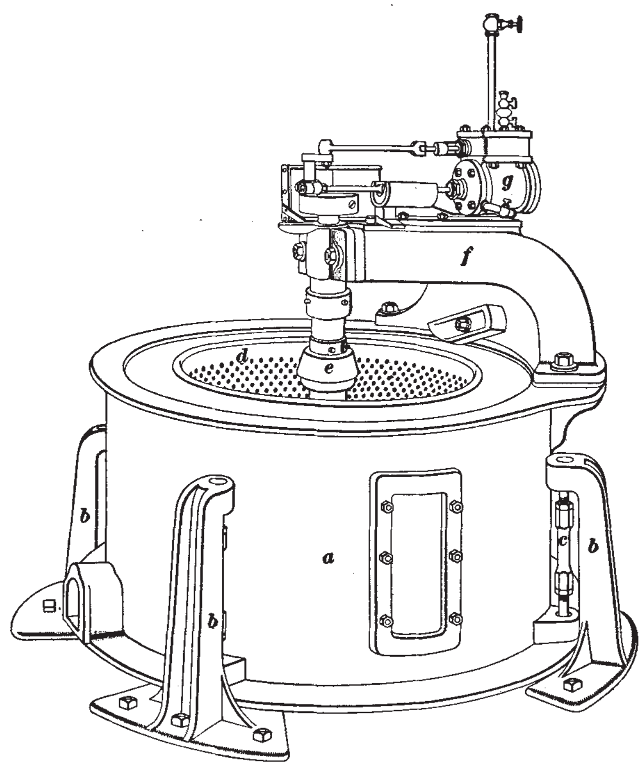


FIG. 5

The basket *d* of the extractor is made of perforated metal and is built on a central shaft *e* supported at the top by a housing *f* that rises from one side of the outer casing and extends to the center of the machine. The basket is driven by a small steam engine *g* carried on the housing. The machine therefore requires no belting or shafting of any kind. The engine is attached directly to the shaft of the basket, and the loaded basket serves as a flywheel when the extractor is in operation. This allows the basket to be started very quickly, as no time is lost by belt slipping, etc., and the machine is at full speed in a few seconds.

In operation, stock saturated with water or other liquids is placed in the perforated basket and the steam admitted to the engine. In a few seconds, the basket is revolving at a high rate of speed and the water is being driven through the perforated sides of the basket by the centrifugal force generated by the rapid rotation. The water removed from the basket is retained by the outer casing, from which it passes off as waste water through a suitable outlet in the casing. In a few moments the bulk of the water contained in the stock is removed and the machine may then be stopped, emptied, and another lot placed in the basket. The extractor should not be allowed to run too long, however, in an attempt to remove too much moisture, or the stock will be rolled and matted. The vibration of the basket is a feature of all hydro-extractors that it is impossible to remedy and is due to the unequal loading of the heavy, wet material. In this extractor, however, the difficulties that would ordinarily arise because of this unavoidable vibration are overcome by carrying the entire machine on movable supports. The machine is thus entirely suspended and is free to vibrate in any direction, if unevenly loaded, thus preserving the parts in their original relation to one another without imparting any of the shaking to the floor or the building in which it is located. This manner of balancing an extractor is far superior to the old way of allowing the basket to wabble, or gyrate, inside the outer casing, which remained stationary, thus requiring a greater space between the basket and casing and necessitating a larger machine for the same capacity. The self-balancing hydro-extractor is made in various sizes, with baskets from 30 to 54 inches in diameter. The speeds at which they run vary from 1,000 revolutions per minute for a 30-inch, to 850 or 900 revolutions per minute for a 54-inch, basket.

WESTON HYDRO-EXTRACTOR

17. While this machine is not of the self-balancing type, but instead has a gyrating basket, many of them are in use and give excellent satisfaction. One advantage of this type is that it is very easy to load and unload, as there is neither housing nor shaft in the way, the entire top of the machine being open and clear. This fact renders the capacity of the machine larger than that of a self-balancing extractor.

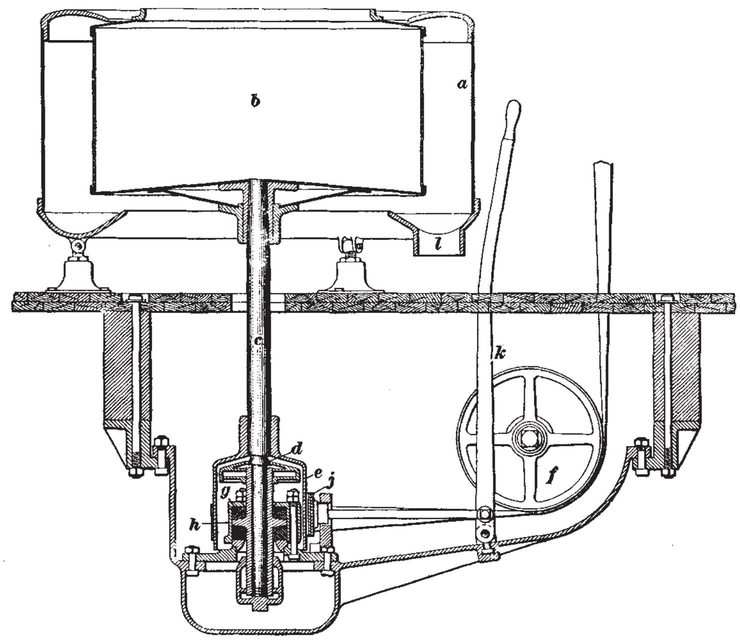


FIG. 6

The machine shown in section in Fig. 6, consists of an outer casing *a* enclosing a perforated basket *b*, which is fastened to a spindle *c* and rotates on the pivot *d*. A pulley *e* is attached to the lower end of the spindle, motion being imparted to the basket by means of a belt passing around this pulley, to which it is guided from a driving shaft by means of two guide pulleys, the one shown being marked *f*.

In order to reduce the vibration and at the same time furnish a certain freedom of motion, the pivot box is supported by rubber cushions *g* carried in a gland *h*. That the machine may be stopped quickly, a brake shoe *j* is arranged to be pressed against the pulley *e* by means of a brake lever *k*. The working parts of the machine are all enclosed in a water-tight, cast-iron trough, or casing, which is bolted to the floor under the extractor; but where this machine is to be erected in basements they are carried in a bedplate set on masonwork.

In operation, the stock to be extracted is placed in the basket *b*, which if unevenly loaded gyrates within the casing *a* until a speed is attained that makes it assume an upright position. The water thrown from the stock is retained by the casing and finds an exit through the outlet at *l*.

BURR PICKING

INTRODUCTION

1. Objects.—**Burr picking,** or **burring,** is the first operation through which the wool passes after it has been scoured and dried, except in some cases where it is run through a duster immediately after the drying. When this is done, it is more for the purpose of making the stock open and lofty, so as to facilitate the work of the burr picker, than for the sake of the small amount of dust that is removed. The primary object of burr picking is to remove all the burrs and vegetable matter possible before the stock is passed to the carding machines. Under the head of burrs, various particles of vegetable matter that become attached to the fleece during the life of the sheep are included, although a burr is really a vegetable seed or husk covered with sharp spines, or prickles. Besides actual burrs, the wool often contains twigs, straws, chaff, etc., which, together with finely divided vegetable matter, as crumbled leaves and organic dust, is commonly known as **shives.**

The nature of the burrs found in wool varies greatly with the locality in which the wool is grown. Probably the worst wools in this respect are those coming from South America, notably from Buenos Ayres and grown in the valley of the Rio de la Plata. These wools are infested with a spiral-shaped burr from $\frac{1}{2}$ inch to 2 inches in length, and curled up somewhat like a snail's shell. They are extremely difficult to remove, since they cling with great tenacity to the wool and often are broken into small pieces before losing their hold on the fibers. These are the worst burrs known;

other wools contain in comparison but few burrs and those generally of a kind much more easily removed. The burrs in this class of wool are often called **mestizo burrs,** this name being given on account of the mixed blood of the sheep of that locality.

2. If the burrs are not removed from the wool they are broken into innumerable small particles during the operation of carding, which, remaining in the roving, make hard bunches that cause the yarn to spin unevenly and to have an irregular, rough appearance, which is characterized as **twitty.** Small particles of vegetable matter thus passing through all of the manufacturing processes and occurring in the cloth are known under various terms; as, **specks, motes, burls,** etc. These must be picked out by hand; and in some cases this causes bad holes to be made in the cloth, which must be mended. Vegetable matter will not absorb dye stuffs in the same proportion as wool fibers; consequently, it is seen on the surface of piece-dyed cloths as specks of a lighter color. Burrs in the wool are also a great detriment to the cards, as they tend to dull, bend, and otherwise injure the card clothing and also choke up the card so that stripping, or cleaning, is necessitated much oftener than would otherwise be required.

From what has been said, it will be seen that burrs are matted with the fibers and must be torn from them with considerable force, thus necessitating the employment of a burr picker; in fact, they sometimes cling so tenaciously that the burr picker removes a considerable amount of wool with the burrs. Another object of the burr picker, although of a secondary nature, is to open the wool and leave it in a more lofty condition for the carding machines. This saves a great deal of unnecessary wear and tear on the cards, which would otherwise be strained in opening out bunches of wool that were matted.

TYPES OF BURR PICKERS

PARKHURST BURR PICKER

3. A very effective machine for removing the burrs from wool, known as the improved **Parkhurst burr picker,** is shown in Figs. 1 and 2; Fig. 3 illustrates the working parts. The construction and operation of this machine are such as to have the greatest cleaning effect on the wool with the least possible damage to the fiber. The machine is of solid construction, the framework being made of iron, with the exception of a few minor parts, which, as shown in Fig. 3, are constructed of wood. The greatest care is taken to have all working parts firmly adjusted and free running, since the high speed necessary in a burr picker, together with the large number of parts in motion, render it a machine requiring a considerable amount of power for driving purposes.

4. Construction.—The stock is fed to the machine on an ordinary form of slatted feed-apron *a* that runs on hardwood rolls, the first roll being provided with a screw adjustment by means of which it can be drawn back and the apron tightened, should it become slack through stretching or wear. The feed-rolls *b* are fitted with steel cockspur teeth, so that large burrs are not broken into minute particles, but the stock is held loosely and is not injured while the picker cylinder opens it out. The cockspur teeth are made separately and are securely fastened in grooves cut around the feed-rolls. The rows of teeth are about 1 inch apart and the teeth of the upper roll pass between those of the lower roll. The teeth of each roll being curved back from the direction in which the roll rotates, the stock is held firmly while at the same time the feed-rolls do not become wound and choked with stock, as is liable to occur with rolls covered with

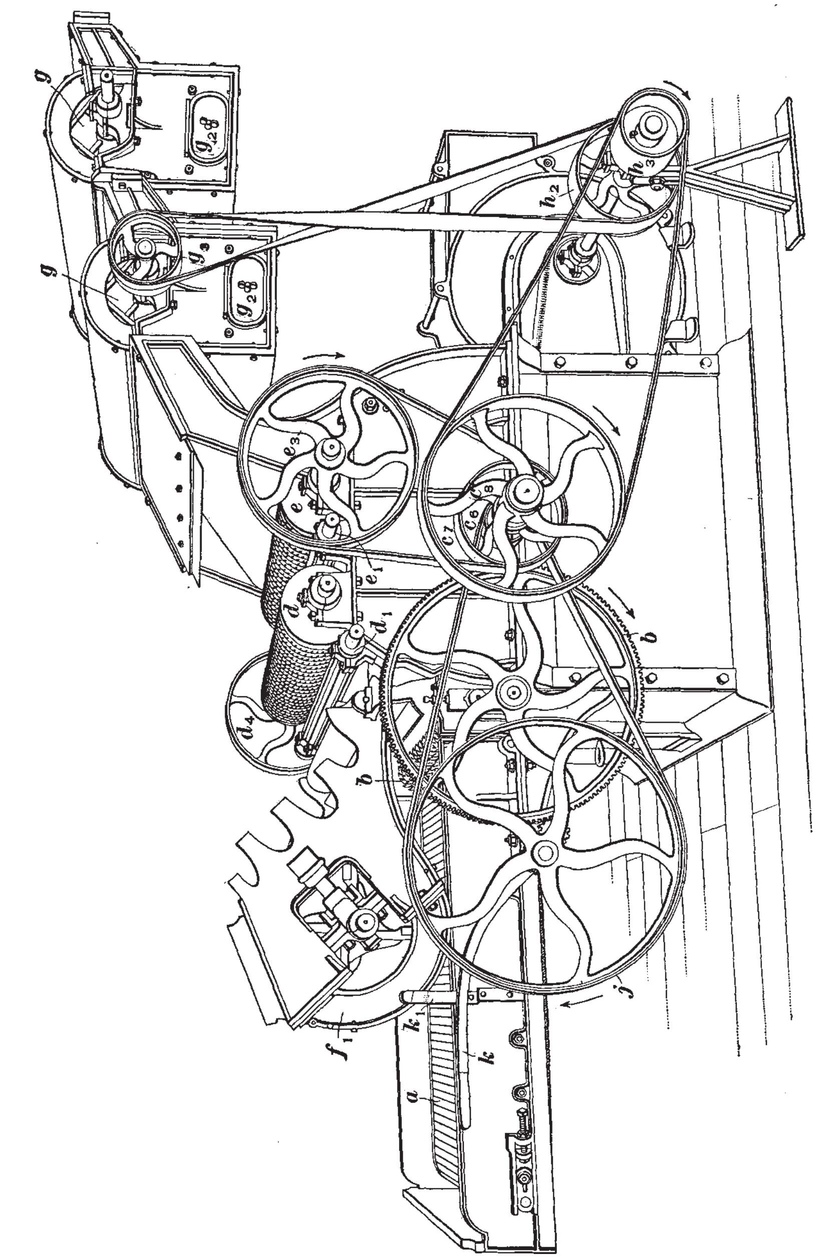


Fig. 1

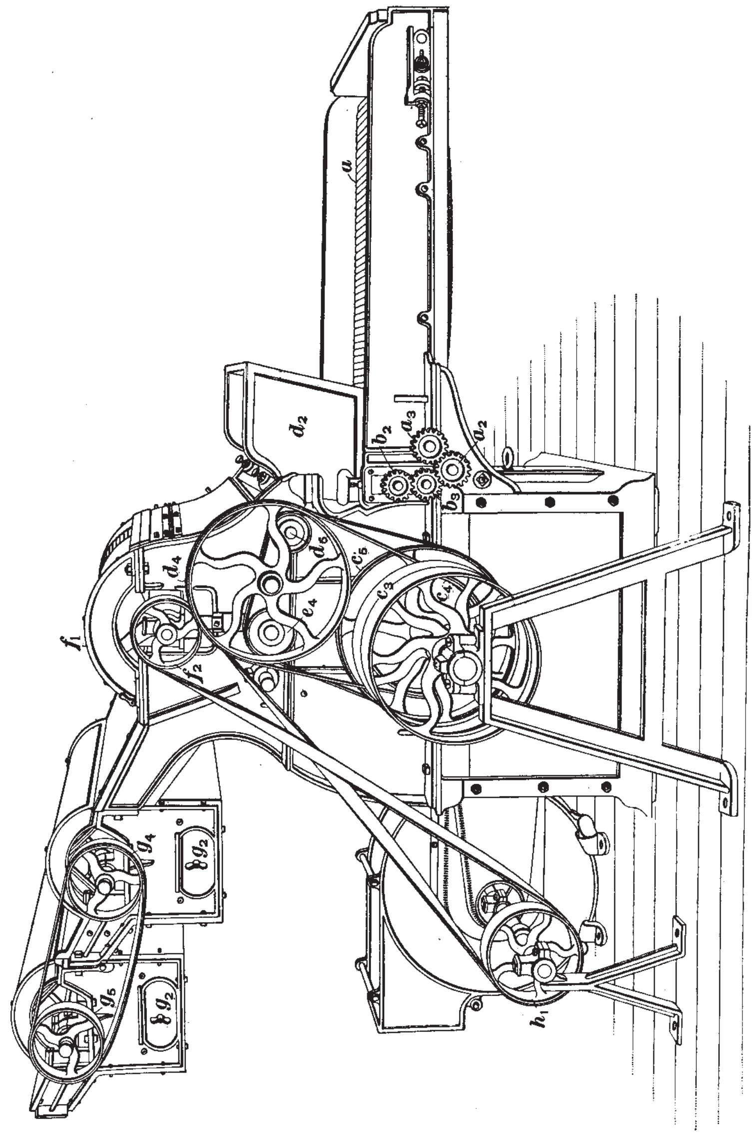


Fig. 2

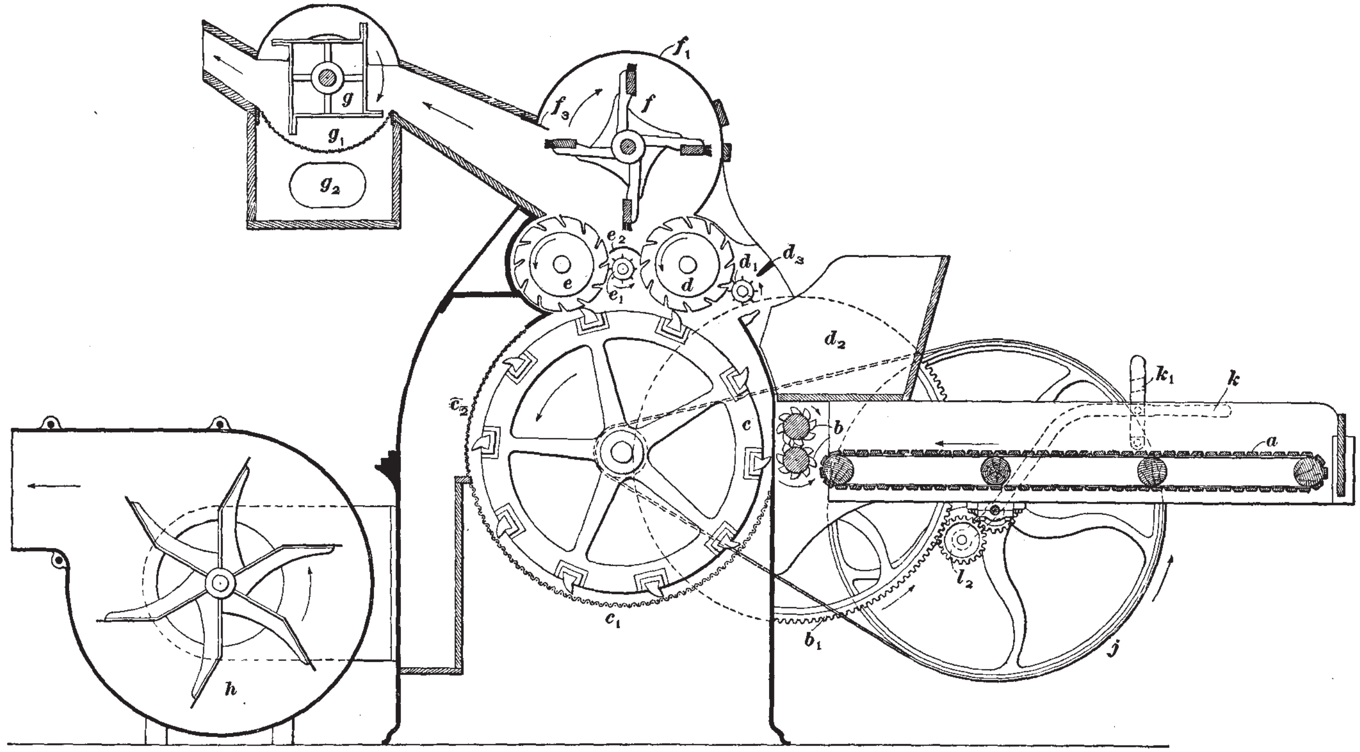


Fig. 3

straight, or pin, teeth. In some machines the top feed-roll is driven slightly faster than the bottom roll, so that the latter will keep the top feed-roll clear of wool and prevent its winding. The picking cylinder *c* running upwards will, in this case, keep the bottom roll clean, but, should the picking cylinder run downwards, the bottom feed-roll should run faster than the top one.

5. The picking cylinder *c* is for the purpose of opening the wool as it is held by the feed-rolls and for conveying it from them to the burr cylinders. It is constructed, in this picker, with ten cross-bars securely fastened to spiders attached to the picking cylinder shaft, which may be considered as the main shaft of the machine. The cross-bars are set with steel teeth, which are dovetailed into them in such a manner as to be securely fastened. As indicated by the arrow, the picking cylinder of this machine runs upwards past the feed-rolls and combs out the wool, making it ready for the burr cylinders.

The two burr cylinders *d*, *e* in this machine are located over the picking cylinder and are of the steel-ring variety. Some burr pickers have only one burr cylinder. Most burr rolls are made by winding Garnett wire in a spiral groove cut around the roll. The steel-ring burr cylinders, which are somewhat better than the wire-wound rolls, are made of steel rings with the teeth cut on them. These rings are slipped on a smooth cylinder, or roll, packing rings being inserted between the rings to keep them an even distance apart. A varying number of rings per inch may be used, depending on the fineness of the stock that is being burr-picked. The whole is fastened securely and makes the best kind of a burr roll, as it is not liable to injury and, if damaged, can be readily repaired. The construction of burr rolls and burr wire will be explained later.

In connection with the burr cylinders there are two burr guards d_1, e_1. These are small rolls in which eight steel blades are placed in slots cut lengthwise of the roll. In operation, the wool sinks into the crevices, or spaces, between the teeth in the burr cylinders and is thus securely held, while the burrs remaining more or less on the surface are knocked out by the blades of the burr guards, which are set close to the surfaces of the burr cylinders. Care should be taken, however, that there is no contact between the burr guards and cylinders, as the latter would be ruined. The wool is removed from the burr cylinders by the brush *f*, which consists of four wooden cross-bars set with stiff bristles from 1¼ to 2 inches in length, and supported by spiders fastened to a central shaft. The brush delivers the wool to the beater *g* by means of the current of air that it produces.

6. The beater is a square, box-like drum built up from a central shaft and having four blades attached; its object is to beat out such loose material as dust, shives, etc., which will then fall through the screen g_1 placed under the beater. Some machines have two beaters, as shown in Figs. 1 and 2; others only one, as shown at *g*, Fig. 3; while sometimes they are entirely dispensed with. The beaters are placed at the spout, where the wool leaves the machine, and, as the stock at this point is opened out nicely, they easily remove a large amount of finely divided dirt that has escaped the previous operations and that would otherwise pass through the machine with the wool.

A large blower, or fan, *h* is placed on the floor at the rear of the machine and creates a draft through the screen c_2 which is placed opposite the feed-rolls, the object being to remove light dirt and dust from the wool and discharge it outside of the mill through suitable pipes. The blower consists of a cylindrical iron box in which a six-bladed fan is mounted on suitable bearings. One important advantage of locating the blower for a burr picker on the floor and at the rear of the machine, is that an under draft is secured, which is an important factor in cleaning stock. The current of air in this case does not hinder the fall of the heavy particles of dirt shaken from the stock by the picker cylinder but rather assists it, and such dirt is therefore readily deposited beneath the screen, or grate, c_1, which is placed under the picking cylinder, while the lighter dust is drawn away through the screen c_2 by the blower.

7. The top of this machine is so arranged that it swings back, carrying the brush with it. This is a great advantage in cleaning the machine, as it exposes the burr cylinders and guards so that they may be easily cleaned and made ready for the next lot of wool. Fig. 1 shows the bonnet f_1 laid back on the feed-apron and the burr cylinders exposed. The machine is provided with hinged doors, located under the feed-apron, for cleaning the space under the picking cylinder, which can be quickly cleaned between lots, as the doors can be opened without removing screws or bolts. Sliding brushes are placed under the screens beneath the beaters for the purpose of cleaning them. There is also a brush for cleaning the screen at the rear of the picker cylinder, which if clogged hinders the draft of the blower. This screen sometimes becomes coated with a gummy substance; if greasy wool is used it must then be taken out and washed with soda, potash, or any compound that will cut the grease. There are also small handholes g_2 for cleaning the spaces under the beater screens and for removing the fine dirt and shives that fall through them.

8. Driving.—The driving of the various parts of the burr picker will be readily understood by the following description in connection with Figs. 1 and 2: The main shaft of the machine is fitted with tight and loose driving pulleys c_3 and all working parts are belted from the main shaft. Only one belt is required to drive the machine, except on the large size (48-inch width) where a double drive is used, that is, a tight pulley on each side of the machine driven from a countershaft on which tight and loose pulleys are arranged. The front burr cylinder is driven by a 12-inch pulley c_4 on the picker shaft, which drives a 16-inch pulley d_4 on the front burr-cylinder shaft. This drive is shown in Fig. 2. The rear burr cylinder is driven on the other side of the machine, as shown in Fig. 1, by a $9\frac{1}{2}$-inch pulley c_7 on the main shaft, which drives a 16-inch pulley e_3

on the shaft of the rear burr cylinder. The blower is driven by a 17-inch pulley c_8 on the main shaft, which drives a 6-inch pulley h_3 on the blower shaft, also shown in Fig. 1.

The two burr guards are driven by a 17-inch pulley c_6 on the main shaft, which drives two pulleys e_4, d_5 on the burr-guard shafts, the pulley on the front burr-guard shaft being 4 inches in diameter and the pulley on the rear burr-guard shaft being 5 inches in diameter; these pulleys are shown in Fig. 2. A driving pulley h_2, 10 inches in diameter, on the blower shaft drives an 8-inch pulley g_3 on the first beater shaft with a crossed belt, as shown in Fig. 1, and on the opposite side of the machine the two beaters are connected by a belt and 8-inch pulleys g_4, g_5, as shown in Fig. 2. A 10-inch

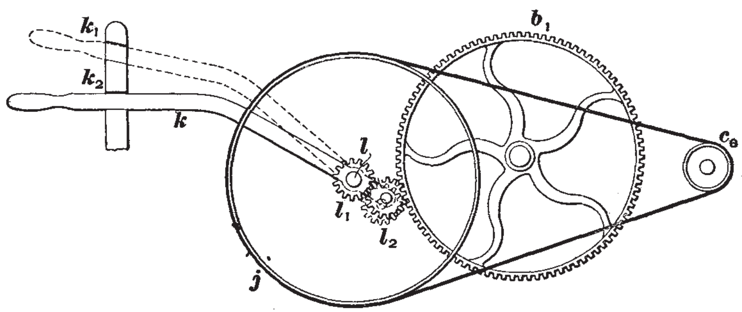


FIG. 4

pulley h_1 on the blower shaft drives a 7-inch pulley f_2 on the shaft of the brush with a crossed belt. The driving of the feed-rolls is shown in Fig. 1, and is as follows: A $4\frac{1}{2}$-inch pulley c_6 on the picker-cylinder shaft drives a pulley j, 24 inches in diameter, on a stud l, see Fig. 4. A pinion gear l_1 with 15 teeth, fastened to the pulley j, drives an intermediate gear l_2, which in turn meshes with a 150-tooth gear b_1 fastened to the bottom feed-roll shaft. The top and bottom feed-rolls are coupled together with 15-tooth gears b_2 and b_3 on the opposite side of the machine, as shown in Fig. 2, the gear on the bottom feed-roll shaft also driving a 17-tooth intermediate a_2 which drives a 17-tooth gear a_3 on the front apron-roll shaft, thus driving the feed-apron.

9. Device for Stopping Feed.—There is a device on this machine for stopping the feed-rolls and apron without stopping the whole machine; this allows the operator to stop the delivery of wool to the picking cylinder immediately when anything wrong is seen with the working of the machine. The mechanism is simple and effective. A lever marked *k*, Fig. 4, is pivoted on the stud *l*. The pinion gear l_1 is loose on this stud, as is also the pulley *j*. The gear l_2 is loose on a stud fixed at the extremity of the lever *k*. Thus, when the lever is raised, as shown by the dotted lines, and held in that position by the slot at k_1, the gear l_2 will be withdrawn from contact with the gear b_1; this stops all motion of the feed-rolls and apron. The slots k_2, k_1 are cut in a piece of steel bolted to the side of the feed-trough and hold the lever firm when the pinion is in or out of contact with the gear b_1.

10. Operation.—In operation, the stock is spread evenly on the feed-apron *a*, Fig. 3, either by hand or by an automatic or self-feed, and is carried forwards to the pair of cockspur feed-rolls *b*. The wool is held by the feed-rolls and is combed and opened out by the rotating picking cylinder *c*, which revolves upwards past the feed-rolls. The picking cylinder carries the wool to the burr cylinders *d*, *e*, and the stock is deposited in the spaces between the rows of teeth on the burr cylinders, while the burrs lie on the surface and are knocked off into the burr box d_2 by the burr guards. The passage of the material from the feed-rolls to the picking cylinder and from the picking cylinder to the burr cylinders, the cylinders being in rapid rotation, results in the wool being beaten, drawn, and opened, the burrs gradually being thrown to the outside and ultimately hanging loosely from the burr cylinders from which they are easily knocked by the burr guards.

11. It may be said with regard to this machine that the burr guard e_1 does not throw the burrs clear of the machine, as does the guard d_1, but instead throws them either on to the first burr cylinder, where they then come under the action of d_1, or else into the picking cylinder, where, unless they fall through the grate, they are carried around until again brought under the action of the burr cylinders.

12. All dirt that is knocked from the wool by the picking cylinder c, if heavy, falls through the grate, or screen, c_1 into the space underneath, whence it can be removed periodically by opening a hinged door underneath the feed-apron of the machine. If the dirt is light, as dust and shives always are, it is removed by the blower h through the screen c_2 and blown outside of the mill through a suitable pipe. The wool fiber is removed from the burr cylinders d, e by the rotating brush f and passed along by the current of air generated by the brush to the beater g, which revolves at a rapid rate and beats much loose matter that has escaped the previous operations through the screen g_1 into the space underneath, whence it may be removed through the handhole g_2.

Two beaters are of great value for fine stock and also for knitting stock, but for ordinary wool one of them is sometimes removed. Frequently when long-stapled stock, such as carpet and other coarse wool, is being run through the burr picker, both beaters are removed. After passing through the beaters, the stock is conveyed by a suitable pipe to the gauze room, where it is ready for the next process.

13. In Fig. 3, a steel straightedge, or knife, is placed at f_3 to prevent the stock from winding around the brush and also to keep the bristles of the brush clean. At d_3 a similar knife is placed to prevent the burrs that are knocked out by the burr guard d_1 from flying back into the burr cylinder d. A guard e_2 is placed over the burr guard e_1 in order to prevent the wool removed from the burr cylinder d by the rotating brush from falling on the burr guard e_1 and being thrown on the picking cylinder c.

14. Burr Cylinders.—Most mills are equipped with two sets of burr cylinders—a coarse set for coarse stock, and a fine set for finer stock. The necessity for this is that if a cylinder with coarse teeth on it is used for fine stock, much of the wool will be pulled from it and cast out. Good burr picking removes the burrs and as little of the stock with it as possible. On the other hand, if cylinders covered with fine set teeth are used for coarse stock, the wool will not penetrate into the spaces between the steel rings of teeth, and there is danger of the fiber being broken and of a good deal of wool being knocked into the burr box by the guards.

The ordinary type of burr cylinder is made of iron, and after being trued has a continuous spiral, or helical, groove cut around it. A specially prepared toothed wire is wound around the cylinder in the groove cut on it and the spaces between the rows of wire carefully staked in order to hold the wire firm. The roll is then ground to a true surface. The burr wire used for the burr rolls of pickers has a flat top; in Fig. 5 two kinds are shown, one with a long and one with a short top. The short-top wire is suitable for fine, short wool, while the long-top wire is especially adapted for

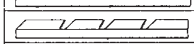
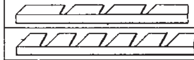
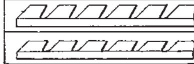
WIRE	SIZE	STYLE	TH'DS PER 1"
	2	Long Top	5 - 8
	3	" "	8 - 12
	2	Short "	5 - 8
	3	" "	8 - 12

FIG. 5

longer and coarser wool. This wire is drawn from fine steel and is made with a rib, or flange, at the base, so that when staked into the cylinder the metal will crowd, or overlap, the base of the wire, thus holding it firm. The teeth are all cut in the wire before it is wound on the cylinder. Garnett wire, as this wire is commonly called, takes its name from that of the inventor, who first used it on machines for tearing up rags in the preparation of shoddy and mungo. Old burr rolls, and other cylinders that are covered with burr, or similar, wire may be recovered when damaged or worn out.

This type is known as the wire-wound roll, but in the Parkhurst picker a special type known as the steel-ring burr cylinder is used. The teeth for this roll are cut on a solid steel ring with a hole of the exact diameter to be slipped on a smooth iron roll. The rings of teeth are kept apart by being alternated with packing rings of the proper thickness that have no teeth, the whole being firmly secured. The advantage of this roll is that it can be repaired without rewinding, as is necessary with the wire-wound rolls.

15. Speeds.—With regard to the speeds of the various working parts of the burr picker, it may be said that high speeds are very necessary in order to accomplish the complete removal of the burrs. The following list gives the speeds of the various parts of the Parkhurst picker, and may be figured by the student with the data previously given in regard to the driving of the parts:

Picking cylinder . .	450	revolutions per minute
Front burr cylinder .	337	revolutions per minute
Rear burr cylinder .	267	revolutions per minute
Blower	1,275	revolutions per minute
Beaters	1,593	revolutions per minute
Front burr guard . .	1,912	revolutions per minute
Rear burr guard . .	1,530	revolutions per minute
Brush	1,821	revolutions per minute
Feed-rolls	$8\frac{1}{2}$	revolutions per minute

16. This picker is built in four widths; viz., 24-inch, 30-inch, 40-inch, and 48-inch. The production of the 48-inch machine is from 4,000 to 6,000 pounds per day according to the amount of stock placed on the feed-apron, and also to the number of times the stock is run through the machine, which depends on the amount of burrs in the stock, once being usually sufficient. This burr picker requires from 3 to 10 horsepower, depending on the width of the machine, and should be driven with at least a 5-inch belt.

SARGENT BURR PICKER

17. In Fig. 6, a burr picker known as the **Sargent multiplex burr picker** is shown with a self-feed attached. This machine works on practically the same principle as the Parkhurst picker. The wool is opened by a picking cylinder and is deposited on a pair of burr cylinders covered with

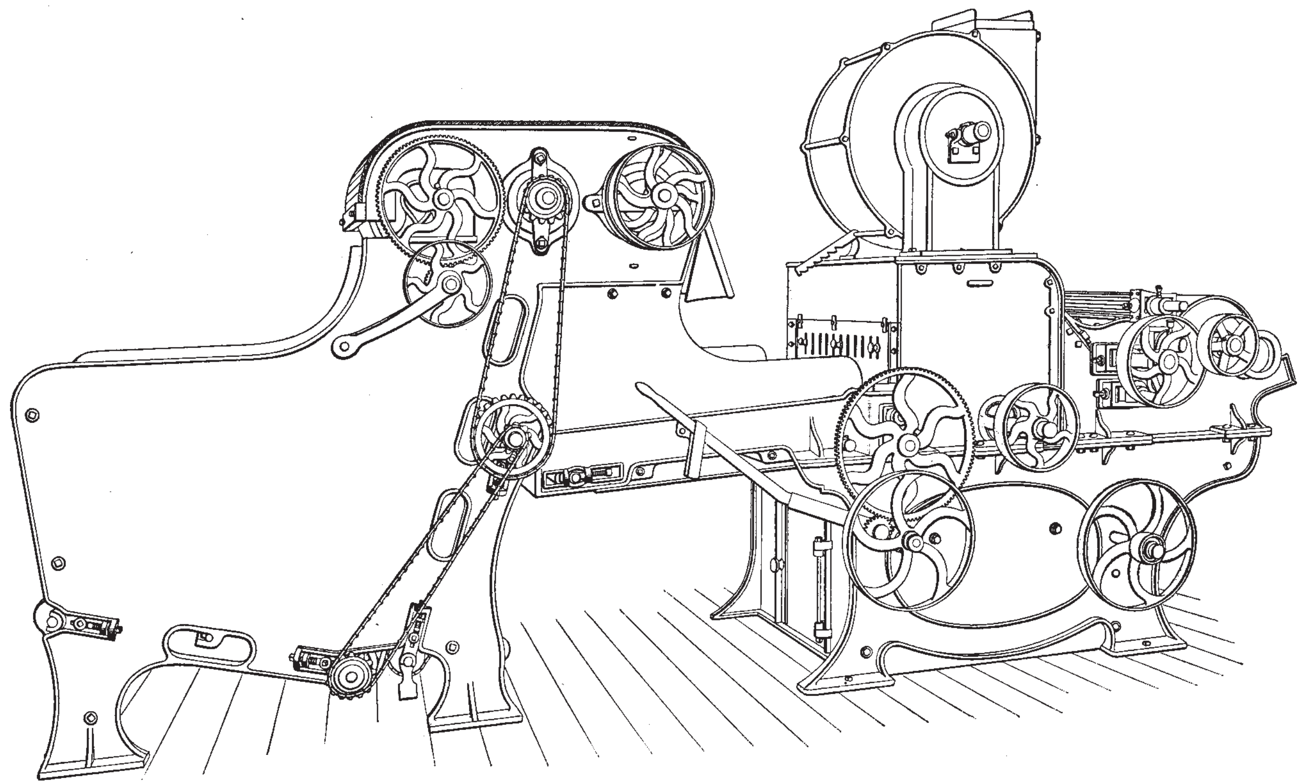


Fig. 6

burr wire, where the burrs are removed by means of burr guards in the usual manner. The machine is constructed, however, somewhat differently from the Parkhurst picker. The burr cylinders and guards are placed opposite the feed-rolls instead of over the picking cylinder. The fan, or blower, is placed on the top of the machine instead of on the floor behind the machine. It removes light dirt and dust from the stock and discharges it outside of the mill by means of a suitable pipe in the usual manner, but as the fan is on the top of the machine, it creates an over draft instead of an under draft through the machine.

The stock is fed on a slatted feed-apron either by hand or by a self-feed. The wool is taken by the feed-rolls and delivered to a picking cylinder similar in construction to that of the Parkhurst picking cylinder, but which runs past the feed-rolls downwards instead of upwards. The stock is subjected to the action of the picking cylinder and the grid, or rack, underneath it, through which drops a large amount of dirt that can be subsequently removed. The wool is then taken by the burr cylinders and sinks into the spaces between the rows of teeth, while the burrs lie on the surfaces of the cylinder and are knocked off by the burr guards. The lower burr guard running in connection with the first burr cylinder throws the burrs on the floor behind the machine, while the upper guard throws the burrs from the upper burr cylinder into a receptacle on the top of the machine. The burr cylinders are stripped by a brush similar to that of the Parkhurst burr picker, and the stock blown to the gauze room by the current of air generated by the rotating brush. The speeds of the different parts of this machine should be about the same as those of corresponding parts of the Parkhurst picker.

The self-feed shown attached to the burr picker illustrated in Fig. 6 is known as the **Sargent low feed.** This self-feed is adapted for burr pickers, cone and carbonizing dusters, mixing pickers, or any similar machine.

SINGLE BURR-CYLINDER PICKER

18. A burr picker with but one burr cylinder instead of two is very popular with mills using wools with few burrs, but in case of very burry stock it is customary to run it through a single burr-cylinder machine several times, so as to be sure that the burrs are all removed, since this machine is not nearly so effective as the double burr-cylinder machines previously described.

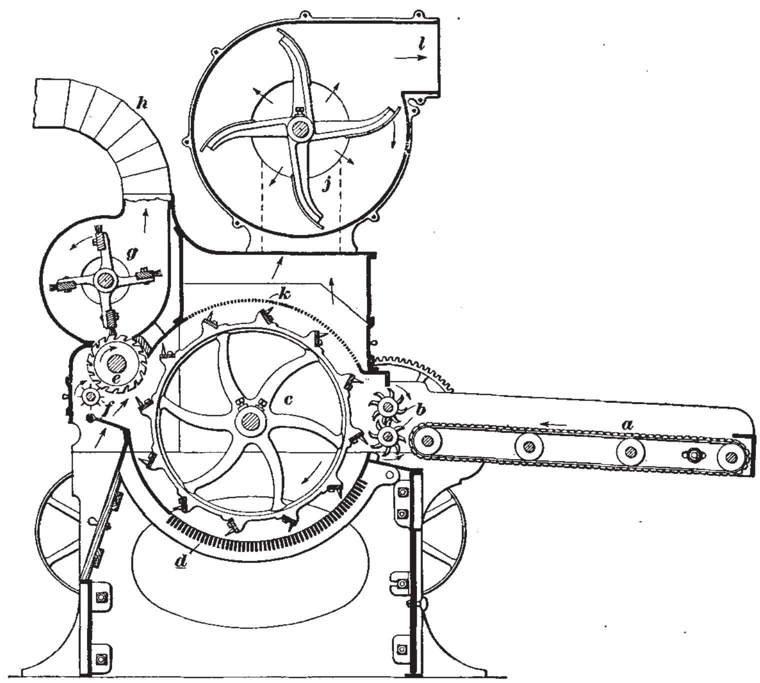


FIG. 7

A section of a single burr-cylinder machine is shown in Fig. 7; its operation is as follows: The stock is fed in the usual manner on a slatted feed-apron *a*, from which it is taken and fed to the machine by the cockspur feed-rolls *b*. The picking cylinder *c* then takes the stock and carries it over the rack *d*, thus shaking out the loose dirt, which drops through into the lower part of the machine, from which it may be removed. The wool is then deposited on the burr cylinder *e*, where the burrs are removed and cast on to the floor at the rear of the machine by the burr guard *f*. The wool is removed from the burr cylinder by means of a rotating brush *g*, which also generates a current of air for delivering the stock through the pipe *h* to the gauze room. A constant current of air is maintained in the machine by the blower *j*, which draws the dust through the screen *k* (which retains the wool) and conveys it to the outside of the mill through the pipe *l*. The inlets for the air are under the feed-rolls and at the back of the machine under the burr guard.

GODDARD BURR PICKER

19. The **Goddard,** or **Curtis and Marble, burr picker** is favorably known to the trade and is found in some of the best mills. It is shown in Fig. 8 and in section in Fig. 9. The machine is constructed with the same objects in view as those previously described; namely, to remove burrs, shives, dust, and other foreign matter from the wool, and also to open the stock and make it lofty for the cards without breaking or injuring the fiber.

The principle of this machine is somewhat different from the burr pickers previously described, but still the same general features are present; i. e., opening the wool with a picking cylinder and delivering it to burr cylinders, from which it is stripped by a rotating brush, the burrs being removed by burr guards.

20. Construction.—The feed-rolls are set with cockspur teeth, which hold the wool securely while the teeth of the picking cylinder thoroughly open it. The bottom feed-roll is stripped by the picking cylinder, and in order to prevent all chance of the stock winding around the top feed-roll, this roll is driven faster than the bottom roll; thus, the wool is cleaned from the back of the cockspur teeth on the top feed-roll by the points of the teeth on the bottom roll.

The feed-apron and feed-rolls in this machine may be stopped by means of a lever without stopping the rest of the machine, as described in the case of the other burr pickers.

21. The picking cylinder is composed of sixteen cross-bars, which are attached to spiders fastened to the main shaft of the machine. The cross-bars are filled with round-pointed teeth of steel, which are placed staggered, so that at each revolution of the cylinder the teeth cover every sixteenth inch of the width of the machine. Above the picker cylinder is a perforated brass screen fastened to an iron frame and held in place by buttons, so that it can be readily removed for cleaning. This screen has perforations of sufficient size to allow fine dust and dirt to be removed from the wool through it. The screen is removable to give access to the picker cylinder for cleaning or other purposes.

Beneath the picker cylinder is a grate, or grid, made of angular iron bars. This grate is made especially firm and will not bend out of shape; thus, the spaces between the bars of the grate are always the same. The grate is made fine enough so that loss of wool is avoided, but the heavy dirt, shives, etc., are allowed to drop through it. The grate is hinged at the rear and may be lowered in order to clean it and the picking cylinder between different lots of wool.

At the rear of the picking cylinder, two burr cylinders are built up on central shafts with alternate steel-toothed rings and solid packing rings. These burr rolls should be made of the right-sized toothed rings, or burr wire, to suit the class of wool that is being operated on, and should be spaced fine or coarse to suit the same. The burr cylinders in the Curtis and Marble pickers are not of the same size, as they are in the machines previously described, but one is smaller and works over the larger one—running in the opposite direction. The larger burr cylinder is provided with a burr guard that knocks the burrs from the surface of the cylinder. Working in conjunction with this burr guard is a smaller one, which prevents the burrs and other refuse from being carried over on to the brush cover. On this machine a rotating brush, with six cross-bars filled with bristles, strips the stock from the burr cylinders and delivers it to the gauze room through a suitable spout or pipe.

22. Oilers.—In Fig. 8, a square tank will be seen placed over the spout where the wool leaves the machine. This is a device for oiling the wool as it leaves the picker so that it

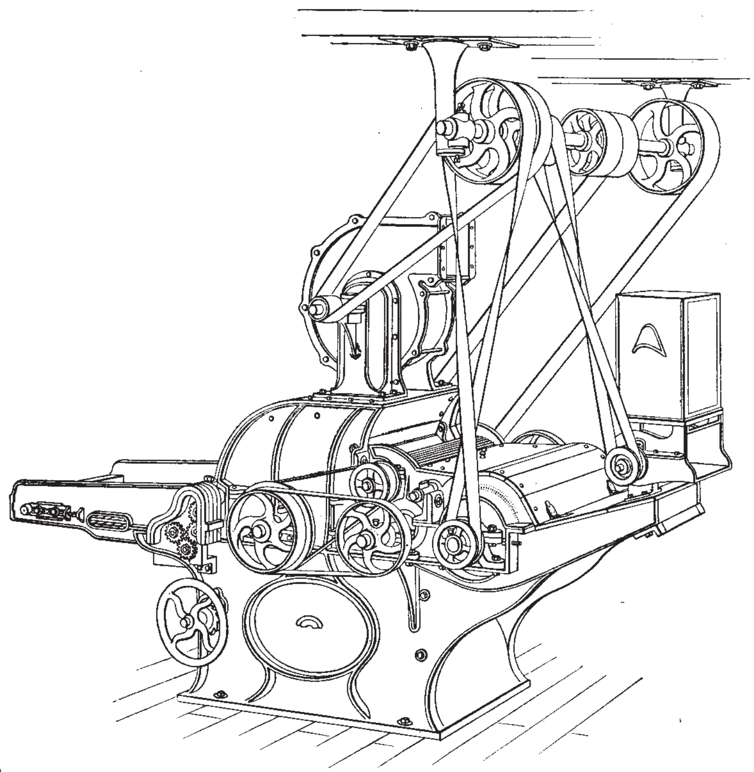


FIG. 8

will be ready for carding. This may be attached to the picker when desired. The **oiler** consists of a revolving brush that throws the oil supplied by a tank over the wool as it passes from the picker. Oiling wool by mechanical devices, either at the picker spout or elsewhere, is not generally approved by the trade. Oilers afford an easy means of lubricating

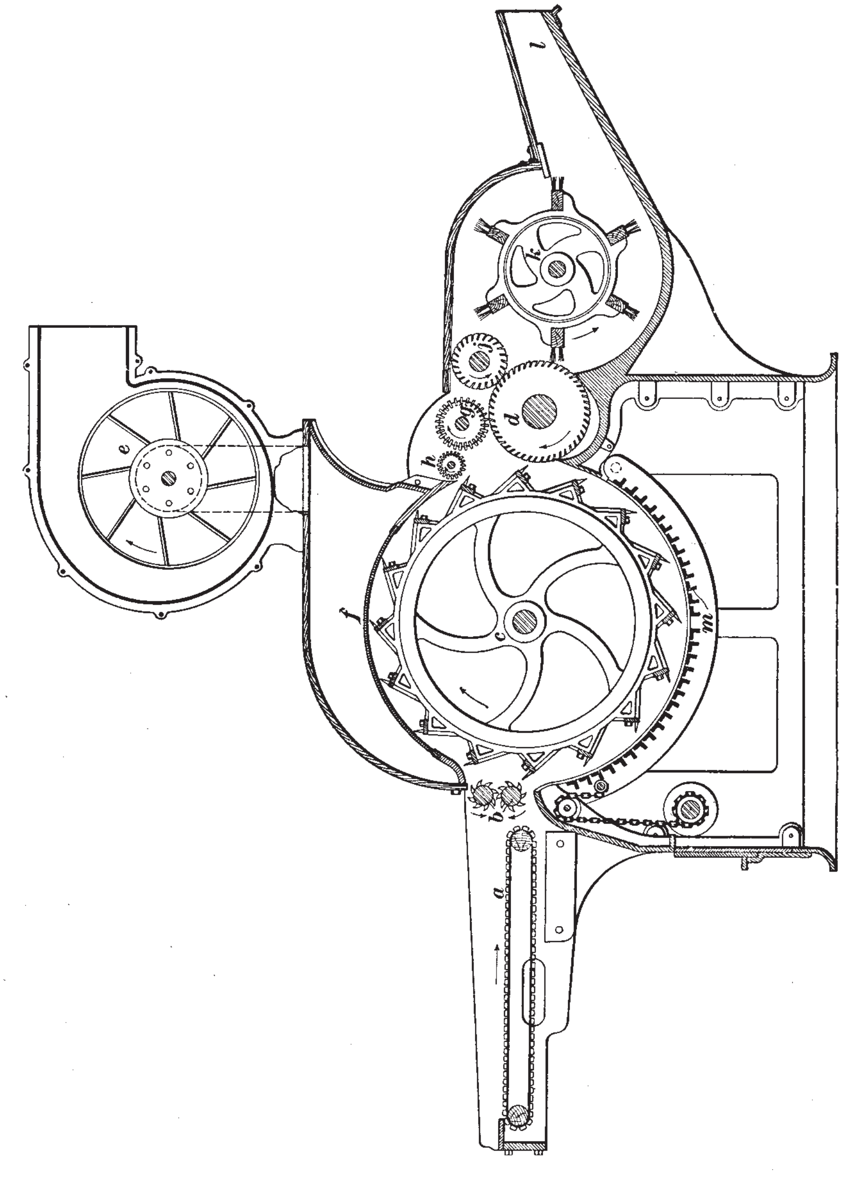


FIG. 9

cheap stock, but are seldom used on fine stock, as will be explained in another Section.

23. Operation.—In operation, the stock is fed to the traveling apron either by hand or by a self-feed. The apron *a*, Fig. 9, carries the wool to the cockspur feed-rolls *b* of the machine, where it is loosely held while being combed and opened out by the picker cylinder *c*. The wool is thus opened out at the start and the burrs and dirt loosened. The picker cylinder revolves upwards past the feed-rolls and carries the wool to the large burr cylinder *d*. The exhaust fan, or blower, *e* on the top of the machine creates a strong draft of air, which removes loose and small particles of dirt through the perforated brass screen *f*, and also lifts the fibers of wool from the picker cylinder, so that they are more readily caught by the teeth of the burr cylinder *d*. This cylinder takes the stock from the picker cylinder, receiving the fibers in the spaces between its toothed rings, while the burrs and other matter being larger than the fibers of wool remain on the surface of the cylinder and are removed by the rapidly revolving burr guard *g*. Working in connection with this burr guard is a smaller roll *h*, which prevents the burrs and refuse from being thrown on to the brush cover. The burrs thrown out by the burr guards are carried downwards by the picker cylinder, and such as do not drop through the grate *m* under the cylinder are carried forwards and thrown into a burr box through an opening beneath the feed-rolls of the machine. A small burr, or cotter, cylinder *j* operates in conjunction with the large burr cylinder, revolving slowly in the opposite direction and opening out cotted lumps of wool. The revolving brush *k* cleans the wool from both burr cylinders and delivers it through the spout *l* to the gauze room.

24. The Goddard picker, as shown in Fig. 8, requires a countershaft. The picking cylinder, fan, and revolving brush are driven direct from the countershaft, as is also the oiler, if used. The other parts of the machine are driven from the main picker shaft. The following table shows the capacity of the different widths of these machines, the amount of work turned off varying, of course, under different conditions.

Size of Picker Inches	Diameter of Picking Cylinder Inches	Capacity per Day Pounds
24	24	600 to 1,200
30	30	1,200 to 2,400
40	30	1,600 to 3,200
46	36	2,200 to 5,000
48	36	3,000 to 7,000

MANAGEMENT OF BURR PICKERS

25. In regard to the management and proper care of burr pickers, it may be said that one of the most important points is to clean periodically the various parts of the machine. All perforated, or wire, screens, grates, conducting pipes, etc. should be kept clean and clear of dirt and grease. If they are clogged up, they hinder the removal of the dirt from the wool and also reduce the efficiency of the fan, thus weakening the strength of the air-currents through the machine. Screens with small perforations will become completely coated with grease and gummy dirt, and when found in such condition should be immediately taken from the machine and washed with a strong solution of soda. When the gum is thick, a good deal of it can be scraped off before the screen is washed. The spaces under the picking cylinder and under the beaters of a Parkhurst picker should be frequently and regularly cleaned out. On the Parkhurst machine the swing-back bonnet is so arranged that it can be lifted back after the belt has been thrown off from the brush, thus allowing the burr cylinder and interior of the machine to be cleaned.

After a batch of wool has been run through the machine, if much fiber is clinging to the burrs that have been cast out, the burrs are sometimes run through the machine again in order to obtain all the fiber possible. As a rule, however, this does not pay, not only because of the time required, but also because of the danger, where there are so many burrs, of some of them passing forwards with the wool instead of being thrown out of the machine the second time. As burr pickers run at a high speed, it is essential that all bearings of rapidly rotating parts be oiled at least twice a day; otherwise, there is danger of the journals heating and becoming fast in the bearings. All belts used in connection with a burr picker should be laced, as there is danger of accidents if belt hooks are used, since the belts are in exposed places and it is necessary in many cases for the operator to work in close proximity to them. The brushes of burr pickers wear out rapidly, and they should be set up closer to the burr cylinders from time to time and ultimately replaced.

26. Setting.—In regard to the setting of the working parts of a burr picker, it may be stated that this depends largely on the character of the stock being run through the picker. For a coarse, long-staple wool, the burr cylinders may be set farther from the picker cylinder than for a finer and shorter wool, when they may be set up as close as possible without any contact. The burr guards should be set as close as possible to the burr cylinders without knocking out the wool as well as the burrs. If set too far from the burr cylinders, many burrs will escape them; while if set too near, they will pull the wool from the cylinder. Great care should be taken not to allow either the picking cylinder or the burr guards to touch the burr cylinders, since, if this is the case, the burr cylinders will be damaged and very soon ruined. The picking cylinder does not require to run very close to the burr cylinders, since the centrifugal force, due to its rapid rotation, will throw the stock from the picking cylinder into the burr cylinders. The brush should be set to strike into the burr cylinders slightly, so as to clear them thoroughly of wool. Care should be taken, however, that the brush does not strike the burr roll with any great force, as this will quickly wear out the brush and necessitate its being replaced. Again, if set too close, there is a liability of the stock being carried around the brush.

27. Gauze Room.—The stock from a burr picker is delivered by the current of air generated by the brush to a gauze room. This is usually a wooden compartment provided with openings covered with wire screening, or gauze. The stock is blown from the burr picker to this room, the object of the gauze-covered openings being to let out the surplus air, but to retain the wool. Such machines as burr and mixing pickers, which deliver the stock by means of a strong current of air, require some such room in which to deposit the wool in order to collect it within a small space. The gauze room should be made large enough to accommodate a batch of wool easily, and should have a door of sufficient size to permit the easy removal of the cleaned stock. The door should have strong and suitable fastenings, and the openings in the room, which are covered with wire gauze to allow the egress of air, should be of sufficient area so that the efficiency of the current of air from the picker will not be impaired. If the gauze room is to be used for wool that is oiled in the burr picker, or for receiving the stock from a mixing picker, the floor of the room should be covered with tin, or preferably zinc, to prevent the oil from soaking into the floor. Care should be taken to prevent fire in a burr picker, or any similar machine that depends on currents of air for its operation, as nothing causes a fire to spread so quickly as an air-current.

28. Calculations.—The only calculations required in connection with a burr picker are those used in finding the speeds of the various parts, which may be readily done by means of the instruction previously given in regard to speed calculations.

CARBONIZING

INTRODUCTION

1. There are two methods in general use for removing the vegetable matter with which all wools are more or less impregnated, namely, the *mechanical* and the *chemical processes*. The **mechanical process,** which consists in the removal of the burrs and other vegetable matter by means of some form of machine, such as is described in *Burr Picking*, has already been dealt with. The **extracting,** or, as it is commonly called, the **carbonizing process,** removes the vegetable matter by means of chemical action whereby the structure of the vegetable matter is destroyed so that it may be easily shaken or dusted from the wool. Wools filled with small burrs, shives, etc., are cleaned much more easily and cheaply by extraction than by burr picking. Wools that have only comparatively few burrs adhering to them are usually run through a burr picker only, while wools that are quite burry are sometimes burr-picked to remove the larger burrs and afterwards carbonized to destroy all the minute burrs and other vegetable matter, as shives, dust, chaff, etc. that may have escaped the burr picker.

The carbonizing process is now becoming very common and is largely replacing the use of burr pickers, although it may be said to be more of a European than an American practice. Where wools are mixed with a large amount of fine chaff and straw, carbonizing, or extracting, is indispensable for their complete removal. In some mills, it is the custom to throw aside the most burry portions of the fleece during sorting and carbonize these portions alone, the rest of the fleece simply being run through a burr picker.

2. The principle of carbonization depends on the action of certain chemicals that will destroy the vegetable matter, but will not injure the wool if the process is properly performed. It is evident that alkaline chemicals are not suitable for carbonizing purposes, since they readily destroy the wool fiber without injuring the vegetable matter. A 2° Baumé (hydrometer) solution of caustic soda will dissolve wool completely if boiled, but it will not affect burrs or even cotton fibers. Acids are, however, particularly adapted for carbonizing, since, if not too strong, there is no injurious effect on the wool, but even a dilute solution will effectually destroy burrs, chaff, cotton, or any other vegetable material. Besides acids, several other substances are used for carbonization; the principal agents in use, however, are sulphuric acid (oil of vitriol), hydrochloric acid (muriatic acid), aluminum chloride, magnesium chloride.

CARBONIZING PROCESSES

SULPHURIC-ACID PROCESS

3. Commercial sulphuric acid, or oil of vitriol, contains varying amounts of water and also other impurities, notably arsenic, iron, lead, sulphur dioxide, etc. In addition, the acid is often discolored by organic dust that has been charred by the action of the liquid. The commercial product, however, is usually pure enough to meet the requirements of carbonizing. In using acid on wool, care should be taken to have the solution weak so that the fiber of the wool will not be injured in any way; for though acids have no appreciable effect on the fiber when dilute, yet if they are strong and any heat is applied, a weakening of the fiber will result, and the stock will have a harsh feeling and a yellow color.

A 1° Baumé solution of sulphuric acid would be sufficient to destroy the smaller particles of vegetable matter in wool, but for effectually carbonizing large burrs, etc. a stronger solution is found to be necessary in actual practice. The strength of the solution should vary from 2° to 6° according to the coarseness of the stock that is being treated and the number of burrs that it contains. Stock that is naturally tender should be carbonized with as weak a solution as possible, while stronger stock may be treated with a stronger solution. In actual practice it is found that a strength of 4° or $4\frac{1}{2}$° Baumé is about right for wool carbonizing solutions in the majority of cases. In diluting acid with water, the acid should always be poured into the water in a thin stream; water should never be poured into strong acid, since a large amount of heat is generated when the acid and water unite, and if a large quantity of acid is present the solution is liable to explode and cause terrible burns if it comes in contact with the workman. Care should be taken also to stir thoroughly the liquor with a pole, as otherwise the acid, being heavier than the water, will settle to the bottom of the tank and the solution, when tested with the hydrometer, will indicate a weaker solution than is actually present. Again, if the liquor is not well mixed, some of the wool is liable to be injured by the action of that part of the liquor where the acid is too strong, while other portions of the stock will not have the burrs effectually carbonized because of their being in contact with only a very weak solution.

METHOD EMPLOYED

4. The operation of carbonizing with sulphuric acid consists of steeping the wool in the dilute sulphuric-acid solution in large wooden tanks. The length of time that the stock is immersed in the acid solution depends on the strength of the acid, which in turn should be governed by the character of the fiber. The strength of the acid solution most commonly used is about 4° or $4\frac{1}{2}$° Baumé, and an immersion of 40 minutes in a solution of this strength is generally sufficient for the most burry stock. The wool should be kept under the solution while it is in the acid tank, as if portions of it are exposed to the air the fibers thus exposed are considerably weakened, owing to the concentration of the acid on them by evaporation of the water. It does not harm the wool to any appreciable degree to stay in the acid solution for some time, provided that the acid is not too strong and the stock is completely submerged. Although it is desirable to have the stock thoroughly saturated with the acid solution, no attempt should be made to pole the stock around in the soaking tank, as the benefit derived is not great enough to compensate for the danger of felting the stock.

5. When the wool is thoroughly saturated with the acid solution it is taken out and the moisture partly removed in a hydro-extractor. The basket of the hydro-extractor should be galvanized or made acid-proof in some manner if used for carbonizing work; otherwise, the acid will attack and destroy it. The liquor driven out of the wool in the hydro-extractor should be allowed to run into a tank, from which it can be pumped back into the soaking tubs and used over again. The excess of acid may be removed before drying by means of a pair of squeeze rolls instead of a hydro-extractor, if so desired. The wool is now dried at a temperature of from 160° to 165° F. in an ordinary hot-air dryer, after which it is run through a second dryer and subjected to a temperature of from 200° to 230° F. A temperature of 210° F. in the second dryer is usually about right for wool that has been properly treated with acid. When wool is dried in this manner, it usually occupies about 20 minutes in running through each dryer. A two-compartment dryer is more convenient than two single dryers for drying wool after acid treatment, the temperature in the first compartment being kept at about 165° F. and in the second at about 210° F. The temperature for drying is sometimes made as high as 250° F., but this does not act so mildly on the wool, and is liable to make the fiber of fine wool tender and of a yellow color. Instead of using two single dryers or a two-compartment dryer, as explained above, some mills have a room where the stock can be subjected to the high temperature after being dried in an ordinary dryer. This method is inconvenient, however, as the stock has to be spread on racks by hand and removed in the same way—a laborious operation as compared with the continuous progress of the stock in a machine dryer.

The temperature in drying must be raised to at least 180° F. or carbonization will not take place. It is always best first to dry the wool, as previously explained, at a somewhat lower temperature and then increase the heat for a short period in order to complete the carbonization. The wool is sometimes dried in an apron dryer with an attachment of crush rolls for pulverizing the charred vegetable matter, in order that it may be more easily removed by the *carbonizing duster* through which the stock is passed after being dried. This machine, which will be explained later, is generally equipped with a series of crushing rolls for crushing the carbonized vegetable matter, as well as means for dusting the crushed matter from the stock. For drying acid-treated stock, it is necessary that the aprons and other metal work of the dryer that are in contact with the stock shall be heavily galvanized, in order to prevent the acid from attacking and destroying them. In order to obtain the best results, the stock should not be exposed to the air for any length of time between acid treatment and drying.

The action of the acid during the drying process—for this is when carbonizing really takes place—is as follows: As the moisture is evaporated, the acid, which has a great avidity for water, attacks the burrs and other vegetable matter, which naturally hold the moisture longer, and extracts it from them, in so doing changing the nature of their structure and converting them into particles of carbon, which crumble to the touch. If the wool is examined carefully, it will be seen that the burrs and other vegetable matter, although they have not lost their form, are in a very brittle state and on being squeezed, or crushed, crumble to a fine dust or powder. When the wool has been dried, it is passed between a series of heavy crush rolls and the carbonized vegetable matter is pulverized and easily shaken or beaten out. The wool is then immediately treated with a soda solution to neutralize any acid that may remain in the fibers. Great care should be taken with the process of **neutralizing,** which is accomplished by immersing the wool in a solution of soda of about 4° strength (never more than this) and allowing it to be in the solution for a sufficient time to be saturated thoroughly. Afterwards the wool should be rinsed in pure water.

Wool carbonized with sulphuric acid will gain from 12½ to 15 per cent. in weight after being stored for a sufficient length of time. This is due to the fact that in carbonizing the natural moisture, which is driven from the wool by the intense heat, will be regained if the wool is allowed to stand for some time. No appreciable deterioration of the wool itself takes place if the process of carbonization is properly performed; in fact, it has been found that wool properly treated with acid seems actually to have gained in strength of fiber. One of the chief dangers to guard against is overheating in the dryers, which will yellow the stock and also make it tender.

HYDROCHLORIC-ACID PROCESS

6. Hydrochloric acid is used for carbonizing, mainly in the form of a gas. The process is one that is never applied in America, but is in use to a limited extent in Europe; it is confined mainly to carbonizing rags, as it is a failure on new wool, owing to the tendency it has of turning the fiber yellow. Carbonization by this method is performed by spreading the rags on racks in a chamber heated from 200° to 230° F., where they are treated with the fumes of the hydrochloric (muriatic) acid. The action is exactly the same as that of the sulphuric-acid process and a 2-hour or 3-hour treatment is sufficient, after which the stock should be dusted and neutralized.

Carbonization by the dry, or gas, method is sometimes accomplished in a large, rotating, iron cylinder, which is surrounded by a coil of steam pipes, in order to obtain the necessary heat. The air is removed from the cylinder by a vacuum pump and the fumes of the acid passed in. The rotating cylinder turns the stock over and exposes all parts of it to the action of the gas.

ALUMINUM-CHLORIDE PROCESS

7. The use of aluminum chloride for carbonizing the vegetable matter found in wool is being introduced into some of the best mills and carbonizing plants, superseding the older method of carbonization by the use of sulphuric acid. Aluminum chloride is a milder agent than acid and acts less harmfully on the wool fiber; therefore, there is less danger of injury to the stock. Another advantage of aluminum chloride is that it does not attack the iron that is used more or less in the construction of dryers, hydro-extractors, etc. If wool that has been saturated with sulphuric acid comes in contact with iron before it is dry, the acid attacks the iron and a rust spot is made on the wool. Aluminum chloride also possesses antiseptic properties, to some extent.

8. The wool to be carbonized is saturated, in a box or tank, with a 6° to 8° (Baumé) solution of the chloride from 40 minutes to an hour, and is afterwards partly dried in a hydro-extractor and then completely dried as in the sulphuric-acid process. This completes the carbonization. The wool is then passed through a carbonizing duster and the carbonized vegetable matter crushed and removed. After the wool has been dusted, it is washed with clear water or water with a small quantity of fuller's earth added, as the residue from the chloride is easily removed. *Fuller's earth* is a clay-like substance that is used in the scouring and fulling of woolen cloth.

The action of the aluminum chloride depends on the fact that when a solution of this substance and water is evaporated, the chloride is decomposed and hydrochloric acid is liberated. The acid attacks the vegetable matter and is the real carbonizing agent. Wool carbonized with aluminum chloride will, after being stored for some time, gain about 5 per cent. in weight.

9. The **advantages** claimed for this process, summed up in as few words as possible, are as follows:

1. It is the simplest method and one attended with the least inconvenience to the workmen, there being no disagreeable acid fumes for them to breathe.

2. Wool carbonized with aluminum chloride retains its elasticity, softness, and natural feeling to a greater extent than wool extracted with acid; nor is there the danger of weakening the fiber by overheating that attends the acid treatment.

3. The danger of staining the wool with iron rust is eliminated, as the chloride does not attack iron as does acid. The wool may thus be dried by steam pipes without danger of injury.

10. Among the **disadvantages** of the use of aluminum chloride as a carbonizing agent may be mentioned the following points:

1. The process is apt to be somewhat uncertain, owing to the tendency of the aluminum-chloride solution suddenly to lose carbonizing strength, whereas the sulphuric-acid process is unfailing.

2. Stock carbonized with aluminum chloride will not take certain colors so well as stock carbonized with sulphuric acid.

3. Aluminum chloride has a tendency to decompose into a sticky, greasy compound that coats the inside of the dryers and dusters, and can only be removed by the use of sharp scrapers. This is a disadvantage in dusting, as the duster should at all times be clean, in order to obtain the best results. No compound of this nature results from the use of sulphuric acid as a carbonizing agent.

COMPRESSED-AIR CARBONIZING APPARATUS

11. The aluminum-chloride process of carbonizing is occasionally performed with apparatus designed to be operated by compressed air. With this apparatus, as usually arranged, the carbonizing liquor is not only forced through the wool by compressed air, but the latter also furnishes power for removing the stock from the soaking tanks. The usual arrangement is to have two wrought-iron soaking tanks about 6 feet in depth and 5 feet in diameter. These are connected at the bottom by a suitable pipe provided with a valve and the tanks equipped with perforated false bottoms. The stock to be carbonized is contained in wrought-iron cages perforated on the bottom and sides and so arranged as to be lowered into the soaking tanks and rest on the false bottom. The carbonizing liquor is stored in a supply tank so placed that the liquor may be run into the soaking tanks by gravity. The compressed air is obtained by means of an air compressor and is stored in a wrought-iron storage tank connected with the soaking tanks by suitable pipes. The compressor automatically maintains a pressure of 60 pounds per square inch in the storage tank.

In operation, the stock to be carbonized is placed in the cage in the first soaking tank and the carbonizing liquor run in from the supply tank until the stock is completely submerged, the connection with the second soaking tank being closed during this operation. The cover is now securely fastened on to the first soaking tank. The second tank is then filled with stock and the connection between the two tanks opened; at the same time the compressed air is admitted to the first soaking tank from the storage reservoir. The pressure thus obtained in the first tank drives the liquor down through the wool in the first tank and up through the stock in the second tank. To resist the tendency of the wool in the second tank to be forced up by the air, a wooden frame is placed across the top.

When the liquor is all out of the first soaking tank, which is indicated by its rising to the same height in the second tank, the connection between the two tanks is shut off, as is also the connection between the first soaking tank and the compressed-air reservoir. Then, by means of an exhaust valve, the compressed air remaining in the first tank is let out and the cover removed. The first tank may now be emptied and refilled, the hoisting and lowering of the cage being accomplished by means of compressed air. The cover is then securely fastened down on the second tank and compressed air from the reservoir admitted to the top of the tank, which forces the liquor (the connection between the two tanks having been opened) down through the wool in the second tank and up through the wool in the first, which is the reverse of the initial operation.

These operations are repeated until the entire batch to be carbonized has been treated with the chloride solution, after which the liquor is removed from the soaking tanks and stored in the supply tank. This may be accomplished by closing all the outlet valves except the one to the supply tank and admitting compressed air to the soaking tank, whereupon the liquor will be rapidly driven back to the storage tank.

MAGNESIUM-CHLORIDE PROCESS

12. The process of carbonization with magnesium chloride is very similar to that employed with aluminum chloride, the effects also being of a similar nature. The stock to be carbonized is saturated in a solution of magnesium chloride of from 5° to 6° (Baumé) strength for one-half or three-quarters of an hour, and is then taken out and the excess of moisture removed in a hydro-extractor. The stock should next be dried as in the sulphuric-acid process, and after being allowed to cool, dusted and washed as in the aluminum-chloride process.

13. Extracting, or carbonizing, is not confined to raw stock, as very often the cloth is carbonized after it is woven. Woven cloth is carbonized either by sulphuric acid or by aluminum chloride, the object being to remove motes or minute particles of vegetable matter that have not been removed in the process of manufacture and that otherwise would have to be picked out by hand. The action of the carbonizing agents is not confined to motes and such vegetable impurities, but extends to cotton and other vegetable fibers. This fact is made use of in recovering the wool fibers (known as extract) from manufactured goods that contain both cotton and wool. The process that is generally used is the sulphuric-acid one, although the dry-gas method is sometimes employed. The rags that contain both wool and cotton threads are steeped in the acid, dried, crushed, and dusted after the manner of the raw wool. The cotton is thus removed from the fabric, and the wool that remains is worked over again, i. e., remanufactured.

An interesting method of forming fancy patterns is based on the principle of carbonization. A fabric that contains both woolen and cotton fibers is taken, and a figure or design printed on it with a paste of aluminum chloride, the cloth being afterwards dried at a high temperature. The effect of this is that the cotton is destroyed in those portions of the fabric that were in contact with the chloride, and the cloth in those places becomes so impoverished as to produce a gauze.

MACHINES USED IN CARBONIZING

14. In order to extract the vegetable matter from wool successfully by means of a chemical process, it is necessary to have suitable tanks for soaking the stock in the carbonizing solution. For this purpose wooden tanks of an appropriate size are the most satisfactory, as they are not affected by the solutions and give a maximum of service with a minimum of cost. Round wooden tanks with iron hoops will stand the action of acid better and give longer service than square tanks as usually built with iron rods piercing the wood.

The hydro-extractor used for extracting the excess of moisture from the stock before drying is the same as has been described, with the exception that the basket should be tinned or galvanized in order to render it acid-proof.

In drying wool that has been treated with acid, it will be found impossible to use a dryer that has cotton aprons, as the acid will immediately destroy the aprons. In the case of aluminum-chloride carbonized wool, the stock can be dried with a multiple apron dryer with heated steam pipes between the aprons; but with sulphuric-acid carbonized wool the vapor of the acid will rust the iron pipes, and the wet rust dropping on the wool or the wool coming in contact with the pipes will result in stains. All metal in the dryer that comes in contact with stock that is saturated with acid must be tinned or galvanized. The aprons in some dryers are made of galvanized wire cloth, which makes a good apron for acid-treated wool. A two-section carbonizing dryer is best and gives the most satisfactory results for this work, the machine being arranged to dry the stock in the first compartment and carbonize it in the second.

THE CARBONIZING DUSTER

15. After the wool comes from the dryer, the vegetable matter that was in the stock before carbonization is greatly changed in character. Instead of being tough and clinging to the fibers of wool with great tenacity, the burrs are brittle and may be easily crushed and shaken out of the stock. The object, therefore, of the carbonizing duster is to crush the burrs and other vegetable matter rendered brittle by the agent used in extracting and to remove them from the wool fibers. A duster built especially for handling carbonized stock is shown in Fig. 1. The principle on which this machine operates is similar to that of the cone duster previously described, with the exception that the carbonizing duster is provided with three pairs of heavy crush rolls *b* for the purpose of reducing the carbonized burrs to powder before the stock is subjected to the action of the rotating cylinder. The rolls are connected by gears and have springs and hand wheels *c* for controlling the pressure, which should be regulated so as to be heavy enough to crush the carbonized burrs, but not enough to cut the wool. The arrangement of the six rolls in this machine, and in fact in nearly all carbonizing dusters, is such that only three crushing points are obtained, as the rolls are arranged in pairs. A better arrangement is to have three bottom rolls and two top rolls, the latter resting between the bottom rolls, so that four crushing points are obtained, although there is one less roll on which the pressure has to be regulated. If this arrangement is used, however, the springs for applying the pressure should be somewhat stronger, as the pressure is divided over two points instead of being concentrated at one. In most carbonizing dusters, the width of the crush rolls is too narrow. A better method is to have wider crush rolls, so that the stock can be fed thin and a better crushing obtained whereby none of the burrs will pass to the duster without being crushed. After passing the crush rolls, the stock can be

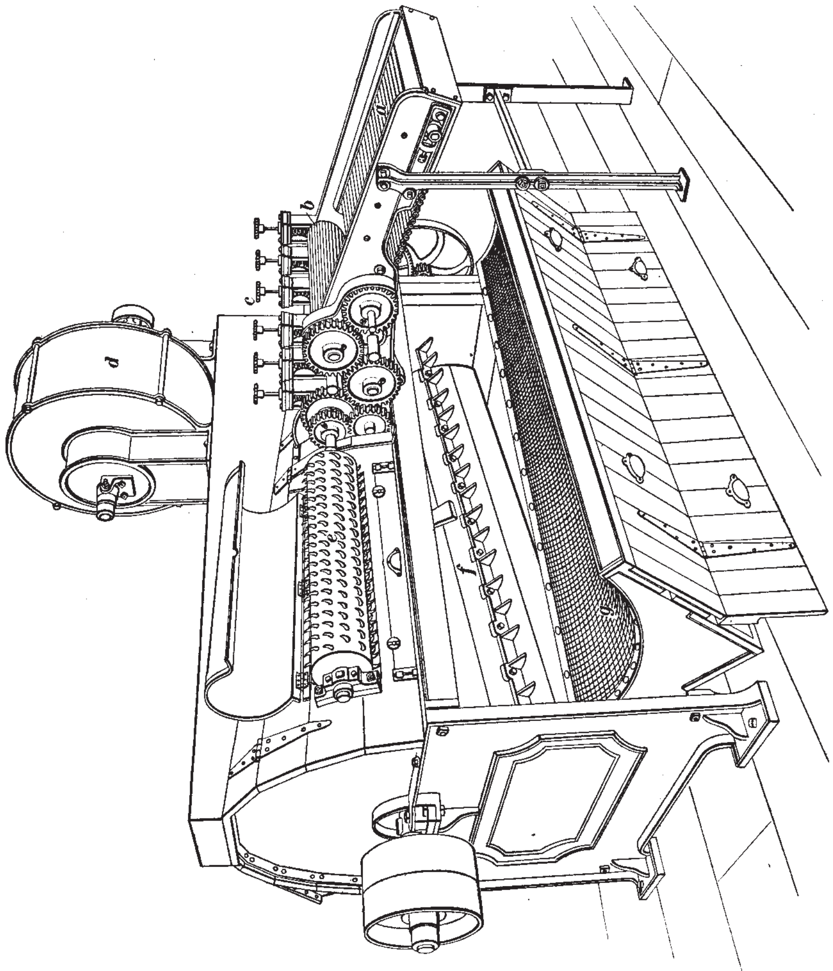


Fig. 1

directed to a narrow apron feeding the duster. Sets of crush rolls can be obtained entirely separate from a duster. . The machine illustrated is built with a worker *e*, which greatly assists in opening out the stock. In operation, the worker rotates slowly backwards, its teeth engaging with the wool that is carried around by the main cylinder *f*. The worker is protected by a sheet-iron bonnet, which is shown raised from the worker. The fan *d* is on the top of the machine; and, since the space under the screen, which is beneath the main cylinder, is air-tight, the air drawn by the fans enters at each end of the main cylinder around the main bearings of the same, through apertures provided for that purpose. Beneath the fan there is a screen that retains the stock, being so made that it may be drawn out for cleaning. The air that passes through the upper portion of the machine sucks away light dust, etc. from the wool, while the heavy particles of dirt fall by gravity through the screen *g* under the cylinder. The screen is made in two sections, one of which may be withdrawn from the front of the machine, as shown in Fig. 1, and the other from the rear. The draw that removes the screen is also provided with a door for access in cleaning out the refuse without removing the draw itself. A good position for the fan of a duster is below the screen, or grate, since if placed in this position, the current of air produced not only removes the dust from the stock, but also aids the fall of the heavier particles. When the fan is on the top of the machine, the current of air, being upwards, tends to hinder the fall of matter through the grate. The cylinder *f* is provided with heavy iron teeth for beating the wool. The machine, being provided with tight and loose driving pulleys, does not require a countershaft for driving. The duster illustrated in Fig. 1 occupies floor space 9 feet by 7 feet and requires a $3\frac{1}{2}$-inch or 4-inch belt to drive it, about 4 horsepower being necessary.

16. Operation of Duster.—In operation, the stock is fed either by hand or by means of a self-feed on the feed-apron *a*, which carries the wool to the iron crush rolls, which successively operate on the stock and reduce to powder the previously carbonized vegetable matter that is contained in the wool. The wool is now delivered to the action of the main cylinder, which revolves upwards at a speed of about

400 revolutions per minute, although sometimes a speed of 450 revolutions is used when stock with a short fiber is to be treated. A longer fiber will require the slower speed, in order to prevent damage to the stock by breaking the fibers. The action of this cylinder, combined with that of the worker *e*, which operates in conjunction with it, is to shake, or beat, out all the dust and pulverized vegetable matter from the wool, the heavier particles of which fall through the screen *g* into a compartment under the cylinder whence the refuse can be periodically removed. The lighter foreign matter and dust are removed by the current of air generated by the fan through the upper part of the machine and conveyed outside of the mill through a suitable pipe. The wool travels from the small end of the cone-shaped cylinder toward the large end, and is finally thrown out through a square orifice at the end of the cylinder in the rear of the duster.

SARGENT'S LOW FEED

17. In connection with the Sargent multiplex burr picker, illustrated in *Burr Picking*, a self-feed attachment is shown. This self-feed is one that is in common use and is adapted not only to burr pickers but to mixing pickers and to carbonizing and other dusters, to which it is often applied. The object of this machine is to feed the stock evenly and uniformly to the duster or picker, and supplant the more laborious method of hand feeding. The principle on which the machine operates is that of a traveling lifting apron filled with spikes that lift the stock from the hopper and deposit it on the feed-apron of the machine to be fed. The apron is made of hardwood slats attached to endless belts, and is supplied with sharp spikes from 1 inch to $1\frac{1}{2}$ inches in length that engage with the stock in the feed-box; the wool is thus carried to a revolving comb that combs off all excess of wool and evens the feed.

The comb in this machine is a cylindrical revolving one, and is fitted with two rows of teeth, which are withdrawn from the surface of the comb after coming in contact with the stock on the spiked apron; this is accomplished by means of an eccentric, which works in a wide-slotted arm to which the teeth of the comb are attached through suitable connections; by this means the stock is prevented from winding around the comb. There is a traveling apron in the bottom of the hopper for the purpose of keeping the stock constantly pressed against the lifting apron. A *beater*, or *stripper*, is provided for stripping the stock from the lifting apron and depositing it on the feed-apron of the duster or other machine to be fed. The speed of the beater should be about 235 revolutions per minute, and the machine is driven from this shaft. The speed of the lifting apron may be changed by means of cone pulleys and change gears. The floor space occupied by the machine, when attached to another machine, is 4 feet 6 inches in length.

18. Operation.—In operation, the wool or other stock is placed in a large, commodious hopper, or feed-box, from which it is extracted by the lifting apron. The wool is kept in constant contact with the lifting apron by means of the traveling apron in the bottom of the hopper. As the stock is elevated to the revolving comb, large bunches of wool are knocked back into the hopper, and the amount of stock fed is thus made uniform and the apron evenly loaded. The stock is then stripped from the lifting apron by the beater, and falls on the feed-apron of the duster or burr picker. The feed requires about 1 horsepower for driving purposes.

WOOL MIXING

INTRODUCTION

1. Importance of Proper Mixing.—Although the importance of proper methods of *mixing* stock before subjecting it to the carding process is often underrated, it may be stated with truth that the character of the yarn ultimately produced depends, to a great extent, on the manipulation of the stock at this point. **Mixing** is the blending, or amalgamation, of different colors or qualities of wool, or of wool and cotton, wool and shoddy, or similar materials, and is resorted to for various purposes. Sometimes the mixture is simply one of colors; for instance, it may be desired to produce a gray mix; this result will be obtained by blending wool that has been dyed black with pure white stock in proportion to the shade of gray desired in the mixed yarn. Again it may be found that a certain grade of goods is costing too much. In such a case, if the cost of production is already reduced to a minimum, the only recourse is to reduce the cost of the material entering into the goods. If a high grade of goods is being made, the cost of the material may be reduced by blending a cheaper grade of wool with the finer stock previously used. If a medium grade of goods is being manufactured, a little shoddy or cotton may be mixed with the stock; while if the lowest grades of goods possible are being made, various kinds of fibers may be blended together, material possessing any spinning qualities at all being of value.

2. At first thought it would seem a comparatively simple matter to mix two or more materials together and spin a yarn from the blended stock, but when it is considered that the materials to be mixed are often radically different in physical structure and that they should be so blended as to be indistinguishable one from the other, the difficulty will be recognized. The yarn spun from the mixed stock should also be as even and level as though only one material were used and, if the mixture is one of color, the blend should be so perfect that the colors of the original ingredients cannot be distinguished except on close inspection.

It matters little how perfect are the color and the design of a fabric, or how carefully the other processes of manufacture are accomplished, if the mixing of the raw stock has been carelessly or imperfectly performed, the finished cloth will show more or less imperfections. Sometimes the cloth will be covered with specks, usually of the lighter-colored stock used in the mix; such cloth must either be sold for seconds or piece-dyed. A thread composed of poorly mixed materials when examined under a microscope reveals, instead of the perfect amalgamation of the individual fibers of different materials, a mass of the fibers of one material in one part and a mass of the other in another part of the thread. The evenness of the thread itself is liable to imperfections, since it is impossible to spin an even thread from unevenly mixed stock. Especially is this true in a case where the mix is composed of materials of different spinning properties and of different lengths of staple. In cases like this the roving will not draw well in spinning and the yarn will be liable to contain *twits*. If the spinner cannot make a first-class yarn out of poorly mixed materials, neither can the weaver make a perfect piece of cloth from an inferior yarn, nor the dyer and finisher produce superior results.

3. Mixing is resorted to, not only for combining colors or qualities of stock, but is also occasionally used in the best mills in lots of one color and quality, since any mistakes in sorting, scouring, dyeing, etc. are by this process equally distributed through the entire batch. The more that wool is mixed and worked over, without injury to its natural qualities, length of staple, and physical structure, the evener will be the yarn and cloth made from it.

METHOD OF LAYING OUT MIXES

4. Whatever may be the materials to be mixed, the same general method is followed in mixing; for though the process of mixing has been in use for many years no improvement has been found on the old method, which consists of spreading the materials to be mixed in thin alternate layers on the floor of the picker room. For a simple example, suppose that a gray mix composed of 50 per cent. black and 50 per cent. white wool is required; the method of procedure will be as follows: Equal quantities of black and white wool will be weighed out first and then, on a clean floor space in the picker room, a layer of black wool will be spread about 10 or 12 feet square, depending on the number of pounds of stock to be mixed, and 7 or 8 inches in depth, care being taken to have it spread evenly and of uniform depth. Then a similar layer of white wool will be spread over the first layer of black, care being taken to have approximately the same quantity of stock in the layer of white as in the layer of black wool. Then another layer of black, then white, and so on until the lot is completed.

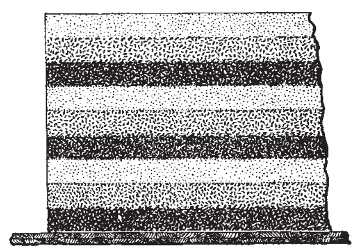


Fig. 1

The mix is now ready to be put through a mixing picker. In taking the stock from the pile on the floor, great care should be taken to break it down from the side or end and not from the top; otherwise, the benefit of laying out the stock in successive layers is lost. If the stock, however, is taken carefully from the end, a portion of each layer will go into the self-feed of the mixing picker in every armful. It is customary to oil the stock as each layer is spread during the mixing, but this process will be described later. In many instances, a mix contains more than two materials; in some cases three, four, or even more components enter into the mixture.

Fig. 1 represents the mixing of three colors of the same material, or three materials. In the illustration, the dark-shaded divisions represent material or color No. 1; the medium-shaded divisions, material or color No. 2; and the light-shaded divisions, material or color No. 3.

5. In making fancy mixes, sometimes with a little study advantageous methods of laying out the mix may be devised; for instance, suppose that a fancy mix composed of 50 per cent. black wool, 25 per cent. white, and 25 per cent. olive is required. If the layers were laid out on the floor in the order and percentages given, to make the individual piles of different-colored wools come out even, or be used up at the same time, it would be necessary to make the layers of black wool twice as thick as those of either the white or olive wool. This would not distribute the different ingredients so well as when the layers of stock were made of the same thickness and distributed in the following order: black, white, black, olive; this process would be repeated until the wool were all used up, and if the layers were of the same thickness they would come out even. This method, of course, would be impossible if there were only two ingredients in the mix.

6. In laying out a mix containing different percentages of materials, where it is not possible to divide the stock so that each layer shall be of the same thickness, care should be taken to make the layers of each material vary in thickness as near as possible according to the percentage of that material in the total blend; otherwise, the ingredient of which there is the smallest amount will soon be exhausted and the rest will have to go on top, thus destroying the evenness of distribution and the uniformity of the blend.

In dealing with mixes of great diversity of quantity as well as color and quality of components, it is often customary to prepare a temporary mix with the small quantity and a part of the larger quantity of material and then finally blend this temporary mix with the rest of the stock. In this manner the small quantity of one ingredient is more evenly distributed through the large amount of the other. For instance, suppose that a mix composed of 90 per cent. black and 10 per cent. white is required. If these are mixed directly there is such a small amount of white present that it will be difficult to distribute it evenly, so that if the amount of mix required is 500 pounds, a temporary mix of 50 pounds of white and 100 pounds of black making a mix of 150 pounds will be prepared. The temporary 150-pound mix will then be mixed with 350 pounds of black, making 500 pounds of the final mix, which will contain only 50 pounds, or 10 per cent., of white wool.

7. In mixes where several colors are used, it is sometimes the custom to mix the smaller proportioned colors together first and run them through the mixing picker, and afterwards mix this temporary mix with the color that occurs in the greatest proportion. For instance, if a mix were being made of 40 per cent. black, 20 per cent. brown, 20 per cent. olive, and 20 per cent. slate, the custom would be to first mix the brown, olive, and slate and afterwards blend this temporary mix with the black. This would insure the colors being more evenly distributed.

In making a mix where there is an extremely small amount of one ingredient, such as an Oxford mix containing 97 per cent. of black and 3 per cent. of white, it is customary to card that stock which enters into the blend only in a small percentage before it is mixed, in order to make it more lofty and enable it to be more uniformly distributed. This is usually accomplished by having an extra breaker card and allowing the stock to drop on the floor from the doffer comb. Or, if this is not convenient, it may be run through the mixing picker several times before mixing. These machines will be fully explained further on.

8. Care must be taken in making fine mixes to have all the materials of approximately the same length of fiber if the best results are to be obtained. If short fibers are mixed with long ones, that is, extremely long in comparison, they do not strengthen the yarn to a great extent, although they make the yarn more bulky. There is also a tendency for the short fibers to bunch up during the carding and the drafting of the roving in spinning and produce twits in the yarn.

In regard to the number of times that a mix is passed through the mixing picker, little can be said, as it all depends on the condition in which the stock is received from the preceding processes and the materials and colors that are being blended. If the stock is well opened and lofty and the mix is carefully made, it will probably not be run through more than twice. Some materials are more difficult to blend thoroughly than others and some colors also have a tendency to show up more than others if not thoroughly amalgamated, even if the stock is the same. The only way to tell whether the stock needs to be passed through the mixing picker again is to examine the mix and see if the fibers are well and evenly blended; if not, and they occur in separate patches, it is well to run the mix through the picker again. Some mills make a practice of running mixes through the picker three times, while others consider twice sufficient. Definite rules, however, should never be allowed to regulate the handling of all mixes.

9. Mixing Wool and Shoddy.—In view of the competition that is now prevalent, many manufacturers deem it wise to mix varying percentages of cheaper material into their goods in order to gain the market against a competitor by underselling him. One of the materials mixed with the wool to cheapen the cost of the raw stock is **shoddy.** This material is, literally, the worked up waste of old, soft, woolen fabrics, such as stockings, knitted fabrics, flannels, and other woolen goods that have not been milled or felted; but in the mill the card waste, strippings, etc. are sometimes considered as shoddy and after being dusted are worked up with the new wool. Usually, however, soft waste is worked up as far as possible with the batch in which it was made, but hard waste is run through a Garnett machine or rag picker and made into shoddy.

In order to make a good mix with shoddy, a short, fine wool will be found to give the best results in the majority of cases. The reason for this is that the shoddy fibers are always of extremely short length and it is difficult to mix a long fiber with a short one and get good results. In selecting shoddy to mix with wool, the length of the shoddy fiber is one of the main points to be observed; the longer the fiber, the more valuable is the shoddy. Where a mill is buying shoddy, care should be taken that it is not adulterated as, the fiber being naturally short, it is easy to adulterate it with extremely short and inferior material that can hardly be detected. Shoddy is not often worked alone, as the resulting yarn would be tender and almost impossible to spin, but in mixtures with pure wool the shoddy has its purpose in *feeding* the yarn, or making it more bulky.

10. The percentage of shoddy used depends on the class of goods that a mill is running on. If a good grade of goods is being made, it is not wise to cheapen the stock too much and, even if shoddy is used, care should be taken to use a good grade; on the other hand, if the goods are cheap, often the larger part of the fabric is shoddy with only enough new wool fibers to hold the yarn together. In blending wool and shoddy, it is a good practice first to run the materials through the picker separately and then to make a mix on the floor by spreading the materials over each other in successive layers. The thinner the layers of the different materials and the more of such layers, the better is the mix.

In running a blend through the mixing picker, it must alway be remembered that the success of the mixing depends largely on the manner in which the stock is taken from the pile spread out on the floor. The stock must always be removed from this pile by taking an armful vertically down from the side or end, and not from the top; this insures the complete amalgamation of the several layers. While a little shoddy may be used advantageously in connection with wool, care must be taken not to make the percentage of the cheapening element in the mix large enough to make the spinning of the yarn so difficult as to involve much extra expense; otherwise, the adulterated yarn will be found to cost almost as much as a pure woolen yarn, owing to the extra cost of manufacture due to lessened production and excessive waste.

11. Mungo, which is the worked-up waste of hard woolen goods such as overcoatings, beavers, meltons, and other hard-felted and milled goods, is mixed with new wool, as is also **extract,** or the recovered wool fibers of union goods composed of wool and cotton or other vegetable fibers. **Flocks,** or the short, fluffy woolen fibers occurring as the waste from nappers and shearing machines, are also used in connection with raw stock for producing mixtures, although they are more often added to the cloth during the finishing.

12. Mixing Wool and Noils.—These two materials are often blended. **Noils** are the short fibers removed from medium- or long-stapled wools by the combing process in the production of worsted yarns; they are pure wool and are sometimes used alone for the production of low-grade fabrics, but they do not possess the elasticity nor the natural wavy and lustrous nature of the original wool, although they make one of the best materials for mixing with wool. Noils should be carbonized before mixing, as they are removed by the comb in connection with burrs, chaff, straws, seeds, and other vegetable matter, the action of the comb being to remove all the impurities in a worsted card sliver as well as the short fibers. Noils and pure raw stock are mixed in the usual manner by being spread in alternate layers and then passed through the mixing picker.

13. Mixing Wool and Cotton.—The addition of cotton to wool in the manufacture of union fabrics is a common practice. Although the adulteration of woolen goods with cotton is not looked on with favor by many people, indeed is greatly deplored, there can be no doubt but that it is beneficial when used in suitable proportion in connection with low classes of goods manufactured from inferior wool, since the cotton imparts to the fabric strength and wearing qualities that would otherwise be lacking. When cotton is introduced into a fabric it may either be in the form of separate threads of pure cotton or the materials may be mixed in the raw stock.

When cotton is mixed with wool it should first be run through the burr picker in order that it may be opened out and made fluffy, so that it will amalgamate well with the wool fiber and not form into individual bunches. It must be remembered that shoddy, mungo, extract, flocks, and noils are in reality pure wool, although more or less injured by the operations to which they have been subjected; but cotton is different in structure and requires different manipulation.

As has been said, the cotton must be picked and rendered open and lofty before being mixed with the wool, and it is all the better for being passed through a single carding process if a fine mix is to be made. The wool must be oiled and also picked before the mix is made; in no case should any oil be applied to the cotton. After the wool is well oiled and picked, the mix can be made. The stock should be laid out in successive layers of cotton and wool and afterwards run through the mixing picker a sufficient number of times to insure perfect amalgamation.

The process of making the so-called *vigogne yarn* is as follows: This yarn is sometimes composed of cotton and wool in about equal proportions, although often only from 3 to 10 per cent. of wool is used. The wool should be of quite fine fiber in order to blend well with the cotton and should also be well scoured, dried, burr-picked, and oiled. The cotton should be of good length of staple and should be run through the burr picker and a single carding process, which is performed on a woolen card. The wool may also be subjected to a single carding process if it is desired to make the best mix possible. The stock is then mixed, in the usual manner, by making a pile of the materials in alternate layers, taking it down vertically from the end, and subjecting it to two or three picking operations. It is, of course, only for fine work that so much trouble is taken as to card the stock. The ordinary method, which gives excellent results, is to oil the wool and pick it, run the cotton through a burr picker, and then blend the wool and cotton in the right proportions and run the mixture through the mixing picker several times.

Cotton is used in connection with wool for low classes of worsteds, cassimeres, tweeds, flannels, etc. The cotton fiber should be as long as possible and the wool as fine as the grade of goods will allow, with a medium length of staple, and should also be sound, strong, and full of life and elasticity. As it is desired to have the goods resemble wool as nearly as possible, care should be taken to regulate the percentage of cotton according to the class of goods to be made, always using as little as possible to get goods out at the proper cost. On dress goods, flannels, and boys' suitings, from 50 to 75 per cent. cotton can be used. The cheapest possible lots of cotton are often selected, but it is better to have some consideration for the character of the wool. Where the wool is not very fine, a coarse, wiry cotton, as rough Peruvian or Brazilian, may be used with good results if the goods are dyed dark shades. American cotton, however, is generally used in American mills and is well suited for blending with wool. For mixing with fine wool, sea-island cotton, which has a long staple, is often used.

14. If a large percentage of white cotton is to be used and the yarn or cloth sold is white, the cotton should have a blue stain put on it in order to kill the chalky white appearance, which is never seen in pure woolen goods. In making a cotton-and-wool mix composed of 50 per cent. white and 50 per cent. black, one material should not be of one color, but preferably half of the wool should be dyed black and the other half left white; the same should be done with cotton and the results will be better than if the mix were made with black wool and white cotton, or vice versa. When using black cotton in wool mixes, the cotton should be dyed a blue black in order to overcome the rusty look of ordinary black cotton, which makes the goods look cheap.

In fancy mixes have the dyed cotton as fast as possible, especially if there is any white or light-colored ingredient in the mix. The reason for this is that unless the cotton dye is perfectly fast, it will *bleed*, or run, in finishing, staining the light-colored material in the mix. The cotton should for the same reason be fast-dyed in goods that have white or light-colored yarns in the pattern. In particular mixes, the stock is laid out in layers the second time, after being run once through the picker. In mixing only small proportions of cotton with wool it is not necessary to observe so many details; still the wool should be oiled separately, care being taken not to let the mix stand too long and thus allow the cotton to absorb the oil from the wool, and the materials should always be first picked separately.

If the mix is well made, the resulting fabric will be free from specks and the care put into the mixing will be well repaid. The cards must be in good condition for working cotton-and-wool mixtures, and the wool used must have good fulling properties, owing to the total absence of this characteristic in the cotton. If a large percentage of cotton is used, the cloth will have to be set finer in the loom in order to obtain the desired finished texture; as the more cotton used, the less the cloth will be shrunk in finishing. When cotton and wool are mixed and spun together, the cotton, if of long staple, has a tendency to go to the core of the thread and be entirely covered by the wool, which stays on the outside of the yarn.

15. Mixing Wool and Silk.—It is sometimes desirable to mix wool and silk waste in the production of fancy mixes. This is attended with some little difficulty, as the silk is extremely hard to card owing to its fluffy nature and its liability to become charged with static electricity if dry and subjected to friction.

When silk is blended with wool, it is desirable to have the silk the color of the largest ingredient in the mixture; if, for instance, the mixture is composed of 80 per cent. black and 20 per cent. white, the silk waste should be dyed black in order to make the blend look even. The silk waste should first be carded before any attempt is made to introduce it into a mix.

It is important that both ingredients should be free from grease and gum. In oiling wool-and-silk mixes, the oil used should be of good quality and free from any acid, the wool being oiled separately as with cotton-and-wool blends. No oil should be applied to the silk. If there is quite a large percentage of silk in the mix and trouble from electricity or from an excessive amount of flyings is experienced in the carding, it may be necessary to dampen the silk with water before mixing. This can be done by spreading the silk in quite thin layers on the floor and covering it with wet bagging. If the bagging is wet enough and allowed to remain on the silk over night the stock will become sufficiently damp. If water is applied directly to the silk, the fibers are liable to mat.

SUMMARY

16. In general, when making a mix, the material should be spread quite thinly over a large area. As many layers as convenient should be made, and if one material enters into the combination only in a very small proportion, care should be taken to make first a temporary mix with this ingredient and a part of the one that forms the ground, or bulk, of the mix. Always break down the pile vertically from the end and run the stock through the mixing picker a sufficient number of times to insure a perfect blend.

If making a cotton-and-wool or wool-and-silk mix, oil the wool separately; otherwise, the cotton and silk will be difficult to mix and card. It is not wise to depend on the materials becoming mixed in the cards. They should be mixed first, so as not to make a mixing picker of the first breaker card. As great care should be taken with all-wool mixes as with wool and cotton in order to insure evenness and perfection throughout the operations following.

FINDING THE COST OF MIXES

17. In mixing materials that vary in cost, it is often necessary to ascertain the cost of the blend per pound in order that the value of the resultant yarn or fabric may be estimated. Again, it may be necessary to obtain the percentage of a cheaper material required in a blend in order that the mix may be produced at a given value. Many other conditions also arise in connection with blending raw stock that require accurate figuring in order that the cost of the finished goods or their character may not be altered.

18. To find the cost per pound of a mix composed of two or more materials of different costs either in equal or unequal proportions:

Rule.—*Multiply the number of pounds of each material by its cost per pound, and divide the sum of the products thus obtained by the total number of pounds in the mix.*

EXAMPLE.—What is the cost per pound of a mix composed of 45 pounds of wool at 28 cents per pound, 25 pounds of shoddy at 14 cents per pound, and 10 pounds of cotton at 9 cents per pound?

SOLUTION.— 45 lb. of wool at 28 ct. per lb. will cost \$12.60; 25 lb. of shoddy at 14 ct. per lb. will cost \$3.50; 10 lb. of cotton at 9 ct. per lb. will cost \$.90. The total cost of the mix will be $\$12.60 + \$3.50 + \$.90 = \$17$. Since the total weight of the mix is 45 lb. + 25 lb. + 10 lb. or 80 lb., the cost per pound of the mix will be $\$17 \div 80 = \$.2125$, or $21\frac{1}{4}$ ct. Ans.

19. To find the proportion of each ingredient in a mix composed of materials of different costs, in order that the resulting blend may have a definite cost per pound:

Rule.—*Arrange the respective values of each material in a column and place the desired cost of the mix at the left. Link these values together in pairs so that one element of each pair is greater and one less in value than the average cost. Find the difference between the average price and each element of a link* *and write it opposite the other element of the same link. Each of these differences has the same relation to their sum as the quantity of each material has to the mix.*

EXAMPLE 1.—It is desired to mix enough cotton costing 10 cents per pound with wool costing 22 cents per pound so that the resultant mix will have a value of 18 cents per pound; what is the proportion of each ingredient necessary?

SOLUTION.—The difference between 18 and 22 is 4, which is placed opposite the 10, to which the 22 is linked, while the difference between 18 and 10 is 8, which is placed opposite the 22, to which the 10 is linked. From this it will be seen that each 12 lb. of mix should contain 4 lb. of cotton and 8 lb. of wool. Ans.

18	10	4
	22	8

PROOF.—This example can be proved, by applying the rule in Art. **18**, as follows: 8 pounds of wool at 22 cents per pound will cost \$1.76; 4 pounds of cotton at 10 cents per pound will cost \$.40. The total cost of the mix will be $\$1.76 + \$.40 = \$2.16$. The cost per pound of the mix will be $\$2.16 \div 12 = \$.18$, or 18 cents.

The rule in Art. **19** can be applied in case more than two ingredients enter into the mix, but care must always be taken to link together a higher and a lower value than the desired average.

EXAMPLE 2.—Suppose that four materials, A at 6 cents per pound, B at 10 cents per pound, C at 16 cents per pound, and D at 20 cents per pound are to be blended; what proportion of each will be necessary so that the resulting mix will have a value of 14 cents per pound?

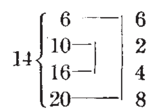
SOLUTION 1.—The difference between 20 and 14 is 6, which is placed opposite 10, to which 20 is linked; the difference between 16 and 14 is 2, which is placed opposite 6, to which 16 is linked; the difference between 10 and 14 is 4, which is placed opposite 20, to which 10 is linked; the difference between 6 and 14 is 8, which is placed opposite 16, to which 6 is linked. From this it will be seen that each 20 lb. of the mix should contain 2 lb. of A, 6 lb. of B, 8 lb. of C, and 4 lb. of D. Ans.

14	6	2
	10	6
	16	8
	20	4

PROOF.—This example can be proved, by applying the rule in Art. **18**, as follows: 2 pounds of A at 6 cents per pound will cost 12 cents; 6 pounds of B at 10 cents per pound will cost 60 cents; 8 pounds of C at 16 cents per pound will cost 128 cents; and 4 pounds of D at 20 cents per pound will cost 80 cents. The total cost of the mix will be $12 + 60 + 128 + 80 = 280$ cents. The cost per pound of the mix will be $280 \div 20 = 14$ cents.

In a case like this it should be noted that by linking different quantities together, taking care to link a higher and a lower value than the required average, the proportions of the different ingredients may be varied and at the same time the correct average cost obtained. To illustrate, take the same example again.

SOLUTION 2.—The difference between 20 and 14 is 6, which is placed opposite 6, to which 20 is linked; the difference between 16 and 14 is 2, which is placed opposite 10, to which 16 is linked; the difference between 10 and 14 is 4, which is placed after 16, to which 10 is linked; the difference between 6 and 14 is 8, which is placed after 20, to which 6 is linked. From this it will be seen that each 20 lb. of the mix should contain 6 lb. of A, 2 lb. of B, 4 lb. of C, and 8 lb. of D. Ans.



PROOF.—This example can be proved by applying the rule in Art. **18.** 6 pounds of A at 6 cents per pound will cost 36 cents; 2 pounds of B at 10 cents per pound will cost 20 cents; 4 pounds of C at 16 cents per pound will cost 64 cents; 8 pounds of D at 20 cents per pound will cost 160 cents. The total cost of the mix will be $36 + 20 + 64 + 160 = 280$ cents. The cost per pound of the mix will be $280 \div 20 = 14$ cents.

In the examples given two of the materials cost more and two less than the required cost of the blend; sometimes, however, only one of the materials may be more or less than the average cost. In a case like this all the other values are linked to this one and the differences added together.

EXAMPLE 3.—Four materials, A at 8 cents per pound, B at 10 cents per pound, C at 15 cents per pound, and D at 22 cents per pound are to be mixed; in what proportion must each enter into the blend in order that the average cost shall be 17 cents?

SOLUTION.—The sum of the differences between the values of A, B, and C and 17 gives the proportion of D that enters into the mix, or 18 lb. in every 33 lb. of the mix, while the difference between 22 and 17, or 5, gives the proportion of each of the other materials.

17	8	5
	10	5
	15	5
	22	$9 + 7 + 2 = 18$

After having found, by the preceding rules, the amounts in which each material enters into the blend, it is a comparatively simple matter to find by proportion the amount of each required in any given number of pounds of a mix.

MIXING PICKERS

20. After the materials composing a mix have been carefully spread in layers on the floor of the picker room, the next operation is to pass the stock through a machine designed to blend and intermingle the various components in such a manner that a homogeneous mix is obtained. In America, the machine most commonly used for this purpose is the **mixing picker;** while in Europe, and to a small extent in America, the same results are obtained with a *Fearnaught*, a machine totally different in principle from the mixing picker. Another object of the mixing picker is to open out the wool so that it will be in suitable condition for feeding to the cards.

The principle on which the mixing picker operates is that of opening the wool and intermingling the fibers by means of a rapidly rotating cylinder armed with strong teeth curved forwards in the direction in which the cylinder rotates.

DAVIS & FURBER MIXING PICKER

21. Construction.—The main, or picking, cylinder of this machine, as shown in Fig. 2, consists of six wrought-iron lags l_1 mounted on three or four spiders l, according to the width of the machine. The lags are firmly bolted to the inside spiders and, being fitted into slots in the two outside ones, are firmly secured by means of heavy wrought-iron hoops that are shrunk over their ends. The teeth l_2 for

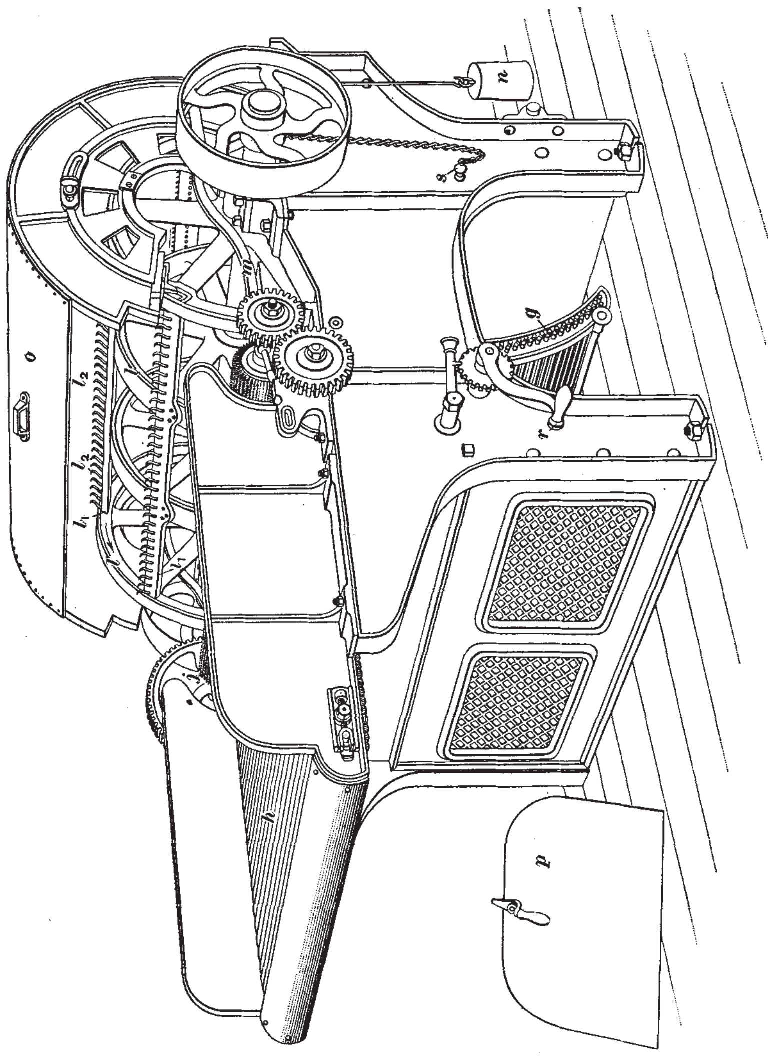


FIG. 2

opening the stock are of cast steel firmly screwed into the lags of the cylinder and fastened by means of setscrews, so as to preserve the alinement of the points of the teeth by preventing them from turning, as they would be liable to do in course of time if simply screwed in. Teeth fastened in this manner can readily be removed if broken and new teeth substituted. The shape of the teeth is such that they will engage with and open the stock without injuring or breaking the staple.

The picking cylinder works in connection with the grate *g*, Figs. 2 and 6, in a manner similar to that employed in burr pickers and dusters, and a considerable amount of dirt and other foreign matter that has escaped the previous operations is allowed to drop through this grate into the space underneath that is provided for its reception. The grate in this machine is constructed of iron bars in such a manner as to expose the least amount of surface possible for the accumulation of grease or gummy deposits, which, of course, are undesirable, as they tend to clog the grate. The grate is hinged at one end and may be lowered or raised by means of the crank *r*, Fig. 2, conveniently located at one side of the machine. This crank operates a pinion gear g_1, Fig. 6, which by means of a rack g_2 imparts movement to the grate. This arrangement greatly facilitates the operation of cleaning the grate. When raised, the grate is locked in place by means of two pins *s*, Fig. 2, on which it rests, one on each side of the machine. The grate is shown lowered from the picking cylinder in Fig. 2. The refuse is removed from underneath the machine at either side, for which purpose removable panels *p* are provided, the one shown in Fig. 2 being removed from the machine.

The feeding arrangement on this machine differs from those on other machines. The stock is not fed by a pair of feed-rolls but by a single roll *j* working in conjunction with a concave dish, or shell, *k*, the arrangement being sometimes known as the shell-and-pin feed. (See Fig. 6.) The curve of the dish is the same as that of the circumference of the feed-roll. The stock is taken by the feed-roll and, being held against it by the dish, is delivered to the cylinder, which revolves close to the edge of the dish. While this method of feeding is sometimes advocated for the reason that the stock is better opened in being taken by the cylinder from the edge of the dish, it is not so good as a pair of cockspur feed-rolls, because the single roll is liable to choke up while in operation. In order to remedy this, however, the pins are set into the roll at a slight angle, so that the action of the picker cylinder will tend to strip the feed-roll. This machine is made with a pair of cockspur feed-rolls if so desired.

Allowance is made for a vertical motion of the feed-roll, which is controlled by two levers *m*, Fig. 2, one on each side of the machine. These levers have heavy weights *n* suspended from their extremities and are so arranged as to bear on the journals of the feed-roll. This allows any bunches in the stock or inequalities of feeding to raise the feed-roll and prevent the machine from being strained or broken. The feed-apron *h* is of the usual type, composed of wooden slats fixed on endless traveling belts, a means being provided for taking up the slack as the apron stretches from wear. Sometimes, however, the slats of the feed-apron are made of iron, the object being to make the machine fireproof as far as possible, since a machine of this description will become very greasy and there is danger of the swiftly rotating cylinder striking fire and starting a conflagration.

22. Operation.—In operation, the wool or other stock is fed either by hand or by a self-feed, as shown in Fig. 6, on a traveling feed-apron *h*, which delivers it to the straight-toothed feed-roll *j*. The stock is held against this roll by the stationary concave dish and the roll in rotating carries the wool to the main cylinder, which is armed with strong curved teeth about 2½ or 3 inches long, which comb out the wool as it is held on the edge of the dish by the feed-roll. The cylinder revolves down past the feed-roll and makes from 700 to 1,000 revolutions per minute, according to the width of the machine.

As the wool is taken from the feed-roll by the cylinder it is swept down over the grate *g* and a great deal of the foreign matter remaining in the stock beaten out and allowed to fall through the grate, while the picked stock is carried by the current of air generated by the rapidly rotating cylinder through the outlet m_1 to the gauze room.

23. The machine described is made in sizes from 24 inches to 48 inches wide and requires from 3 to 8 horsepower for driving. The larger sizes, which require more power, are made with a pulley on each side allowing two belts to be used for driving. This, of course, requires a countershaft. The diameters of the pulleys are from 10 inches to 14 inches, according to the width of the machine. The capacity of the largest machine is from 2,000 to 2,400 pounds per hour, the narrower machines producing less in proportion to their width.

ATLAS MIXING PICKER

24. Construction.—The mixing picker shown in Fig. 3, although similar in general principle, is somewhat different in a few points from the machine just described. The object is the same as that of all other mixing pickers; namely, to open the stock for the cards and also to mix thoroughly and blend any mixtures of colors, qualities, or materials that may be passed through. The only wood used in the construction of the picker is for the feed-apron slats, and the machine is therefore practically fireproof and especially adapted for the use of oiled stock.

The feed-rolls of this machine are one of its distinctive features and instead of a single roll or a single pair of rolls there are two pairs j_1, j_2, the second pair running one-third faster than the other pair; this makes what is known as a *draft* between the two sets of rolls. In textile machinery when fibers are drawn between two or more pairs of rotating rolls and one pair of the rolls rotates faster than the other, a draft is said to be produced. The amount of draft where the two pairs of rolls have the same diameter is found by dividing the speed of the quicker rolls by the speed of the slower ones. Thus, if one pair of rolls makes 14 revolutions per minute, and another pair 21 revolutions per minute, both being the same diameter, the draft is $\frac{21}{14} = 1.5$.

25. Driving.—The driving of the feed-rolls is as follows: A pulley on the picker-cylinder shaft on the left side of the machine drives a pulley on the first auxiliary shaft, which is located at the rear of the machine. This drive is not shown in Fig. 3, being on the opposite side of the machine. A pulley on this first auxiliary shaft drives a pulley t on the second auxiliary shaft located under the feed-

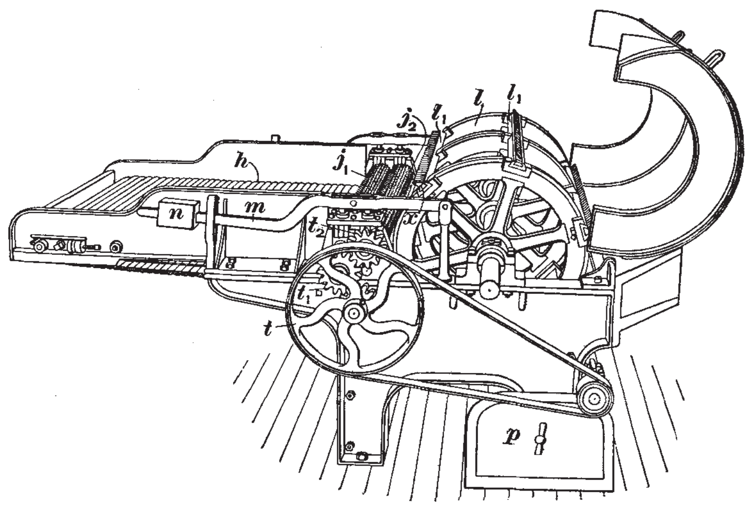


FIG. 3

rolls. On the right-hand side of the machine, a gear on the second auxiliary shaft drives a gear t_1 on the first bottom feed-roll shaft, which in turn drives a gear t_2 on the rear top feed-roll shaft. On the left-hand side, but not shown in Fig. 3, a gear on the end of the second auxiliary shaft drives a gear on the rear bottom feed-roll shaft, which in turn drives a gear on the first top feed-roll shaft.

The feed-apron h is driven by means of a gear on the bottom feed-roll shaft on the opposite side of the machine, from that shown in Fig. 3 which drives a gear on the apron-roll shaft through a small intermediate gear on a stud. There is about $\frac{1}{2}$ inch space between the apron and the feed-roll, which allows heavy foreign materials to drop to the floor so as not to enter the picker. Both the front and the rear top feed-rolls are controlled by levers *m*, one on each side of the machine, on which weights *n* are fastened; these give the rolls a little play, or up-and-down motion, to allow for bunches in the stock and for irregular feeding.

The picker cylinder of this machine is composed of three iron spiders *l* fastened on the main shaft, to which are dovetailed six steel lags l_1. Flat steel teeth are dovetailed with the lags, doing away with setscrews for fastening them. The main shaft is equipped with tight and loose pulleys, or with a tight pulley on each side for double driving, which is advisable with the wider machines.

The grate under the picker cylinder may be drawn out on a slide for cleaning. The space under the grate is cleaned from either side by the removal of panels *p*.

26. Operation.—In operation, the stock is fed on the slatted apron *h* either by hand or by an automatic feed and is delivered to the first pair of feed-rolls j_1, which holds the wool while the second set j_2, running one-third faster, combs and opens it out.

The advantage of a double set of feed-rolls with a draft between them is that the stock is more thoroughly opened, straightened, and mixed than by the ordinary picker with a single pair of rolls; and it is also impossible for bunches of stock to pass directly to the cylinder and the fibers to become broken by being opened too quickly, as the first pair of rolls holds the stock while the second pair, running faster, gradually opens it out and pulls it apart. This insures a thorough opening and mixing of the stock with very little liability of injury to the fiber. The stock is next delivered to the picker cylinder, which revolves downwards and beats the wool over the grate, finally delivering it through a trunk to the gauze room.

POINTS IN MANAGEMENT

27. Pickers require frequent cleaning and should never be allowed to become clogged with gummy grease, as will happen if they are not cleaned between different lots of stock operated on. The cylinder of the picker should be examined frequently for loose or broken teeth, which should be tightened or replaced at once since they reduce the efficiency of the machine; the picker-cylinder bearings should be oiled at least twice a day, as they are very apt to heat, owing to the high speed and the weight of the cylinder. A 36-inch picker may be run at 1,000 revolutions per minute, but the wider machines, as for instance, the 48-inch, should not make more than 800 revolutions per minute. These speeds may be regarded as maximum speeds, and it will be found that a picker will give longer and more satisfactory service if driven somewhat slower. For the best results it will be found advantageous to feed the picker somewhat light rather than to have bunches of stock to open out on the card.

The heavy cylinder of a picker armed with strong, sharp teeth and rotating with great velocity is a source of great danger, and many accidents occur owing to carelessness and neglect of even ordinary precaution. A good rule to follow is never to remove the bonnet or to take out the grate while the cylinder is in motion. When cleaning the cylinder or the grate underneath, the bonnet may be lifted and a stout stick or an iron bar thrust through the cylinder to prevent any one from unwittingly starting the machine while it is being cleaned.

FEARNAUGHT

28. While this machine is used for the same purposes as a mixing picker, it is entirely different, both in principle and construction. The principle of the Fearnaught may be considered as that of opening the wool by means of a large rotating cylinder filled with cockspur teeth, which work in conjunction with similar teeth placed in smaller rolls arranged over the large cylinder. The combined action of the cylinder and smaller rolls, which are known as workers, is to separate all bunches of wool and to intermix the fibers thoroughly.

29. Construction.—While wood enters to a larger extent in the construction of a Fearnaught than of a mixing picker, this is not objectionable, since the slower speeds of the parts of this machine render them less liable to cause fire than the rapidly rotating cylinder of a mixing picker. As shown in Fig. 4, the feed-apron *h* is of the usual construction; the iron feed-rolls *j* are filled with intersecting cockspur teeth and are self-cleaning. The main cylinder *l* and

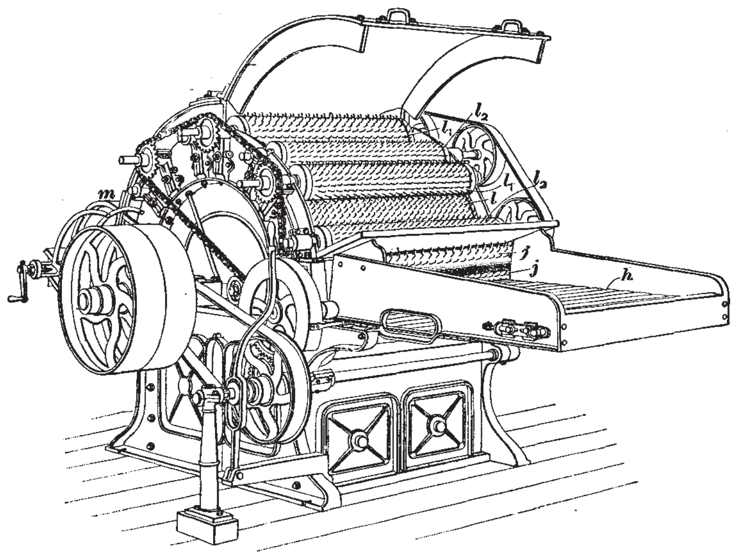


FIG. 4

workers l_1 are of wood and are filled with cockspur teeth forged from square steel rods and firmly driven into the wood. The machine is usually constructed with four workers. In order to keep the workers clear of wool, a stripping roll, or stripper, l_2 works in conjunction with each worker. The strippers are filled with teeth similar to those in the main cylinder and workers except that they are straight. Owing to the strain of opening the wool, the workers must be driven with a chain, but the strippers, as they are subjected to but little strain, may be driven with a belt. There is a beater, or fan doffer, *m* (similar in construction to the beater shown at *f*, Fig. 6) at the rear of the machine. This takes the stock from the main cylinder and throws it out of the machine.

30. Operation.—In operation the stock is spread evenly on the traveling feed-apron and is taken by the cockspur feed-rolls, which hold it as it is combed out by the main cylinder. The cylinder then brings the stock under the action of the workers, and the passing of the teeth on these rolls between those on the cylinder results in the wool being thoroughly opened and combed out. The strippers take the stock from the workers and pass it back to the main cylinder, which besides opening out the wool in conjunction with each of the workers acts as a carrier, conveying the stock from the feed-rolls to the fan doffer. The doffer takes the stock from the main cylinder and by virtue of the current of air that it generates, delivers it through a trunk to the gauze room.

31. The Fearnaught is an excellent machine for opening and mixing wool, doing its work with no perceptible injury to the fiber. Its gentle action is due to the principle of its construction and the comparatively slow speeds of its moving parts.

A Fearnaught with a cylinder 36 inches in diameter should make about 225 revolutions per minute; one having a cylinder 48 inches in diameter should make 175 revolutions per minute; while a cylinder 55 inches in diameter should not have a speed of more than 100 revolutions per minute. Its capacity varies, according to its size, from 800 to 1,500 pounds of wool per hour. The machine is built in three widths—36-inch, 40-inch, and 48-inch—having cylinders 36 inches, 48 inches, and 55 inches in diameter, respectively. The 48-inch machine is used for carpet wools and long worsted stock.

THE BRAMWELL AUTOMATIC PICKER FEED

32. The object of automatic, or self-feeding, devices is to deliver the stock to other machines evenly and uniformly and at the same time to allow the operator to care for a maximum number of machines with a minimum amount of

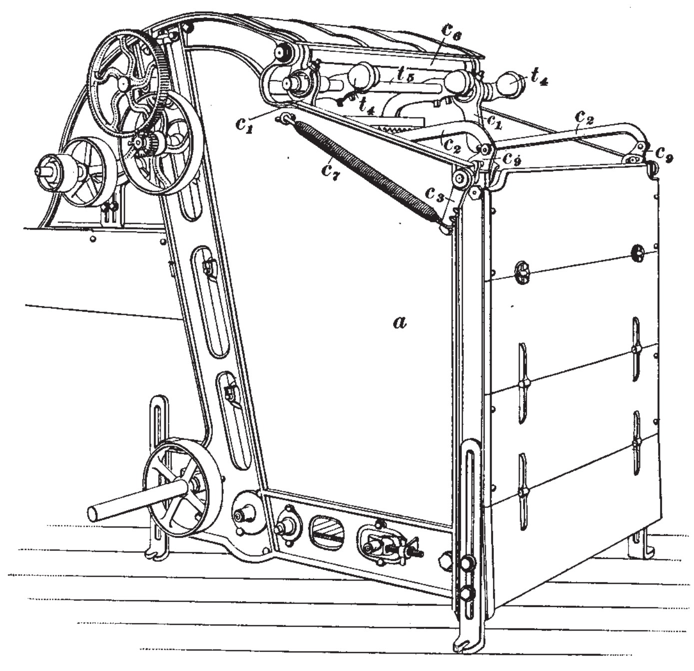


FIG. 5

labor. The general features of the Bramwell self-feed as adapted for feeding mixing pickers, burr pickers, dusters, and similar machines are shown in Figs. 5 and 6, the latter being a sectional view and showing the machine as connected with a mixing picker.

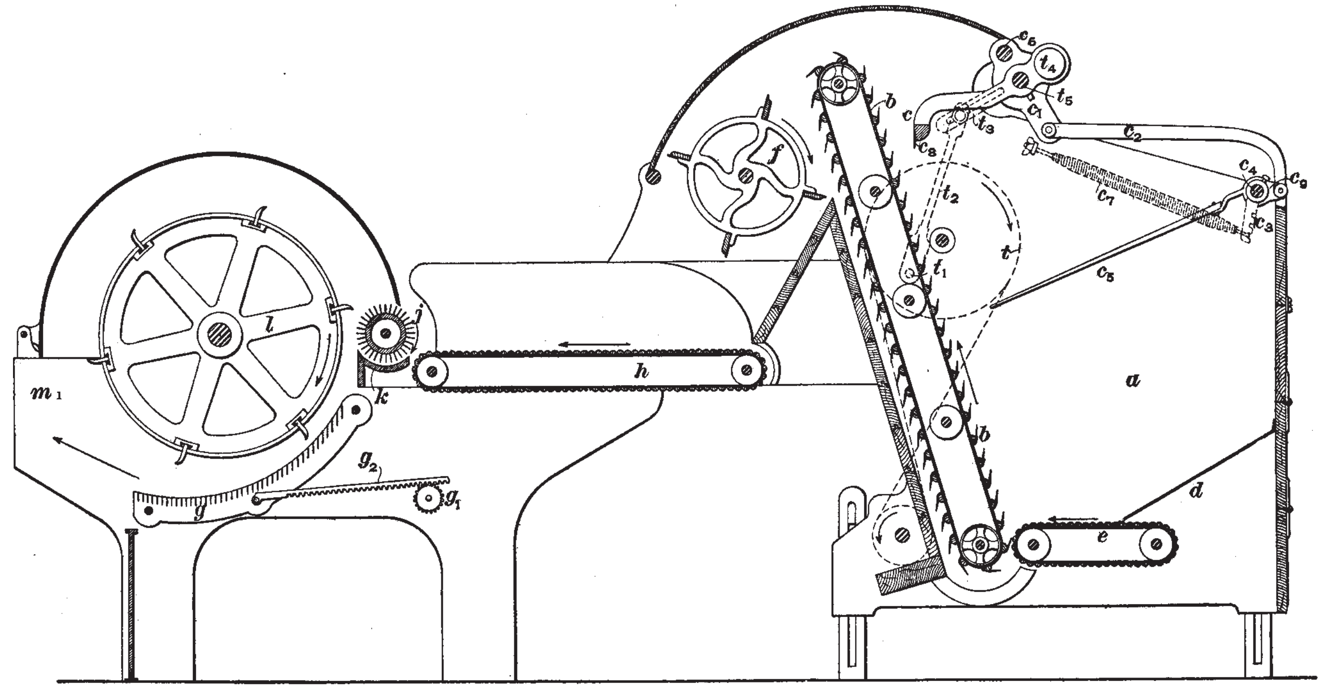


Fig. 6

33. Construction.—As shown at Fig. 6, the machine consists primarily of a large feed-box, or hopper *a*, which the operator keeps supplied with stock. At the rear of the hopper is an endless apron *b*, called a lifting, or elevating, apron. This apron, which travels in the direction indicated by the arrow, is provided with a series of slats fitted with sharp spikes about an inch in length and inclined forwards in the direction in which the apron is traveling. The apron extracts the stock from the hopper and carries it to a beater *f*. This beater strikes the wool from the apron and deposits it evenly on the feed-apron of the machine to which the feeding machine is attached. The amount of stock carried by the lifting apron is regulated by an oscillating comb *c* that strikes off all large bunches of wool that the apron extracts from the hopper, thus rendering the apron more evenly loaded and the feed more regular. The greater part of the machine is of iron, but the rear end of the hopper is boarded up, provision being made by means of hinges and iron buttons for removing the boards, so that the hopper may be brushed out when the machine is cleaned. At the bottom of the hopper there is a traveling apron *e* for the purpose of keeping the stock in the hopper in contact with the lifting apron at all times. Both this apron and the lifting apron are constructed of hardwood, half-round slats riveted to leather belts. There are adjustments on the wooden rolls on which these aprons run by means of which the aprons may be tightened in case they grow slack from wear or stretching. In the lower part of the hopper there is also a tin slide *d*, placed at an angle of about 30° with the bottom of the hopper and sloping downwards toward the lifting apron. This slide causes the wool to move forwards to the traveling apron, so that when the machine is allowed to run empty no stock will remain in the hopper. The beater is constructed with four blades having strips of leather attached; these sweep the stock from the spikes in the elevating apron without in any way injuring the wool. There are adjustments on the bearings of the beater by means of which it may be set nearer to or farther from the lifting apron as occasion demands.

The self-feed is usually driven from the main shaft of the mixing picker, when connected to that machine, with a cross-belt and is provided with tight and loose pulleys on the shaft at the bottom of the machine. The driven pulleys are not shown in Fig. 5. There is a belt shipper so arranged that the feed may be stopped from either side of the machine. The beater is driven by a cross-belt from the lower, or main, shaft of the feeder. The lifting apron is driven from a pulley on the main shaft, which drives a pulley on a stud with a crossed belt. Fastened to this pulley is a small gear, which is the change gear for the speed of the aprons, an increase of its size giving a greater speed to the lifting and traveling aprons and a heavier feed to the mixing picker. The change gear, as shown at Fig. 5, drives a large gear on the shaft of the top lifting-apron roll, which carries the apron. On the opposite side of the machine the traveling apron is driven from the shaft of the bottom lifting-apron roll by means of a short train of gears connecting with the front roll of the traveling apron.

The oscillating comb c, Fig. 6, is driven from a pulley on the main shaft of the machine, which drives the pulley t on a stud; on this pulley there is a crankpin t_1 to which a connecting rod t_2 is attached; the latter is also connected with an arm t_3 attached to the comb shaft t_5. There is a slot in this arm, which admits of changing the position of the connecting-rod, thus varying the throw of the comb. Weights t_4 are attached to the comb in order to balance it, so that its motion may be more regular. The comb is provided with triangular teeth c_8, which comb off the excess of stock that is extracted from the hopper by the lifting apron.

34. Comb Regulating Device.—There is a device for regulating the proximity of the comb to the lifting apron by means of which, if the wool is nearly exhausted from the hopper, the comb is moved from the apron and less wool struck from the lifting apron. This makes the feed uniform whether the hopper is full or nearly empty. If such an arrangement were not provided, a large amount of the wool would be passed forwards when the hopper was full and a small amount when nearly empty.

The principal parts involved in this device are suspended from a fixed shaft c_6, Fig. 6, by means of arms c_1, one on each side of the machine. These arms, with the shaft t_5, can be pushed nearer to the lifting apron, thus reducing the distance between the comb and the apron, or drawn farther away, thus increasing the distance, by means of the horizontal curved arms c_2, of which there are two (one on each side of the machine) attached to the lower ends of the arms c_1.

The comb arms c are attached to the central shaft t_5, to which is also attached the arm t_3 on the outside of the machine, which receives an oscillating movement from the pulley and crank arrangement shown by the dotted lines. This oscillating motion of the comb, however, has nothing to do with regulating its distance from the lifting apron, which is governed by means of a comb regulator, or finger rack, c_5. The normal position of the rack is very nearly at right angles with the lifting apron when the hopper is empty, it being held in that position by means of two springs attached to short arms c_3 fastened to its shaft c_4, one on each side of the machine, the spring shown being marked c_7. The tension of these springs may be regulated by means of thumbscrews. When the hopper is filled, the wool is thrown on the top of the rack, pressing it downwards until it is forced against the back of the hopper into an almost vertical position. The rack is attached to the shaft c_4 and, by means of short arms c_9, is pinned to the curved ends of the rods c_2 that operate the ends of arms c_1.

As the lifting apron extracts the stock, the amount remaining in the hopper will be diminished and, consequently, the pull of the springs c_7 will raise the finger rack as fast as the weight of the stock in the hopper is decreased. The motion thus imparted to the shaft c_4 will move the levers c_9 backwards and, by means of the connecting-rods c_2, the levers c_1 will be drawn in the same direction. Since the comb is supported by arms attached to the shaft t_5, which is carried by the levers c_1 fulcrumed on the fixed shaft c_6, the upward motion of the finger rack will draw the comb from the lifting apron, which will result in less wool being struck from the apron. When the hopper is refilled, the rack will be pressed down again by the weight of the stock, thus moving the comb nearer to the lifting apron so that there will be no increase in the amount of stock passed forwards to the picker in consequence of the hopper being full. By this means the feed is kept uniform without regard to the amount of stock in the hopper. The comb should not be set too close to the lifting apron and the latter should be allowed to carry a fairly heavy feed, except on fine stock.

35. Operation.— The self-feed and mixing picker shown in Fig. 6 operate as follows: The hopper *a* of the self-feed being supplied with wool, the spikes on the lifting apron *b* extract an amount of stock in excess of what is required. This excess of stock being struck off and the feed kept uniform as explained, the apron conveys the wool to the beater *f*, which sweeps off the stock and drops it on the feed-apron *h* of the picker. The stock is then delivered to the feed-roll *j*, which, working in conjunction with the concave dish *k*, passes the wool to the picker cylinder *l*, the stock being finally passed in an open and lofty condition to the gauze room through the trunk at m_1.

The feed requires very little extra power, possibly 2 horsepower for the largest machine when feeding heavy. With smaller machines and lighter feeds, the horsepower required will be correspondingly reduced.

WOOL OILING

LUBRICATION OF WOOL

1. **Object of Oiling Wool.**—Owing to the removal of the natural, preservative, greasy matter, or yolk, by the scouring, it is necessary to lubricate the fibers of wool with oil before carding and spinning, in order to preserve the serrations of the fiber from injury during the carding process. At the same time, oiling wool enables it to be worked with the least waste possible in the carding and to be spun into the finest yarn possible consistent with the quality of the stock. Also, the natural elasticity and softness of the fiber are uninjured if the stock is lubricated and the oil used is suitable for applying to wool. The oiling of wool before carding and spinning, therefore, is an important process and should be carefully done, not only with regard to the kind of oil used, but also with regard to the quantity used and method of application. Imperfect oiling results in gummed-up cards, uneven work, and also in the destruction to a greater or less extent of the elasticity of the resultant yarn.

Especial care should be taken with the wool for cloth that is to be heavily milled; the oil used for such stock should be pure and one that easily saponifies, thus aiding in the fulling and scouring of the cloth. Impure oil or oil that will not saponify easily will make the dyeing streaky and uneven. If oil is not applied in suitable proportions to wool that, when made into cloth, must be fulled, there is danger of impairing the felting properties of the fiber by injuring the serrations of the fiber. The oiling of wool also lessens the amount of flyings from the cards, and consequently the percentage of waste.

LUBRICANTS

2. Among the oils used for lubricating wool may be mentioned *olive oil*, *lard oil*, *oleine*, and *red oil*.

3. Olive Oil.—Although universally acknowledged to be the most suitable for applying to the wool fiber, **olive oil** is only used on the finer and more expensive grades of stock, owing solely to its cost. The olives, which grow in warm countries, chiefly in California and in Southern Europe, are collected when ripe, and ground into a pasty mass and pressed. The oil obtained from the first pressing is called *virgin oil*, and is colorless; it is principally used for table purposes. The material, however, is not exhausted by the first pressing, but is treated with hot water and further pressed. The oil obtained by the second pressing is of a fine yellow color and is the olive oil commonly used for lubricating wool before carding and spinning. By a third pressing of the ground olives, an inferior oil is obtained, which is used in making soap. The specific gravity of hot-pressed olive oil is about .92.

The best olive oil for wool is that known as *Gallipoli*, but many other olive oils are used, the only precaution necessary being to obtain an oil that is free from impurities. Olive oil is often adulterated with cottonseed oil, and the difference between the pure and impure article can be detected only by an expert.

For the finer grades of woolen goods, olive oil is often used, since it enables the stock to be carded with the least waste and spun to the finest counts. Olive oil softens the stock and preserves the natural serrations of the fiber from injury during the carding process, and even after lying in an oiled state for a long time, the fiber will not become hard and stiff nor the oil rancid or stale, provided that the oil used is pure.

When using olive oil on wool, a good proportion is 6 quarts per 100 pounds of wool; this, of course, may be varied to suit different cases. As a rule, dyed wools require more oil than white wools, especially those dyed dark shades. The oil should be mixed with enough hot water to form an emulsion of sufficient quantity to be applied to the entire lot of wool. All kinds of oils are usually applied in the form of an emulsion, which is merely a mechanical mixture of oil and water in which the oil exists in a state of the finest division and is particularly well absorbed by the wool fiber. In order to make this emulsion, it is necessary to add some substance that will enable the oil and water to unite, or, to use a common expression, *cut* the oil. There are two substances used for this purpose—ammonia and borax. The former is preferable on account of its volatile nature, but the latter, also, is quite extensively used.

In making emulsions the best method is first to add the substance that aids the water and oil to unite (either ammonia or borax) to the heated water and then gradually add the oil, stirring well until a milky solution is formed. By dipping the fingers into this solution and rubbing them together, it is easily determined whether the emulsion contains sufficient oil and is therefore greasy enough.

An emulsion of olive oil for fine wools that has been found to give excellent results is made as follows: To 10 quarts of hot water add a cupful of ammonia, and to this add 6 quarts of pure olive oil. This will be sufficient for lubricating 100 pounds of wool.

For fine wools, and in cases where the yarn is going to lie for a considerable time before being woven, it is always well to use olive oil, as this will keep better in the yarn than any of the cheaper oils, being less liable to grow rancid or gummy.

4. Lard Oil.—The most common lubricant used in connection with wool is **lard oil,** which is applied in varying proportions according to the condition of the wool that is being worked. If the stock is very dry or harsh, more oil is required than if the scouring and drying had been properly performed and the wool were soft and contained just enough natural lubricating matter. When of good quality, lard oil is all that can be desired for an ordinary quality of wool. While not so desirable as olive oil for the finest classes of wools, it meets all the requirements of a good lubricating agent for medium wool without being so expensive as olive oil. In regard to the quality of the lard oil to be used, it may be stated that it varies according to the stock in hand. For wool well scoured and dried about 5 quarts of oil and 5 quarts of water are used to 100 pounds. This may be reduced to 4 quarts of oil if the wool is quite moist and soft, or increased to 6 quarts if the stock is harsh and brittle.

In making the emulsion, take the boiling water and add to it about 1 ounce of borax or a cupful of ammonia; the latter is to be preferred on account of its being volatile and not remaining on the wool. To the solution of water the oil should be added slowly, with constant stirring, until a milky emulsion free from bubbles is formed.

Another recipe for a lard-oil emulsion is as follows: Best lard oil, 4 gallons; water, 5 gallons; borax, 4 ounces. Dissolve the borax in a little warm water and then add the solution to the boiling water; agitate, and then gradually pour in the oil, constantly stirring. Boil a few minutes and the emulsion is ready for use.

For ordinary stock, 16 per cent., by weight, of this solution will be found to be about right, but it must be remembered that no hard and fast rule regarding the amount of lubricating matter to be used on wool can be given. Much depends on the condition of the wool, either naturally or as a result of the scouring or drying, which may injure the wool so that it will require much more oil than would otherwise be sufficient.

5. Oleine.—Another substance that is used quite extensively for lubricating wool is known as **oleine.** It occurs as a by-product in the manufacture of stearine candles, and when free from impurities, is an excellent substance for the purpose. In the process of making stearine candles, stearine and oleic acid are produced, and the stearine is afterwards freed from the oleic acid by means of sulphuric acid. Oleine is a product obtained from the oleic acid, but the sulphuric acid that was used to free the stearine from the oleic acid should be removed by distillation, as if present it injures the card clothing.

Oleine, when employed for lubricating wool, is used in varying proportions according to the stock in hand, a good proportion being 4 parts of oleine, free from acid, to 6 parts of water. Add a little ammonia or borax to aid the oil and water in uniting and use from 20 to 25 per cent. of the weight of the wool. If the stock is dyed dark colors or heavily weighted with any dye stuffs, it is a good plan to use less water and more oil.

Another good emulsion may be made with 10 per cent. oleine and 15 per cent. water of the weight of wool to be oiled. The water should be hot and the borax or ammonia added to it, in order that the oil and water may unite. For wools that are dyed dark colors and heavily weighted with dye stuff, 10 per cent. of water will be sufficient.

6. Red oil is practically the same as oleine and, like it, is liable to contain free acid. There are two kinds of red oil in the market—the saponified, or ordinary red oil, and the distilled, or oleine, oil. The former is not generally considered as suitable for oiling wool as the latter.

In the preparation of the saponified oil, the tallow or grease is treated to a jet of live steam, and after a certain period breaks up into stearine and oleic acid. The material is now placed in bags and the oil pressed out. Red oil obtains its red color from the iron in the presses, which becomes rusted and stains the oil.

7. Mineral oils are frequently used for oiling wools and are preferred by some manufacturers; but they are more difficult to remove from the yarn or cloth by scouring, as they do not easily emulsify. In the presence of some saponifiable oil, such as lard oil or olive oil, mineral oil appears to emulsify more easily and for this reason is often used mixed with lard oil, with which it is easily scoured from the cloth or yarn.

TESTS FOR OIL

8. Oleine is sometimes sold under the name of *elaine oil*, both oils having the same composition and both being liable to contain sulphuric acid; in fact, they are rarely free from acid, the commercial oil containing usually at least .5 per cent. of acid and sometimes a great deal more than this. If acid is present in any great quantity it will attack the card clothing during the carding of the stock, and if the oil is regularly used, will in time destroy the wire. The acid also burns the hands of the operatives if much is present.

A good test for the presence of acid in oil is to place a drop of the suspected oil on blue litmus paper; if a red color is immediately developed, acid is present. This test, however, does not give any idea of the amount of acid present, since the least amount will turn the litmus paper red. A better way to test the acid in oleine is by means of the hydrometer. The specific gravity of pure oleine is about .91, but if it contains acid, the oil is heavier in proportion to the amount that it contains.

Another test for a good oil for wool is as follows: Take two parts of a solution of sodium carbonate 3° Baumé and add to it three parts of oil. If, on stirring, a milky solution free from bubbles is formed, without oily drops on the surface, it is an indication of good lubricating qualities.

It is of the greatest importance that a suitable oil should be selected for oiling wool. The use of cheap oil is false economy, owing to the increased amount of waste in the carding and spinning and the decreased production and quality. The price of the oil used is cheap compared with the cost of the wool, and the amount used should not be stinted any more than the quality.

The following characteristics should be possessed by an oil that is suitable for lubricating wool: It should be readily emulsified by an alkali, in order to be easily removed from the yarn or cloth by scouring; it must not be oxidized by exposure to the air nor become rancid; and it should be free from mineral acid, sulphuric acid being present in low grades of oleine. An oil for oiling wool should also be devoid of color and smell, as far as possible, and must not stain the wool.

METHODS OF OILING

OILING BY HAND

9. There are many methods and means of applying the oil to wool, the oldest, the most used, and the one considered by the majority as the best being the method of oiling by hand. If oil is unevenly distributed over the stock, the result will be noticed in the carding and spinning. Some fibers of the stock will be barely touched by the oil, while others will receive more than their due proportion, which, with the refuse material often found on dyed wools, will form a coating completely covering them. This will harden gradually and affect the pliability of the fiber. The poorly oiled fibers exert a controlling influence and the result will be a general deterioration (as when shoddy is mixed with wool); thus, the more even the distribution of the oil, the more nearly perfect will be the resulting yarn.

In former times, the oiling of the wool was usually attended to by the boss carder himself. He removed his shoes and stockings and taking a pail of warm oil walked from right to left over the thin layers of wool on the floor, distributing the oil by dipping his hand into it and then shaking it from his fingers as he passed slowly along. Each layer of wool was whipped with poles, after the application of the oil, to mix thoroughly the oil with the wool. This is the method employed in many mills today, with the exception that, instead of sprinkling the oil with the fingers, a can resembling a garden sprinkler is used. This can is provided with a **T**-shaped nozzle pierced with several rows of holes.

Suppose that 10 quarts of emulsion is to be applied to 100 pounds of wool. The emulsion should be prepared first;

then 10 pounds of wool should be spread evenly on the floor in a thin layer and 1 quart of oil sprinkled over it as evenly as possible. This layer of wool should be whipped, or beaten, with a long pole in order to distribute the oil as evenly as possible throughout the layer of wool. This operation is repeated ten times, each layer of wool being placed on top of the preceding one, oiled, and beaten until the 100 pounds of wool are used up and the 10 quarts of emulsion applied.

When using the sprinkling can in oiling a lot of wool, the oil should be distributed as evenly as possible and care should be taken not to apply a double supply to any one portion of the stock. The whipping, or beating, of the layers of wool should be thorough, as on this depends, to a great extent, the equalizing of the distribution of oil.

The stock is run through the mixing picker once or twice and is then ready for the cards, but it is well to let oiled stock lie for a short time, say over night, in order to allow the oil to penetrate the fibers. Stock oiled with lard oil, however, should not remain more than 48 hours between oiling and carding, or the carding properties of the wool will be impaired owing to the stiffening of the fiber and oxidizing of the oil.

In oiling all-wool mixes, each layer of material is sprinkled as it is laid down and is then beaten with poles. In cotton and wool mixes, however, the wool is oiled separately and the stock is carded as soon as possible after mixing, so that the cotton will not absorb the oil from the wool, in which case the cotton is much more difficult to card, having a tendency to become stringy and bunch up.

The same plan is followed with wool and silk waste mixes as with wool and cotton. The silk, being especially hard to work, needs extra carding and should be run through a card previous to mixing. In order to get rid of the electricity, which is troublesome in carding, silk may be dampened by lying under wet burlap over night, being mixed with the oiled wool and carded in the morning.

When shoddy has been lying around for some time and is very greasy and gummed up, it is well to use a large proportion of water and a small proportion of oil in the emulsion that is used for lubricating.

AUTOMATIC OILERS

10. Although in many mills the old method of hand oiling prevails, there are some mills that use automatic oilers, of which there are several makes designed to oil the stock at various points in the process of manufacture. The work of any of these devices is not absolutely what could be desired, but they furnish a means of oiling a maximum quantity of stock with a minimum amount of trouble and at the least expense.

11. Spencer Oiler.—This machine is designed to lubricate the wool, noils, or other stock as it passes into the mixing or burr picker, being attached to the mixing picker in most cases. The object of the oiler is to do away with the manual labor of lubricating wool and perform this operation in connection with the picking. At the same time it is designed to apply the oil evenly and uniformly to the stock and to effect a saving in oil, which is often wasted in large amounts when the oiling is performed by hand.

The principle on which this device is based is that of applying the oil to a rotating brush into the bristles of which a stationary blade or knife is set. The rotating brush striking against this knife throws the oil in a fine spray on the wool, which is evenly spread on the feed-apron of the picker.

The partly assembled parts of the Spencer oiler are shown in Fig. 1. It is practically impossible to show this machine set up as in operation, because the connections, etc. of such a machine as an oiler must necessarily vary to suit different circumstances and the needs of different mills. The large tank *a* that contains the supply of oil or emulsion is often located some distance from the picker where the wool is oiled, or it may be placed on the floor beside it.

As shown in Fig. 1, the oiler consists of an arch-like frame that, when attached to the frame of the picker, spans the feed-apron and carries the various parts of the machine, with the exception of the oil tank and pump, which are usually placed on the floor. The essential features of the machine

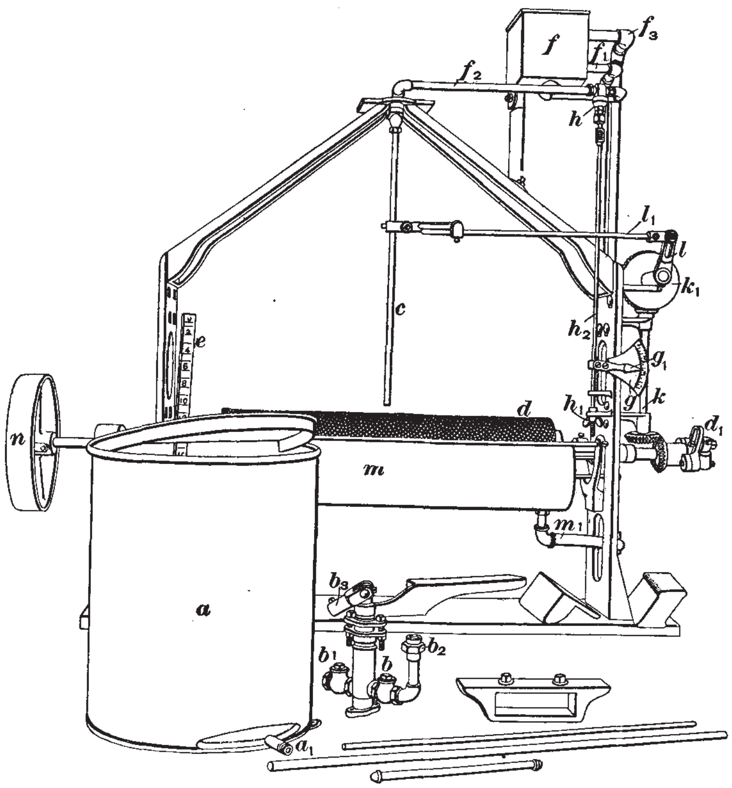


Fig. 1

are the supply tank *a* for holding the oil, the pump *b* and oscillating pipe *c* for supplying the oil to the brush *d*. The knife blade working in connection with the brush is hidden from view in the figure.

The supply tank is of sufficient size to hold the oil for a large batch of wool. It is provided with a float to which the gauge e is attached and by means of which the amount of oil or emulsion that the tank contains can readily be ascertained at any time.

12. When the various parts of the oiler are set up for operation, the feedpipe b_1 of the pump is connected to the delivery pipe a_1 of the supply tank. The delivery pipe b_2 of the pump is connected with the pipe f_1 that opens into the reservoir f. The pump is driven by means of the crank d_1 on the shaft of the rotating brush, which by means of a suitable rod is connected with the plunger of the pump at b_3. In operation, the pump takes the oil from the supply tank and forces it to the reservoir f through the pipe f_1. The oil flows by gravity from this reservoir through a stationary pipe f_2, and by means of an oscillating pipe c is applied evenly to the rotating brush that extends across the feed-apron of the picker, 2 or 3 inches above the wool spread thereon. The brush rotates rapidly, and, being charged with oil from the pipe c, throws the same on the wool on the feed-apron of the picker when the bristles strike the knife blade that is set into them. The oil is thrown on the wool in a fine spray, and as the stock passes through the picker, the oil is thoroughly mixed with the fibers. A trough m collects the oil that does not fall directly on the stock, and through suitable connections with the pipe m_1 returns the same to the supply tank. The oscillating motion of the pipe c is obtained by means of a crank l, which is connected to it by means of a rod l_1. Motion is imparted to the crank by means of a gear k_1, which is driven from the brush shaft through bevel gears and an upright shaft k. The oscillating pipe should not swing quite the entire length of the brush, for if it does, there is a liability of the ends of the brush receiving more oil than the central portion, and consequently of the wool on the sides of the picker being more heavily lubricated. The amount of oscillation may be regulated by moving the connecting-rod l_1 in the slot of the crank l. The reservoir on the top of the machine is supplied with an overflow pipe f_3

that connects with the supply tank on the floor. Thus there is no danger of an overflow if the delivery of oil is shut off and the pump left running.

The amount of oil supplied to the brush is regulated by means of the supply valve h, which may be set to deliver any desired amount by means of a pointer g_1 that operates the rod h_2 connecting with the valve. This rod may be locked in the desired position by means of a thumbscrew h_1. The amount of oil supplied to the brush is indicated by the pointer g_1 on a dial g.

The pump may be set for a different length of stroke by means of a slot in the crank-arm that drives the same. The stroke of the pump should be so adjusted that there will be a very small stream running down the overflow pipe f_3 when the oiler is spraying the largest amount of oil that will ever be required. This keeps the oil in constant motion, which is an important point when applying emulsions, since they are liable to become separated into their component parts if allowed to stand.

To regulate the amount of oil per hundred pounds of wool, place in the tank only the amount of oil required for the batch of stock that is to be run through; set the valve so that when one-fourth of the batch is run through, the tank gauge will show that one-fourth of the oil or the emulsion (as the case may be) is applied, and when one-half of the lot has passed through the picker, one-half of the oil is used, and so on, until by experience the exact place to set the pointer on the dial to use a given amount of oil for a given amount of stock is found.

The rotating brush and knife blade should be as level as possible each with the other, so that the oil will not run off to the side of the knife blade, which should be set at an angle of about 45° into the brush to throw a fine spray of oil. The knife blade should be set into the brush about $\frac{1}{4}$ inch. In order to attain the most perfect results, the oil or emulsion in the tank should be heated with steam pipes, as better results in oiling are always attained when warm oil is applied.

The power is applied to the machine by means of a pulley *n* on the shaft of the brush, which may be driven either from the main shaft of the picker or from the shaft of the beater on the self-feed. To attain the best results, the brush should make about 60 revolutions per minute.

13. Sargent Oiler.—Another machine for automatically oiling wool is shown in Figs. 2 and 3, its object being to lubricate the stock as it passes into the feed-rolls of the first breaker card. The oil is broken into finely divided particles, as is the case with the oiler previously described, and precipitated on the wool, which is evenly spread on the feed-apron of the card. The principle on which this machine depends is that of an oscillating, instead of a rotating, brush that extends across the feed-apron and, being moistened with oil, throws the same on the stock.

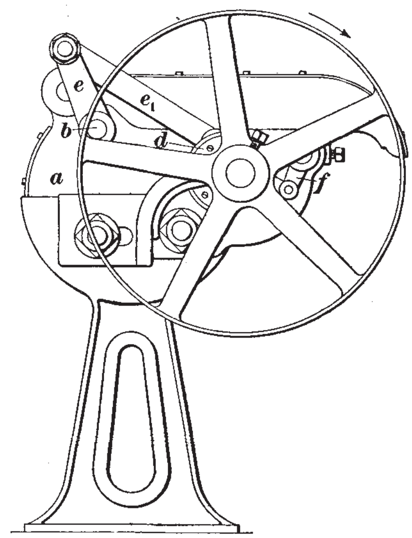


FIG. 2

The machine consists of two stands that carry an oil tank *a* stretching across the feed-apron of the card, and also carry the driving parts of the machine. The tank has a capacity of about 4 gallons of oil or emulsion, and contains a dipper shaft *b*, which carries a dipper b_1; this brings the oil from the tank to the vibrating brush *c*.

The driving pulley of the machine is fastened to a short shaft, which carries an eccentric *d* on its opposite end. A lever arm *e* on the dipper shaft is connected to a crankpin on the side of the eccentric by a connecting arm e_1, by means of which the dipper is given an oscillating motion, bringing the oil from the tank and depositing it on the oscillating brush, which is driven by the eccentric through the arm *f*.

The amount of oil deposited on the stock depends on the speed of the machine. The driving pulley should make about 30 revolutions per minute for coarse stock, which passes through the cards rapidly. For fine stock, which goes

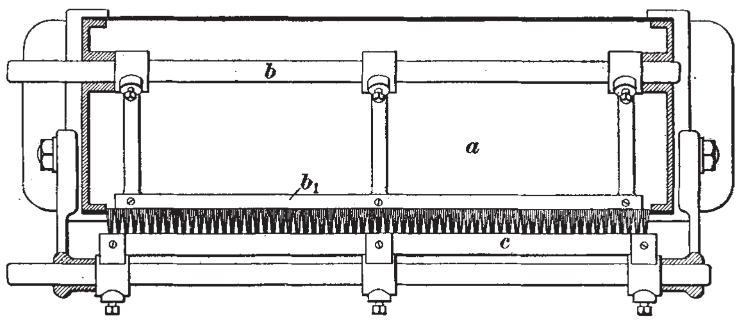


FIG. 3

more slowly, about 20 revolutions per minute is sufficient. The amount of oil used per hundred pounds of stock with a certain speed can only be determined by experiment. The machine is driven from the first worker shaft of the card.

The advantage of oiling the stock at the first breaker card is that there is but little chance for evaporation, as the wool is only exposed to the air after lubrication in passing through the cards. This is especially advantageous if emulsion is used, as an emulsion evaporates faster than pure oil. Another advantage of lubricating the stock at the first carding process is that large lots of wool or mixes can be picked beforehand and kept in reserve for the cards, there being no danger of injury by rancid or gummy oil.

The great disadvantage of this oiler is that as the oil tank gets empty, the amount of oil deposited on the stock is reduced because the dipper will not bring up as much oil to the vibrating brush. If more oil is required than is being supplied to the stock, the machine must be speeded up by increasing the size of the driving pulley on the worker shaft.

14. Goddard Oiler.—By referring to Fig. 8, *Burr Picking*, it will be noticed that there is located over the outlet spout of the burr picker a square box-like device, which is a form of automatic oiler, called the **Goddard oiler.** This consists of a case with a revolving brush inside and an oil tank that rests on the top of the case, in which oil or emulsion is placed and fed through a faucet and tube into the oiler case containing the revolving brush. The oil is brushed across an oscillating bar and thrown as a fine spray over the wool as it leaves the burr picker.

The amount of oil is easily regulated by the faucet; still there is some difficulty in knowing just how much oil is being used per hundred pounds of wool. Another fault with this method of oiling is that the stock can be picked only as it is needed by the cards, because it will not do to let oiled stock lie around, owing to the fiber becoming stiff and the oil gummy.

WOOLEN CARDING

(PART 1)

INTRODUCTION

1. Condition of Stock.—In order that the best results may be obtained in **carding,** the preparation of the stock in previous processes and by the preparatory machines must be thorough. The wool must be well scoured and dried and the fiber soft and pliable. Harsh-feeling stock that has been injured in the washing and drying processes will not card well, nor is it possible to spin a fine, elastic yarn from such material after it is carded. Such stock will also have a tendency to make an excessive amount of waste owing to the flyings, which cannot be wholly avoided in carding and the amount of which increases as the quality of the stock deteriorates. *Flyings* are the short, fluffy fibers that are thrown from various machines, particularly the cards, owing to the rapid rotation of certain parts of the machine.

In order to card well, the stock must be well burr-picked or carbonized and as much as possible of the vegetable matter and other dirt removed. The removal of the vegetable matter from the wool occurs at every possible point in the manufacture of the yarn, so that when the wool is ready to be spun it should contain none of the foreign substances that became attached to the fleece during the life of the sheep. Vegetable matter remaining in the wool, if spun into the yarn, causes a rough, uneven thread, thus greatly deteriorating the value of the yarn and of the resultant fabric.

Stock that has been mixed, either for color or quality, must be well blended before the carding is begun, for otherwise the cards will have to perform the work of the mixing picker as well as card the wool or mixture, and inferior work will result. The wool should be run through the mixing picker as ufficient number of times to open the stock thoroughly; the work of the cards will thus be greatly improved, because the stock will come to them in an open condition and with few matted lumps to be opened out. It should be well lubricated with oil or emulsion in order to preserve the natural structure of the fiber from injury during the carding process. If not well oiled before being put on the cards, the serrations of the fiber will be injured by the friction of the fibers with each other and with the card clothing. It will also produce a large percentage of flyings owing to its dry condition. If, however, the stock is lubricated, the serrations of the fibers become filled with the lubricant and slip past one another easily, thus becoming disentangled without difficulty and allowing the natural formation of the wool in locks, or staples, to be broken and an artificial arrangement of the fibers made that is necessary to the objects in view. No amount of oil will restore to its perfect natural condition stock tha has been made harsh in the scouring or drying, but the application of good oil in liberal quantities will aid its carding and spinning to a great extent.

It may be briefly stated, therefore, that before carding the wool should be well scoured, dried, and oiled so as to leave the fiber soft and pliable. It should also be well burr-picked in order to remove vegetable matter and burrs, which, if not removed, make the yarn uneven, and which, appearing in the resultant cloth make specks that may require the cloth to be either carbonized or speck-dyed.

2. Objects of Woolen Carding.—Carding has for its object the opening out of the fibers of the wool and their arrangement into an artificial form from which they can be spun into a uniform and even thread, and may therefore be said to be a continuation on a more systematic principle of the opening-out process, which begins in the burr and mixing pickers. Although the wool in the burr picking and mixing was opened out, the fibers themselves were not separated from each other, but rather the wool as a whole opened out and rendered lofty. The carding not only opens out and disentangles the locks and bunches of wool, but actually separates the stock, fiber from fiber, and rearranges the individual fibers in a mixture of uniform density; it may, therefore, be said to be the first point where the wool is manufactured, or brought to an artificial condition.

It is obviously impossible to spin a thread from wool when it is in the condition of a large mass of stock, as in the previous operations; so when the stock is taken from the last carding operation, it is divided into **ribbons.** These ribbons are rubbed, by means of leather-covered rolls or aprons, into round threads of carded wool called **roving.** The roving is taken to the woolen mule and spun into yarn; in order that the yarn spun from it shall be even, the roving must be uniform in structure and absolutely free from particles of vegetable matter. The term roving is corrupted in some mills and districts into **roping;** as both terms are used more or less indiscriminately, each will be considered allowable.

Carding is sometimes looked on as the last process of opening out the wool, but it is also a good plan to consider it as the first operation in the manufacture of the yarn, since, when the stock leaves the finisher card, it is condensed into rovings, whereas hitherto the stock has existed only in a loose state. Rovings have no *twist*, but are simply continuous ribbons of carded wool, the fibers of which are rubbed together into a round thread, or strand.

By **twist** is meant a continuous spiral formation of a thread, which will be plainly seen by examining any ordinary thread. In the manufacture of woolen yarn a very small amount of twist is inserted at the side drawings of the first and second breaker cards by a rotating tube through which the sliver passes, and also to a much larger extent when it is spun into yarn on the mule.

The object of woolen carding is not so much to lay the fibers parallel as to mix and intermingle them on a uniform system so that the individual fibers will be thoroughly blended with one another. Thus, the object of woolen carding is different from that of either worsted or cotton, the carding of which tends toward parallelism. This is a fundamental feature of difference between the preparation of a woolen yarn from that of a worsted or cotton yarn. The fibers of carded wool point in every direction, while when on the fleece they had the same general direction; that is, the fibers being disposed in staples all pointed away from the back of the fleece.

3. The process of carding has been said to result in the breaking up of the natural and substituting an artificial arrangement of the fibers, but there are other ends to be attained and the various objects of woolen carding may be said to be: (1) To break up the natural formation of the wool, in which it clings together in small tufts, or locks; (2) to accomplish a thorough amalgamation of the individual component fibers and their rearrangement into a uniform artificial blend; (3) to clean the wool of refuse matter that has escaped the previous operations (this is generally in the form of dust and short straws, commonly called shives); (4) to accomplish a division of the carded stock into ribbons of equal weights and condense them into rovings suitable for spinning.

On the thoroughness of the carding depends the accomplishment of the results named, and the resultant yarn is usually good or bad according to the manner in which the carding is performed.

METHODS OF CARDING

4. Carding by Hand.—The former method of carding wool was by means of hand cards, which are small flat boards about 12 inches long and 5 inches wide, having a handle attached to one side. The face of the board is covered with leather, through which fine wires are placed, forming what is technically known as *card clothing*. The method of making card clothing has changed and it is now made automatically by machinery, but formerly the sheet of leather was pierced with holes by hand and the wire cut to the right length and bent in the form of a staple with a pair of pincers, after which it was thrust through the prepared sheet of leather. The wires, or teeth, of the card clothing were also bent forwards at an angle toward the handle of the card. Thus, if a lock of wool were drawn across the card against the points of the teeth it would engage with them, but would not catch if drawn in the opposite direction.

The method of carding wool by hand was as follows: A hand card was held in the left hand with the handle pointing away from the operator; the wool to be carded was spread on it and a similar hand card drawn lightly over the first card, which was held rigid. The bent teeth of the card clothing worked against each other and thus opened and combed out the wool. This constitutes the action of carding; i. e., combing the wool by means of card clothing working point against point, and is the same whether performed by hand cards or on modern carding machines. When the operator thought the wool was sufficiently carded, the handles of the cards were brought together and a peculiar shuffling motion commenced, the surfaces of the cards being drawn lightly across each other, which had the effect of bringing the wool from the cards in a roll or, as it was called, a **rovelling.** This was due to the teeth of the cards working point against back and is known as **stripping;** the action is the same, namely, point against back of tooth, on the woolen card used today.

Hand carding is employed today for matching mixtures in the mill. A small amount of wool of the various colors in the mix in the right proportion is carded by hand and, after the colors are thoroughly blended, the handful of wool is felted by hand into a sample *swatch*.

5. Modern Methods.—From hand carding the science quickly advanced to the roll, or cylinder, cards, which are in use at the present day. The first cylinder carding machine in America is in existence at the present day. There is some doubt as to whether it was built in England or America, but it made its appearance in the American woolen industry in 1792. Even with its wooden frame and clumsy appearance, it embodies the principles used in modern card construction.

The system of carding for woolen yarn practiced in most American mills consists of performing the carding on three cards, called the *first breaker*, *second breaker*, and *finisher cards*; taken collectively they are termed a *set of cards*. The finisher card in some districts is known as a *condenser card*, because as the wool leaves this card it is condensed into rovings by a machine, called a *condenser*, or *rub*, attached to the end of the card. The size of American woolen mills is gauged by the number of sets of cards.

The cards that constitute a set are usually coupled together by various kinds of feeds and carrying devices so that, with the exception of the feeding at a creel at the second breaker, the stock has a continuous motion from the self-feed of the first breaker until the rovings are wound on a jack-spool on a winding stand at the end of the finisher card. Each card has one main cylinder and its corresponding complement of other rolls.

Carding for woolen yarn as performed in Europe differs from the usual American system. Carding for worsted yarn differs from carding for woolen yarn both in America and in Europe. In accordance with the method adopted in this Course, one standard system will be taken into consideration; namely, that of the American system of carding for woolen yarn.

6. Principles of Carding.—The two vital principles involved in the carding process are: (1) The carding proper, which consists of opening and carding the wool by means of rotating cylinders that carry on their surfaces card clothing filled with wire teeth, carding action taking place when the teeth on the cylinders work point against point; (2) the strip-

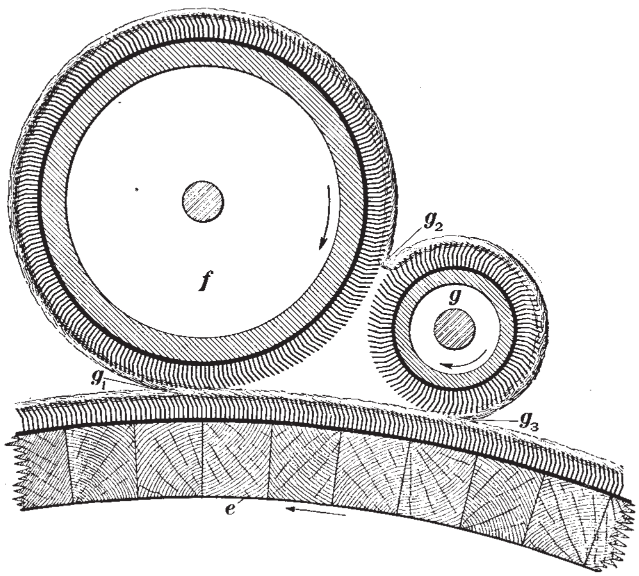


FIG. 1

ping of the carded wool from the cylinder that has performed the carding, which occurs when the points of the card clothing on one cylinder work against the backs of the teeth on the other.

It is important to consider the inclination of the teeth, or the direction in which they point. The teeth of card clothing are all bent forwards in one and the same direction, so that if a lock of wool is drawn across the clothing against the back of the teeth, it will not engage with the teeth; but, on the other hand, if drawn the other way, the clothing will quickly catch the wool. This inclination of the card wire is also known as the **keen** of the tooth. It will be readily seen that the operations of carding and stripping are both dependent on the inclination of the wire teeth of the card clothing, because if the teeth were straight, that is, at right angles to the foundation of the clothing, there would be no such action but the clothing would act simply as a brush. The principles of the carding and stripping action of card clothing are common to the carding of all fibers and with all carding machines.

Fig. 1 shows how the workers and strippers of a woolen card work in conjunction with the main cylinder and illustrates the principle of the carding and stripping actions of a card. The main cylinder e of the card revolves rapidly in the direction of the arrow, while the worker f slowly rotates in the direction shown by its arrow; thus the teeth on the main cylinder pass the teeth on the worker point against point. It will be seen that the actual carding, therefore, takes place at the point g_1 between the main cylinder and the worker, the wire teeth of the clothing on the cylinder e carrying the wool, which projects from the teeth and is readily caught by the clothing on the worker. The stock is thus combed, or carded, open, and deposited on the teeth of the worker; and, as this roll revolves, it is brought around to the point g_2, where it encounters a small, fast-running roll g, called a *stripper*. The clothing on the stripper works with its points against the backs of the teeth on the worker f, thus lifting the wool from the worker. From this it will be seen that the action of the stripper and worker at the point g_2 is not one of carding, but of stripping.

As the stripper revolves, the wool is taken from it by the teeth of the main cylinder, which work with their points against the backs of the stripper teeth and have a velocity in excess of that of the stripper teeth. Thus, the action at the point g_3 is also that of stripping. The stock is then carried forwards by the main cylinder to the next complement of workers and strippers, which are placed over it.

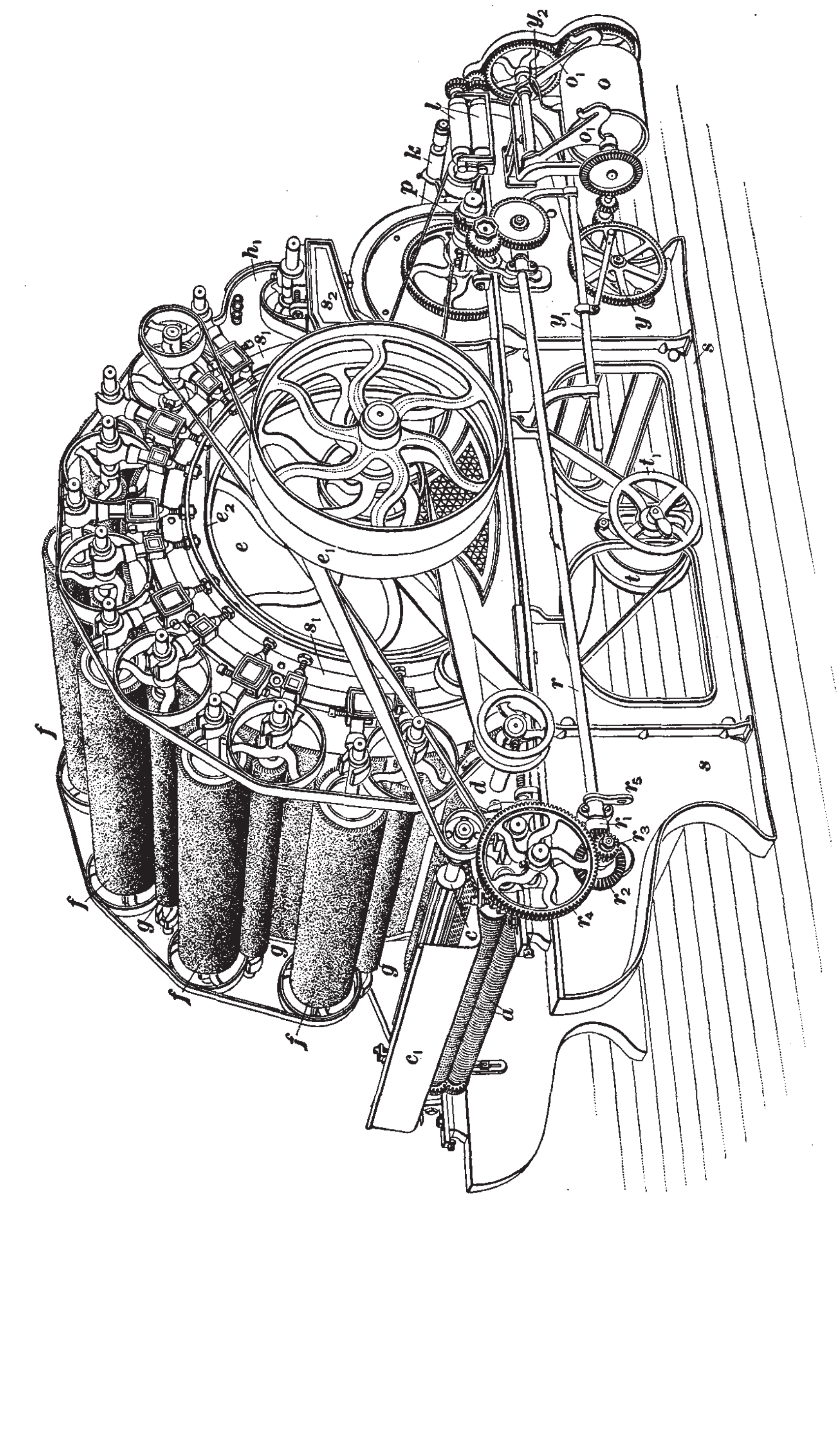
It must be understood that not all of the wool on the main cylinder is taken by the first worker, but that some may pass to the second worker, each worker taking a portion of the wool on the main cylinder; then, again, if the wool is not carded properly by the first worker and projects from the card clothing of the cylinder, it may pass around the same worker twice or even more times before passing to the next worker. With the exception of the *fancy* and the *feed-rolls*, the functions of which will be explained later, every roll on the card has either a carding or a stripping action on the wool, all depending on the inclination and relative velocities of the card clothing, which if it works point against point always cards the wool, and if working point against back of tooth has a stripping action.

CARD CONSTRUCTION

7. Dealing with the American system of carding for the production of woolen yarns, a suitable equipment of cards and machines for feeding the same would be as follows: *Automatic weighing and feeding machine*, *first breaker card*, *balling machine and creel*, *second breaker card*, *intermediate feed*, *finisher card*, *condenser*, *winding frame*. These machines constitute one set of woolen cards, as generally considered; that is, a set of cards consists of the first and second breakers and the finisher card with their respective feeding and doffing arrangements, although in ordering cards the feeds are not included. Before giving any instruction on the numerous feeding and other devices connected with woolen carding, the cards themselves will be thoroughly discussed.

THE FIRST BREAKER CARD

8. The object of the **first breaker card** is to perform the first carding process in the manufacture of a woolen yarn; consequently, as the wool is not so open when fed to this card as when it comes to the others, the clothing of the first breaker is made of heavier wire and the *set* of the card



is more open. By the **set,** or **setting,** of the cards, the proximity of the rolls of the cards to each other is meant, as will be explained later. The principle of the first breaker is that of opening the wool by means of rotating cylinders covered with card clothing and adjusted to one another so as to carry out the principles of carding.

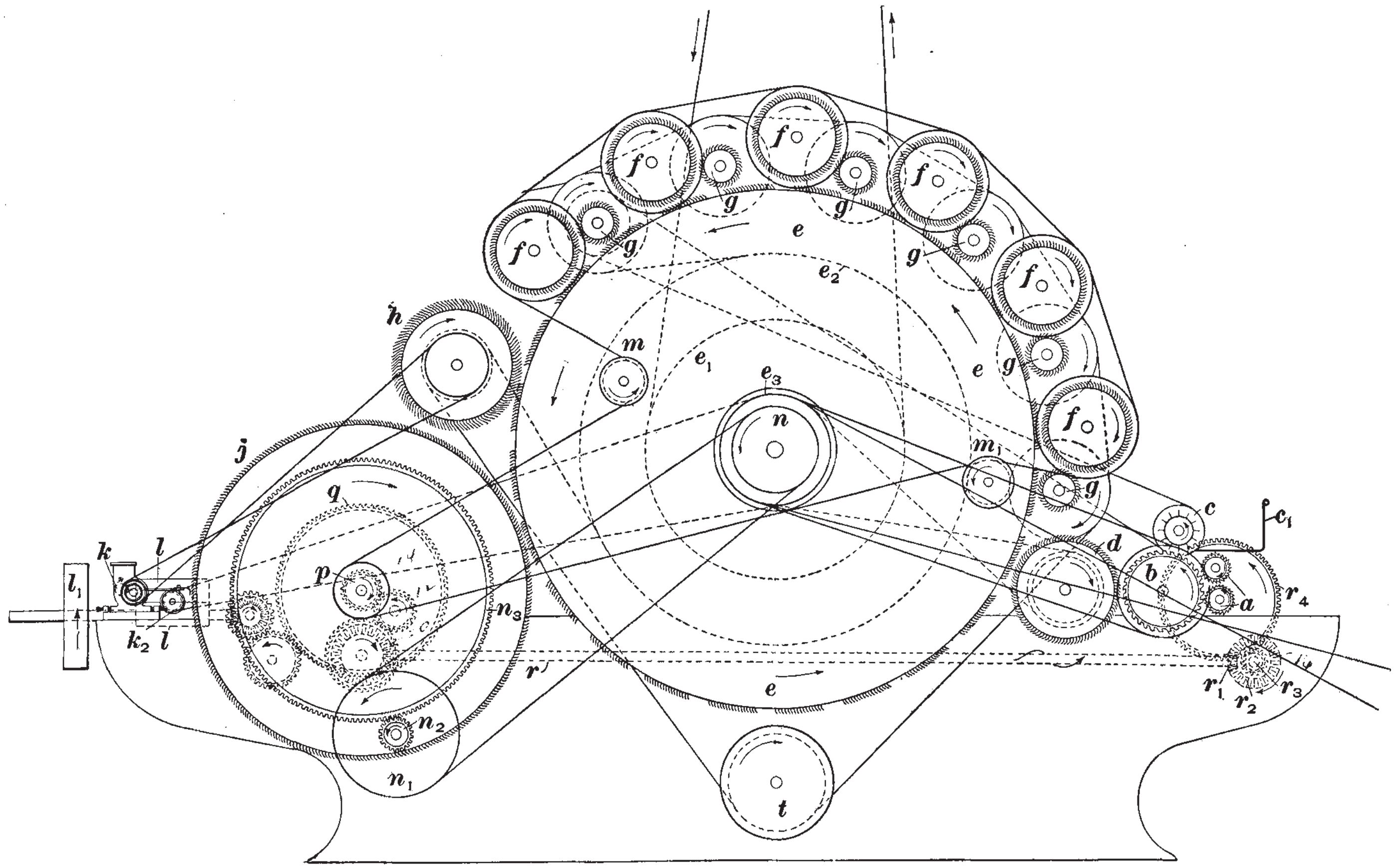
CONSTRUCTION

9. It will readily be seen that as the carding operation is such a delicate process and involves the separation of the individual fibers and their rearrangement, the construction of the machine on which this operation is performed is a very important element in governing the quality of the work produced. Owing to the fine settings and adjustments on a card necessary to accomplish these results, the greatest possible accuracy in their construction is observed.

In the Davis & Furber card, Fig. 2, the working parts are primarily supported by two straight-top frames, or beds, *s* that are connected by cross-pieces passing from one side of the card to the other and varying in length according to the width of the card. The tops of the two bed pieces, or frames, are carefully planed and leveled in order to secure firm and true bearings for the arches. The two arches s_1 are supported by the bed frames, to which they are firmly bolted, and carry the workers *f*, strippers *g*, and fancy, which is enclosed in a bonnet h_1. They are built in the form of arcs of circles and have projecting brackets, or arms, s_2 for the purpose of supporting the fancy. In this type of construction the main-cylinder bearings are carried by the arches.

In the process of making the cards, the frames and arches are carefully planed in pairs, each pair being used in the same card; this insures the uniform size and shape of each side of the card. In Fig. 3, the outline of the frame of the card is shown, but the arch is omitted so that the workers and strippers, which are carried by the same, can be clearly shown and also the belting plan of the card.

The working parts of the first breaker are carried either by the arches or by the frame and consist of the following: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c₁
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t

FIG. 3

Feed-rolls a, burr cylinder b, burr guard c, tumbler d, main cylinder e, six workers f, six strippers g, fancy h, doffer j, doffer-comb shaft k, doffer comb k_1 (not lettered in Figs. 2 and 3), drawing-off rolls l, and pulley l_1 for driving balling machine.

10. Feed-Rolls.—The rolls *a*, Fig. 3, that perform the function of feeding the wool to the card are 2 inches in diameter and are covered with metallic feed-roll wire. They are metallic and the wire used in winding is similar to that employed for the burr cylinders of burr pickers except that the form of the tooth is pointed instead of having a flat top.

11. Burr Cylinder.—This roll *b* is 7 inches in diameter and is covered with burr wire similar to that used for the burr cylinders in burr pickers. The **burr cylinder** is constructed entirely of metal and has the burr wire wound around it in a spiral, or helical, groove and firmly staked in.

12. Burr Guard.—Working in connection with the burr cylinder is a small roll *c*, known as the **burr guard,** that knocks any burrs remaining in the wool from the surface of the burr cylinder into a burr pan c_1 provided for such a purpose. The burr guard on the card is similar to the burr guards on the burr picker, with the exception of the number of blades, the one in the card being provided with twelve.

13. The **tumbler** *d* is a large roll 9 inches in diameter; its function is to take the wool from the burr cylinder and deliver it to the main cylinder of the card. It is usually made of wood with a steel shaft, but is made of iron when so desired. It is the first roll of the card that is covered with card clothing; the covering used here is known as *filleting.*

14. Card Clothing.—In order that the terms used in connection with card clothing may be understood (although this subject will be taken up later) the following explanation will not be out of place. There are two kinds of card clothing with which woolen cards are covered; namely, *sheet* and *fillet clothing.* **Sheet clothing** is prepared in sheets

5 inches wide and corresponding in length to the width of the card. This clothing is used only for covering the main cylinders of the first and second breaker and finisher cards, although most carders prefer filleting for the cylinder of the finisher. **Fillet clothing** is prepared in continuous lengths, or strips, of any desired width, usually from 1 to 2 inches. Rolls are covered with fillet clothing under tension so that the clothing will not become loose, the filleting being wound around the roll continuously, as a spiral, and securely fastened. Fillet clothing is applied to all rolls of a card that are covered with clothing with the exception of the main cylinders of the first and second breakers and the ring doffers, which are covered with special clothing.

15. The **main cylinder** is usually 48 inches in diameter and is one of the most important parts of a card, as on it falls the largest amount of work, since most of the other parts of the card are set to it. It not only acts in conjunction with each of the workers and the doffer in carding the wool, but acts as a conveyer, carrying the stock from the tumbler to the doffer. There are three methods of building main cylinders used for woolen cards; viz., wooden lag cylinders, wooden block cylinders, and iron cylinders.

Wooden lag cylinders are the ones usually attached to a woolen card unless some other construction is specified when ordering. This cylinder is built of carefully kiln-dried wooden lags on spiders attached to a central shaft, which in the Davis & Furber card is supported in brass-lined bearings enclosed in the arches. After the cylinders are put together they are turned down and carefully trued in order to insure accurate running.

Wooden block cylinders are, perhaps, the least used of all and are only furnished when especially ordered. The block cylinder is made by building the rim of the cylinder of blocks, or boards, set edgewise to the surface and carefully nailed or pegged and glued together. Block, as well as lag, cylinders are securely bolted to spiders attached to the main shaft of the card.

Iron main cylinders are coming into use more and more on woolen cards. An important advantage of the iron cylinder over the wooden is its immunity from the effects of atmospheric changes, which are apt to warp, either temporarily or permanently, a wooden cylinder so that its circumference will not run true.

The iron cylinder, if carefully trued in the machine shop, will run for years without any trouble, while the wooden cylinder may have to be trued or turned down every year, or even oftener, until it is thoroughly shrunk, owing to the uneven shrinkage of the wood. If an iron cylinder is once sprung out of true it is much more difficult to remedy the defect than is the case with a wooden cylinder and it usually necessitates the shipment of the cylinder to the machine shop where it was made; but when carefully made this ought seldom, if ever, to happen. In cotton carding, iron cylinders have entirely replaced wooden cylinders.

When a mill is shut down for some time the cylinders of the cards, if wooden, should be turned over by hand once or twice a week because, if allowed to stand in one position, there is liability of their warping out of true. It is well known that many types of textile machinery deteriorate more when standing idle than when in actual use.

The speed of the main cylinders of woolen cards is, for ordinary wool, from 90 to 100 revolutions per minute. There have been instances where the cylinders of woolen cards have been speeded up to 120 revolutions per minute, but the increased amount of flyings, or fibers of wool thrown from the card, in consequence of the velocity of its parts, and the liability of inferior work do not warrant this speed. For low stock, or with cylinders 60 inches in diameter, the speed should be slower; some carders on low stock run the cards at only 60 revolutions per minute.

16. The **workers** *f*, as their name implies, are the rolls of the card that, in conjunction with the cylinder, perform the larger part of the carding since the clothing on their surfaces works point against point with that on the surface of the cylinder. On the card shown in Figs. 2 and 3, six 7-inch workers are placed over the main cylinder either in open brass-lined or in sleeve bearings, which are carried on stands having suitable means of adjustment, so that the setting of the workers to the main cylinder and to the strippers may be easily and accurately accomplished. Workers are usually made of wood, but may be made of iron if desired; the iron worker is less liable to get out of true, but if once sprung has to be returned to the machine shop to be remedied.

The number of workers placed over the main cylinder of a card varies according to the diameter of the cylinder, more workers naturally being placed over a 60-inch than over a 48-inch cylinder; however, the number of workers may vary even on cards with the same diameter of cylinders, eight workers being frequently used with 48-inch cylinders, although the standard equipment is six.

17. Strippers.—There are six 3-inch **strippers** *g* operating in conjunction with the workers on the first breaker card; owing to their small diameter, they are always made of iron. The strippers are placed in open brass-lined or sleeve bearings, which are fitted with a device for adjusting the proximity of the stripper to the main cylinder, but which admits of no lateral adjustment, as the setting of the worker to the stripper is performed by moving the worker to or from the stripper. The strippers and workers operate in pairs; there is always the same number of each on one card.

18. Fancy.—The function of the **fancy** *h* is unique. It has neither a carding nor a stripping action, but acts as a brush. The clothing has longer wires than the ordinary card clothing and they are set so as to dip slightly into the clothing on the main cylinder. The surface speed of the fancy is in excess of that of the main cylinder so that the clothing raises the wool to the points of the teeth on the cylinder, from which it is easily removed by the doffer *j*. The fancy is made of wood and is 10 inches in diameter, being enclosed in an iron bonnet h_1, Fig. 2, which is made so as to be easily removed and is provided with a hinged cover. The fancy shaft is set in covered brass-lined bearings.

19. Doffer.—The first breaker card is provided with a 24- or 30-inch **doffer** *j*, made of wood or iron as preferred, which takes the wool from the main cylinder. The preferred size is 30 inches in diameter. Working in connection with the doffer is a doffer comb, which takes the stock from the same and from which it passes through a rotating tube to the drawing-off rolls. The oscillating doffer comb will be described later.

DRIVING

20. The feed-rolls of the card are driven from the doffer by a small gear *p*, Fig. 2, on the doffer shaft, which is the change gear for altering the weight, per yard, of the sliver or card end. This gear drives a train of gears, a pair of which are bevel gears, and turns a shaft *r*, known as the side shaft, running the length of the card. On the other end of the side shaft the bevel gear r_1 drives a larger bevel gear r_2 compounded with a small pinion gear r_3 that drives a large gear r_4 on the bottom feed-roll shaft. This drive is also shown in Fig. 3.

The two feed-rolls *a* are coupled together with gears on the opposite side of the machine, as seen in Fig. 2. The gear r_3 that drives the large gear r_4 on the bottom feed-roll shaft may be changed for an alteration in the weight of the side drawing, or sliver, from the card, as well as the gear *p* on the doffer shaft, which has been mentioned as the change gear. An increase in the number of teeth on either of these gears will result in a heavier sliver. The gear *p* on the doffer shaft is the one that is ordinarily changed for altering the weight of the sliver.

There is a device for throwing the small bevel gear on the feed-end of the side shaft of the card from contact with the bevel gear with which it meshes, thus allowing the feed-rolls to be stopped, which, consequently, stops the delivery of wool to the card. This is accomplished by means of a small lever, or handle r_6, which is shown on the side shaft of the first breaker card, Fig. 2, and also in the illustration of the second breaker, Fig. 7; the device is the same in both cases. The feed-rolls of a card are always stopped and the card allowed to run out, or to clear itself as much as possible, before stripping or grinding.

21. In Fig. 2 it will be noticed that the card is equipped with the ordinary side-balling attachment, for the purpose of winding the side drawing, or sliver, from the card into balls that are placed in a creel and the slivers unwound and fed to the second breaker card. This arrangement consists of a drum *o* driven by bevel gears from a shaft located just beneath the doffer. The delivery rolls *l* are driven from a train of gears from the drum shaft and the sliver of wool as it is delivered passes through a reciprocating guide y_2 and is wound on a spindle supported by the arms o_1. The guide is fastened to a bar y_1 that receives a reciprocating motion by means of a crank-movement from the gear *y*. The rotary motion necessary for winding the sliver of wool into a ball on the spindle is obtained by means of the constantly rotating drum on which the ball of wool rests as it is formed.

This balling arrangement is not attached when a balling machine is used, but a pair of delivery rolls, as shown in Fig. 3, is substituted.

By referring to Fig. 3, which is an illustration of a left-hand card, the driving of the various parts may be determined. There is considerable difference of opinion as to what constitutes a right- or left-hand card, but the weight of opinion seems to be that a right-hand card is one in which the driving pulleys are at the right of a person standing at the doffer end of the card and facing the machine, while a left-hand card has the driving pulleys on the left of a person standing in the same position. In Fig. 3 the bed frame of the card on the driving, or left-hand, side only is shown, the other, or right-hand, bed frame and both arches being removed and the parts of the card left unsupported, in order that all the parts may be clearly shown. All parts that are on the left-hand side of the card, that is, the same side as the main driving pulleys, are shown in dotted lines where other parts intervene, and all parts on the right-hand side in full lines.

Cards are often made right- and left-hand and the sets arranged with the driving pulleys of two sets together.

The power is supplied to the card by means of 24-inch tight and loose pulleys e_1 on the main-cylinder shaft, as shown in Fig. 2. The doffer is driven by the small gear n_2, Fig. 3, engaging with the large gear n_3 on the doffer shaft. Compounded with n_2 is the pulley n_1 which is driven by the pulley n on the main-cylinder shaft. On the right-hand side of the machine is a 5-inch pulley on the doffer shaft, which drives all the workers. The belt passes over six 9-inch pulleys on the worker shafts and also around two movable flange binder pulleys m, m_1. The strippers and the fancy are driven from a 36-inch flange e_2 on the main-cylinder shaft on the driving side of the card. A belt passes around this flange and over pulleys on the fancy and stripper shafts. It also passes around an arbor pulley t, which may be lowered or raised by means of a rack and pinion operated by a hand wheel, thus allowing the stripper belt to be tightened when necessary.

The burr cylinder is driven from the pulley e_3 on the main-cylinder shaft on the right-hand side of the card. On the opposite side of the machine the burr guard is driven from a pulley on the last stripper shaft by means of a cross-belt. The tumbler is driven from a pulley on the main-cylinder shaft by means of a cross-belt on the left-hand side of the machine. In Fig. 3, there is also shown a crossed belt running down to the right, from a pulley on the main-cylinder shaft, which is for the purpose of driving the self-feed.

The main features of the device for driving the oscillating doffer comb k_1 are shown in Fig. 4, while in Fig. 5, the working parts that are enclosed in an oil-tight casing are shown. The comb is driven from a two-step pulley on the fancy shaft, which in turn drives a two-step pulley on the crank-shaft k_5 of the comb-driving mechanism on the right-hand or left-hand side of the card as desired, but usually on the opposite side from the main driven pulleys (this drive is shown in Fig. 3). The crank carries a square, split block k_2, Fig. 5, that works between the tines of a fork k_3 setscrewed

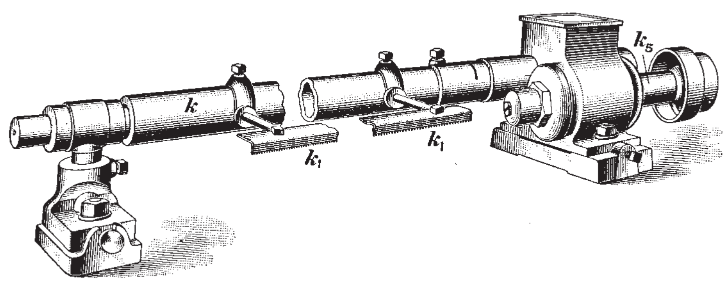

FIG. 4

to the comb shaft k. As the crank-shaft rotates, it gives an oscillating motion to the comb, the horizontal play of the crank being taken up by the block sliding in the fork. This block is kept from working out from between the tines of the fork at the sides by means of two circular plates k_4 on the crank-shaft, one of which is shown. These parts are enclosed in a casing and are run in oil, the casing being oil-tight. The casing of the comb shaft and the bearing on the other side of the card are carried on slides, which allow for setting the same to the doffer.

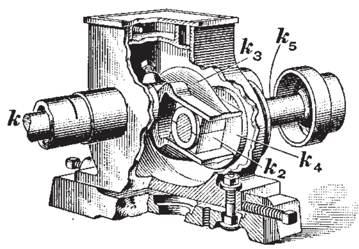

FIG. 5

When carding low stock with a short fiber, it is often advisable to speed up the doffer comb; but when carding long, coarse stock, the comb should be slowed down, which may be readily accomplished by means of the step pulleys by which it is driven. The stroke of the comb should be such that its center is at its closest proximity to the doffer, and this point should be about opposite the center of the doffer. For short wool it is sometimes advantageous to arrange the stroke of the comb so that when it is at the limit of its downward movement it will occupy a position somewhat higher than is necessary for long wool. The doffer comb makes from 1,200 to 1,800 strokes per minute, depending on the stock and the speed of the doffer.

SIDE DRAWING

22. The side-balling device shown on the card in Fig. 2 is not used except in the older mills. The method of taking the end from the card when a balling machine is used is shown in Fig. 6. The doffer comb is attached to the comb shaft k and removes the carded wool from the doffer j,

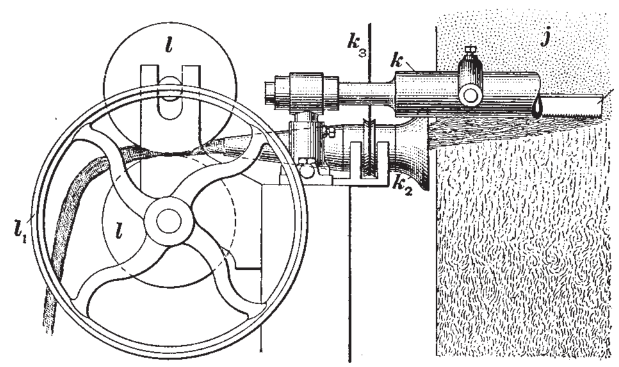

FIG. 6

whence it passes through the rotating tube k_2, which is driven by a grooved pulley on the main-cylinder shaft by means of a round belt or cord k_3. The object of the tube is to put twist into the card end in order to give it sufficient strength to be wound on the wooden spools in the balling machine. From the tube, the card end is passed through a pair of fluted-iron delivery, or drawing-off, rolls l. The bottom roll is driven by a train of gears from the gear q on the doffer shaft, Fig. 3, and the top roll is loose and rests on the surface of the bottom roll. A pulley l_1 is fastened on the shaft of the bottom delivery roll and drives the balling machine.

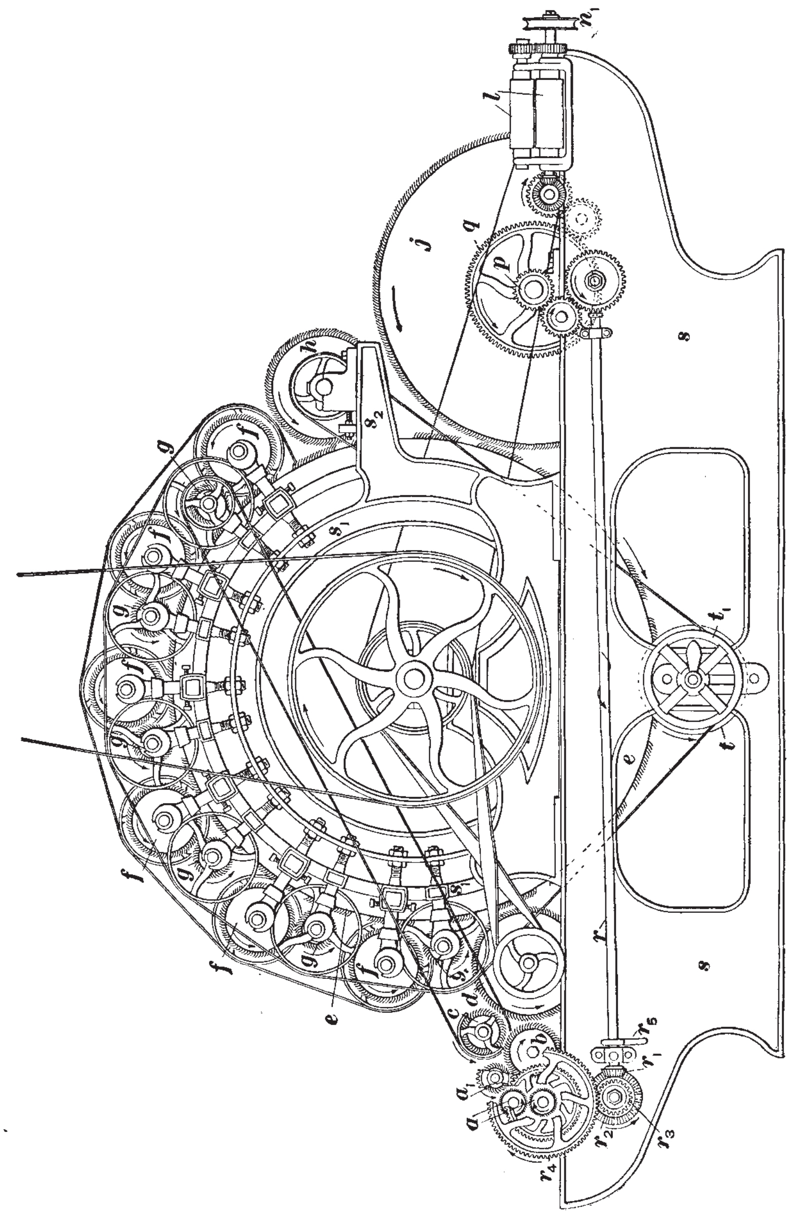

FIG. 7

THE SECOND BREAKER CARD

23. The **second breaker,** or **intermediate, card** is so similar to the first breaker as to require only a brief description. It has a main cylinder and other rolls of the same dimensions as the first breaker with the exception of the burr cylinder, which is replaced in the second breaker card by a cylinder called a **licker-in** covered with card clothing instead of burr wire. The reason for replacing the metallic burr cylinder with a licker-in covered with card clothing is that the wool as it comes to the second breaker is supposed to be free from large burrs and is already opened out by the action of the first card; it therefore does not need so strong an action as is necessary on the first breaker. A small roll running in connection with the licker-in, called the **licker-in fancy,** keeps the licker-in clean by raising the stock on it so that it can be taken by the tumbler.

The main features of the second breaker card are shown in Fig. 7; it will be seen that it is practically the same machine as the first breaker, the chief difference being that the card clothing is finer and set closer. It will be noticed, however, that the drawing-off rolls on the second breaker are of a slightly different pattern from those on the first and are also geared together; but this is unimportant. The feed-rolls on the second breaker are clothed with a very coarse sharp-pointed wire, known as *diamond-point wire*. A small feed-roll stripper keeps the feed-rolls clean and clear of wool; this takes the wool from the top feed-roll, where it tends to accumulate, and passes it to the licker-in.

In Fig. 7, a are the feed-rolls; a_1, the feed-roll stripper; b, the licker-in; c, the licker-in fancy; d, the tumbler; e, the main cylinder; f, the workers; g, the strippers; h, the fancy; j, the doffer; l, the drawing-off rolls.

24. The method of driving the second breaker card is the same as is used with the first; therefore, if any change is made in the number of teeth in the gear p on the doffer shaft or the gear r_3, a corresponding change will be made in

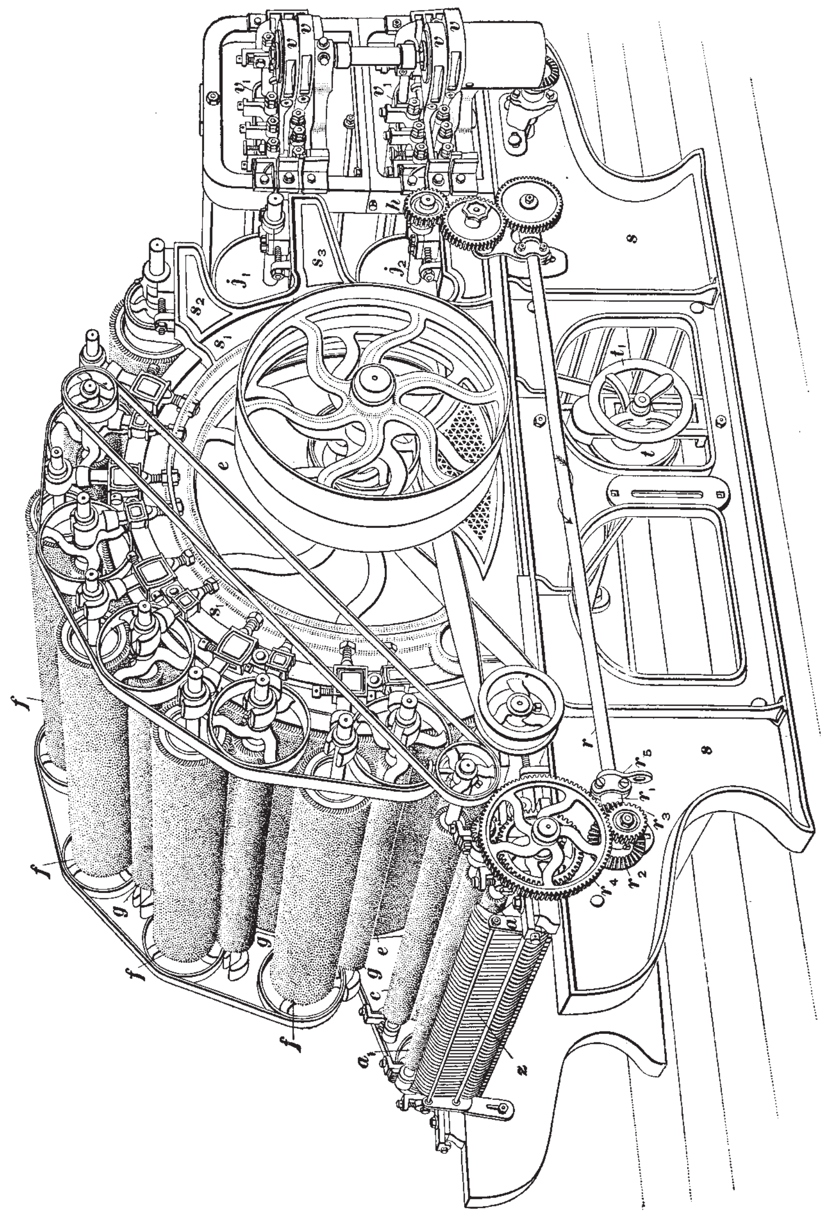

Fig. 8

the size and weight of the card end from the second breaker. As both of these gears are drivers, an increase in the number of teeth of either will produce a heavier sliver.

The train of gears for driving the delivery rolls of the second breaker is also shown, these gears being the same as those in the first breaker for the same purpose. A grooved pulley n_1 drives the overhead carrying rolls, which carry the sliver from the second breaker to the intermediate feed on the finisher card.

FINISHER CARD

25. The **finisher card,** Fig. 8, has the same general features as the first and second breaker cards. It is usually, but not always, of the same width as the other two cards of the set, but the cylinder is of the same diameter, as are also the workers, strippers, and other rolls of the cards with one or two exceptions, notably the doffers, of which there are generally two. This card is equipped with a pair of $1\frac{3}{4}$-inch feed-rolls *a* (which are a trifle smaller than those in the first breaker, although this is unimportant), $1\frac{3}{4}$-inch feed-roll stripper a_1, $5\frac{1}{2}$-inch licker-in, 3-inch licker-in fancy *c*, 9-inch tumbler.

The main cylinder *e* is of the same dimensions as those of the first and second breakers and, although sometimes covered with sheet clothing, is preferably covered with filleting. Many carders order their cards this way or recover the cylinders themselves, because the carded wool is taken from the finisher cylinder in continuous ribbons, which are condensed into rovings, and it is obvious that an even, continuous ribbon is not so easily obtained if there is a break in the clothing every 5 inches around the main cylinder, as is the case on a cylinder covered with sheet clothing. There is also an increased amount of carding surface when the main cylinder is covered with filleting.

There are only five workers and five strippers on the finisher card, owing to the extra room taken up by the two doffers. The fancy is of the same construction as those on the other cards.

26. Ring Doffers.—The two 12-inch iron doffers on the finisher are covered with card clothing in rings, which is an entirely different way of covering a roll from either the sheet or fillet method. **Ring doffers** are not entirely covered with the card clothing, but are divided into spaces, which are alternately covered with strips, or individual rings, of clothing.

Fig. 9 shows the details of the top and bottom doffers j_1, j_2

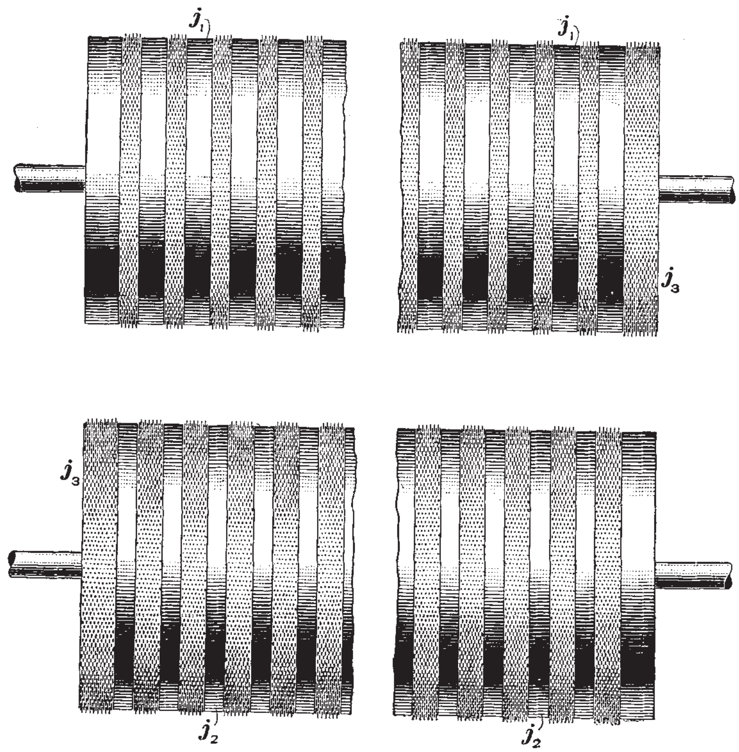

FIG. 9

on the finisher card. When the two-doffer system was first introduced, the rings on the top and bottom doffers were of the same width, but it was found that the rovings from the top doffer were heavier than those from the bottom, owing to the top doffer making the first stripping from the main cylinder. In order to remedy this defect the rings on the bottom doffer j_2 are made wider than those on the top doffer. This is shown in the illustration, where it will be noticed that the rings are alternated so as to cover the whole of the width of the main cylinder.

The rings marked j_3 are the **waste-end rings.** They take the wool from the edges of the cylinder, where it is always heavier and uneven. The waste ends are wound on small spools at each side of the winding stand, which, when full, are doffed and the waste pulled apart and placed back in the first breaker feed. Occasionally a **waste-end conveyer** is used to carry the end back to the first or second breakers. There are several devices for this purpose, one carrying the ends back by means of a narrow traveling belt running overhead through a tube and depositing them on the second breaker, while another blows the waste ends through a pipe by means of a fan.

The clothing, or rings, of the ring doffers should be carefully cared for in order that the wire may not be bent or otherwise injured. Even and uniform roving cannot be obtained without the doffer rings being in first-class condition. The width of the rings varies according to the width of the card, and the number of rings according to the number of ends, or rovings, taken from the card. The number of rings and the number of rovings, of course, coincide, as each roving is condensed from the ribbon of carded wool stripped from a single ring.

The usual number of rovings for a 48-inch card is 48 plus the 2 outside, or waste, ends that must result when the usual type of intermediate feed is used, owing to the doubling of the sliver from the second breaker as it is laid across the feed on the finisher card. On a 60-inch card there are usually 60 rovings plus the 2 waste ends, but when a card is running on fine work, doffers with a greater number of rings are frequently used, and sometimes 80 rovings are taken from a 60-inch card. Sometimes 72 ends are taken from a 48-inch card and wound on three jack-spools instead of two, the number generally used for a two-doffer card. If a card is under 48 inches wide, say 44 inches, there are generally 48 ends plus 2 waste ends taken off, although sometimes 40 ends are taken from a 40-inch card.

It must be understood that the respective cards of a set are usually of the same dimensions; that is, if the first breaker is 48 inches wide, the second breaker and finisher cards are also of the same width. Finisher cards, however, are sometimes built from 4 to 8 inches narrower than the first and second breakers.

27. A finger rack *z* is shown in Fig. 8. This is for the purpose of separating the slivers of wool and distributing them evenly across the entire width of the card when the latter is fed by a creel. The finger rack is removed when the finisher card is fed by an intermediate feed.

A gear on the bottom doffer shaft will change the speed of the feed-rolls, but it must be remembered that this will not change the weight of the roving when the finisher is fed continuously from the second breaker, since the size of the roving depends on the amount of wool delivered to the finisher from the second breaker. Therefore, in order to change the weight of the roving when the second breaker and finisher are coupled together with a continuous intermediate feed, it will be necessary to change the gear on the second breaker card. However, if the finisher card is not fed by the second breaker, but is fed separately by a creel or otherwise, as is sometimes the case with the older type of machinery, the gear on the finisher will change the weight of the rovings.

28. It is customary to run the workers on the finisher card in the opposite direction to that in which they run on either of the other cards, so as to prevent flyings and at the same time to strip the workers more evenly than when stripped in the ordinary way. The flyings settle around the ends of the workers and strippers and get into the cards, making the outside rovings more or less uneven and also heavier than the others.

With the worker running in the ordinary direction, about four-fifths of its circumference is loaded with wool, which passes up and over the roll before it comes in contact with the stripper, the tendency of the stripper being to pull the stock off in flakes and bunches. This does not happen with the worker reversed, as it is only loaded for about one-fifth of its circumference and the wool passes on the worker directly from the main cylinder to the stripper without going completely around the worker. The stock is also subjected to more carding action with the workers reversed, because more teeth are passing each other between the workers and the main cylinder. The reversing of the workers is accomplished by crossing the worker belt as it passes from the pulley on the doffer shaft.

In woolen carding, the finisher card should have the most particular care, as on the manner in which this card manipulates the stock depends the character of the roving and, no matter how perfect may be the carding on the first and second breakers, if it is not performed correctly on the finisher and the rolls are not set right on the finisher, perfect results cannot be attained.

29. Width of Cards.—Woolen cards are made in various widths, the width of the card being reckoned as the width of the card clothing from one side of the card to the other. The customary widths are 36, 40, 44, 48, 54, 60, and 72 inches. The 48-inch card is the standard width, but a great many 60-inch and a few 40-inch cards are used; the other widths are rarely made unless the machines are especially ordered. Sometimes the finisher card for 48-inch first and second breakers is made 44 inches in width.

The set of cards described is made in the following sizes:

Width of card clothing, in inches	48	48	60	60
Diameter of cylinder, in inches	48	60	48	60

30. The power required for a single woolen card varies from 2 to 4 horsepower, depending largely on the width of the card. It is also dependent somewhat on the character of the stock that is being carded, the weight of the material passing through the cards, and the speed at which the machines are run. A set of cards requires approximately three times the power necessary for a single machine.

31. Weight of Cards.—The average weight of a woolen card is about 5,000 pounds; that is, for a card with an iron cylinder and workers. If a wooden cylinder and rolls are used, the weight of the card is slightly less. The first and second breaker cards weigh approximately the same, but the finisher usually weighs more. A fair average weight for the finisher is 6,000 pounds, the extra weight being due to the *condenser*. The weight of an entire set of woolen cards may be estimated at from 15,000 to 20,000 pounds, according to the width and other factors.

32. Floor Space and Arrangement.—The average length required for a set of cards, including the intermediate spaces between the cards, is 42 feet 6 inches. Of course this varies somewhat in different mills according to the arrangement of the cards, although they are usually arranged with 4 feet or more between the ends of the frames for ordinary cards. The usual arrangement of cards in a woolen mill is to have the card room about 50 feet in width, placing the cards of each set end to end and arranging the sets of cards across the room parallel to each other. The length of the card room varies according to the number of sets, each card taking up from 7 to $8\frac{1}{2}$ feet in width, depending on the width of the cylinder. Occasionally, however, where an old room must be adapted for a card room and it is too narrow to permit the cards to be placed end to end, they are placed side by side.

33. Capacity.—The amount of work turned off by a set of woolen cards is such a variable quantity, and so many factors enter into the result, that no definite capacity can be determined on. It may be said, however, that the greater the width of the cards and the coarser the roving being made, the greater is the production. A fair average production for a set of cards 48 inches in width may be estimated at from 300 to 350 pounds of roving per day for 4-run yarns, and from 150 to 200 pounds for 8-run yarns. In carding for coarser yarn, the production often runs up to 500 pounds per day, and even more in some cases.

34. Speed.—The speed of a woolen card depends on the condition of the work. It is not advisable to run a 48-inch cylinder faster than 90 revolutions per minute, nor a 60-inch cylinder faster than 75 revolutions per minute; for low stock, cards are frequently run as slow as 60 revolutions per minute. Low stock has a tendency to make a large amount of flyings and, consequently, the card must be run slowly. It is also necessary to run a 60-inch diameter cylinder more slowly than a 48-inch one, owing to the increased centrifugal force of the large diameter, which throws the stock and increases flyings and waste, and also owing to the increased surface velocity of a large cylinder.

The best way to judge the speed of woolen cards is to find the surface speed of the rolls rather than the revolutions per minute. For fine stock, the surface velocity of the main cylinder should be from 1,000 to 1,200 feet per minute; for low stock, the surface velocity should be less, depending on the quality of the stock (length of fiber, etc.); it is frequently as low as 700 feet per minute. Harsh, dry stock also requires a reduced speed.

To find the surface velocity of a rotating cylinder covered with card clothing:

Rule.—*Add $\frac{3}{4}$ inch (allowance for height of card clothing) to the diameter of the roll, expressed in inches; multiply the sum thus obtained by 3.1416 and by the revolutions per minute of the cylinder. This product divided by 12 inches gives the surface velocity of the cylinder, in feet, per minute.*

EXAMPLE.—A 48-inch main cylinder on a woolen card makes 90 revolutions per minute; what is its surface velocity?

SOLUTION.— $\frac{48\frac{3}{4} \text{ in.} \times 3.1416 \times 90}{12 \text{ in.}} = 1,148.6475$ ft. per min. Ans.

CONDENSERS

35. There are many accessory appliances connected with cards which, although necessary, may be considered separately, since in many instances they are not built by the same builders as the cards proper. While a **condenser,** sometimes called a **rub,** is usually sold with and connected to the finisher card, it is sometimes furnished by other builders. It is a machine for taking the ribbons of carded wool from the ring doffers of the finisher card and condensing, or rubbing, them into threads, or rovings. The several methods of making the flat ribbon of wool into a roving are all based on a rubbing of the roving between leather surfaces.

ROLL CONDENSER

36. A section of what is known as the **roll condenser** is seen in Fig. 10, which shows one doffer of the finisher

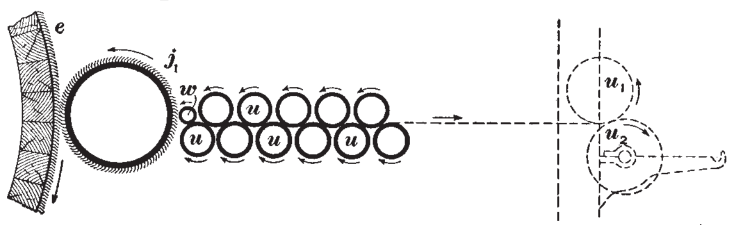

FIG. 10

with its corresponding **rub rolls.** In the ordinary card there are two doffers and two sets, or nests, of rub rolls, while on some cards there are three doffers and three sets of condensing rolls. In Fig. 10, the cylinder of the card is marked e; j_1 is the top doffer and w is a wipe roll that strips the wool from the doffer rings and passes the ribbons to the rub rolls u. The wipe roll is usually covered with corduroy, but is sometimes covered with wire for special purposes. It passes the stock to the rub rolls, of which there are sometimes 7, 9, 15, or (as shown in Fig. 10) 11 to each doffer. The rolls rotate in the direction shown by the arrows and also have a reciprocating, or traverse, motion imparted to them by means of eccentrics located at one side of the condenser. The rub rolls, being covered with leather and being a slight distance apart, rub the flat sliver taken from the doffer rings into a round thread, or roving. There is no twist put into the roving; the rolls simply rub the wool into a round form, the bottom rub rolls traversing to the right while the top rolls move to the left, and vice versa.

There is usually a draft of 1 tooth in a roll condenser; that is, the rolls farthest from the doffer are driven slightly faster. This draws out the threads, or rovings, to a slight extent and makes them smoother and more even. After being condensed, the rovings are wound on a jack-spool u_1 by surface contact with the rotating drum u_2 on the winding frame. A roll condenser gives excellent results on fine stock, but is not so well adapted to cheap material containing a large percentage of short, weak fibers.

APRON CONDENSER

37. The best condenser for all classes of work and the only one that can be successfully employed on very low stock is the **apron condenser,** which substitutes for the leather-covered rolls a series of leather aprons, usually two pairs of aprons to each doffer. The ribbons of wool passing between the aprons, which have forward and traversing motions imparted to them, are gently rubbed or rolled into a thread-like form.

A two-deck double-apron condenser is shown in Figs. 11 and 12; the former shows the gear end, while the latter shows the eccentric end of the machine. The condenser is designed to rest on the end of the finisher-card frame and consists of eight aprons v_1, v_2 suitably mounted and connected so as to have a reciprocating and also a forward motion. The aprons are honeycombed with fine indentations so that the rovings are more easily held and rubbed. A wipe roll, which is not shown in Figs. 11 or 12, is on the opposite side of the machine next to the ring doffers of the card, from which it takes the ribbons of wool.

Two belts are required for driving the condenser, one of which drives the gears imparting the forward motion to the rub aprons and wipe rolls, while the other drives the eccentrics on the opposite end of the machine, which imparts the traversing motion to the rub aprons. The power is supplied from the main-cylinder shaft of the finisher, a belt driving the large pulley v_3, from which the rub-apron shafts and wipe rolls are geared, as shown in Fig. 11.

The driving ends of the rub-apron shafts are made so that their section, or end, view is shaped like a cross. This

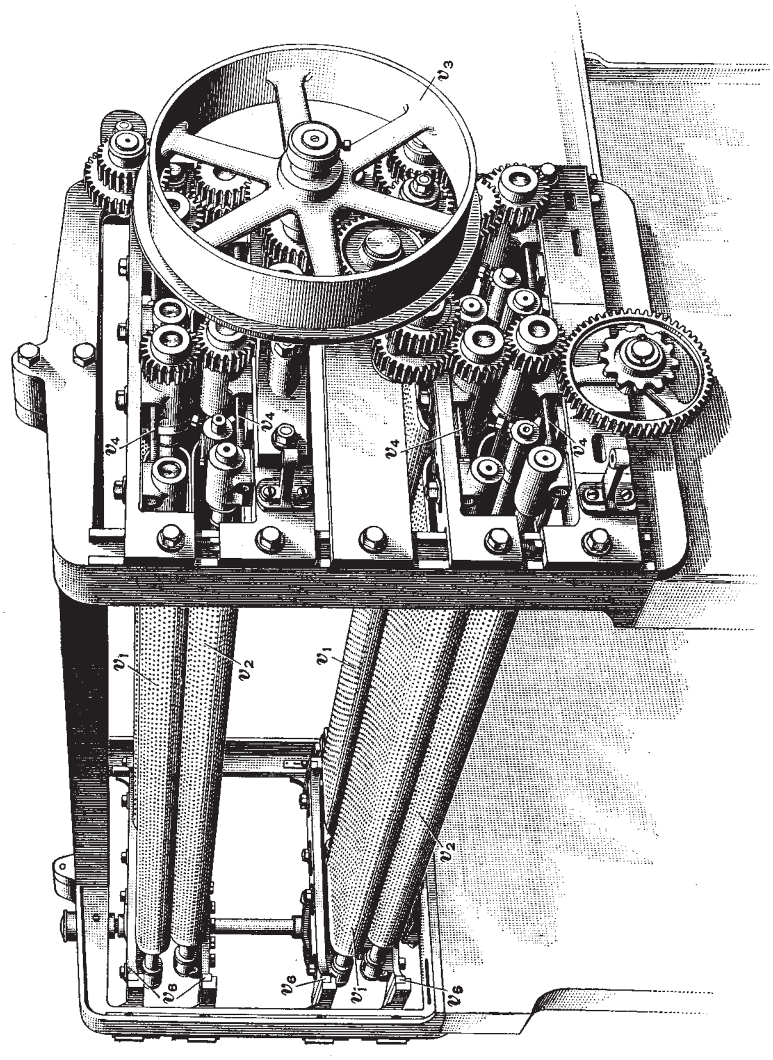

Fig. 11

allows the driving gears, which are made with holes to fit the shafts, to drive the apron rolls and at the same time allows the shafts to be thrust through them so that the traversing motion may be imparted by the eccentrics located on the other side of the condenser, as shown in Fig. 12.

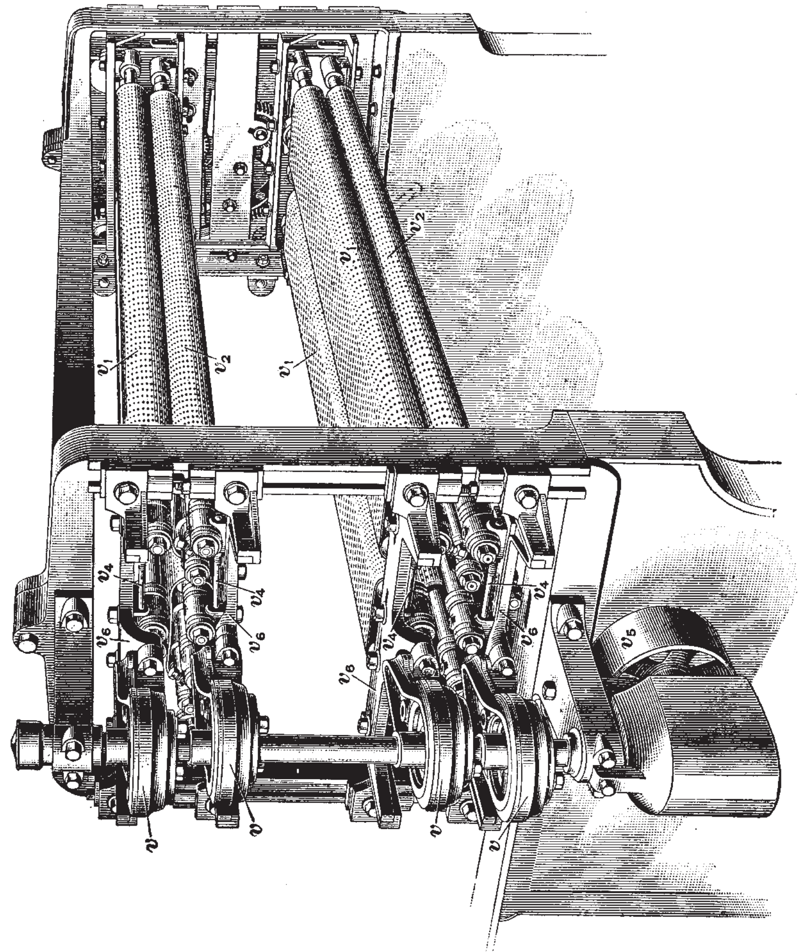

FIG. 12

The driving gears on the apron shafts are recessed in order to retain the oil and to keep the machine clean, it being necessary to have all parts of a condenser well oiled. The gears on the aprons nearest the doffers are 1 or 2 teeth larger, as the case may be, than the gears on the last sets of aprons and are thus driven slower. This makes a slight draft between the two pairs of aprons on each deck, which is for the purpose of making the rovings evener and smoother. With low stock there should not be more than a 2-tooth draft between the aprons, for there is a liability of straining the rovings and making weak places, or **twits.** Fine stock will stand a draft of 3 teeth between the front and rear pairs of aprons, because the fine stock is more elastic, the fibers generally longer, and the spinning power of the wool better.

The adjustments for taking up the slack of the rub aprons, when they stretch, are placed on the rolls that do not carry the driving gears (only the front roll of each apron being driven and the apron running over a binder roll at the rear). They consist of screws v_4 with which the bearings of the apron roll can be forced back after they are loosened. As the screws for taking up the slack of the aprons move only the binding rolls, the aprons may be tightened without disturbing the driving gearing.

38. The wipe rolls have change gears that are made of the same diameter, but with a difference of 1 or 2 teeth, which is accomplished by changing the pitch of the gears. This allows the speed of the wipe rolls to be changed, as is sometimes necessary, in order to remove different kinds of stock from the ring doffers without disturbing their setting to the doffers. The two doffers of the finisher card are geared from the gear-end of the condenser, being driven from the front top apron shafts of each deck of rub aprons. The top doffer is driven from the top deck and the bottom doffer from the bottom deck.

39. Fig. 12 shows the eccentric end of the double-apron condenser and illustrates the method of imparting a traverse motion to the apron, by means of which the ribbons of wool are rubbed into rovings. The eccentrics v are fastened to a vertical shaft that is driven from the main-cylinder shaft of the finisher card through a pulley v_5 on a short shaft and a pair of bevel gears, which are protected by a guard. It will be noted that the eccentric shaft is driven from the opposite end of the machine from the gear-end, but sometimes the driving shaft that carries the pulley driven from the finisher-cylinder shaft is continued under the rub aprons and the pulley placed on the other end, thus bringing both driving belts of the condenser on one side of the machine.

There are four eccentrics attached to the vertical eccentric shaft, which imparts the reciprocating motion to the top and bottom aprons of both decks, or nests. The bearings of the apron rolls on this side of the machine are carried on slides v_6 that are pivoted to the eccentrics, Fig. 12, by means of shell connectors on which the eccentric operates. The eccentrics may be readily adjusted to give more or less throw, according to whether more or less rubbing action is needed, by loosening two nuts on the under side of each eccentric.

The connection between the eccentrics and the slides may be lifted and the amount of eccentricity determined by means of an indicating pin; the farther the eccentric is out of center, the greater will be the traverse of the aprons and the more rubbing action there will be on the roving.

As this eccentric is really a shell eccentric and is made oil-tight, there is no leakage of oil. The setting of the aprons to each other was formerly accomplished by means of adjusting screws and was a difficult task, as the rub aprons should be set the same distance from each other on both sides of the machine. The setting on the condenser shown in Figs. 11 and 12 is accomplished by means of small slotted disks of sheet iron, which are made in two thicknesses, $\frac{1}{16}$ inch and $\frac{1}{8}$ inch; these are placed under the bearings of the apron rolls. If it is desired to give the roving a hard rubbing, the $\frac{1}{16}$-inch disks are inserted under the apron bearings; but if it is desired to have less rubbing action, the aprons are set farther apart by means of the $\frac{1}{8}$-inch disks.

Some classes of stock, especially low stock with harsh, short fibers, require more rubbing and the aprons must be set closer than with fine, lofty stock, in order to make the roving strong enough to hold together to be spun. More rubbing action may also be obtained by increasing the throw of the eccentrics.

40. In operation, the ribbons of carded wool are removed from the ring doffers by the corduroy wipe rolls; the slivers so removed are passed between the leather rub aprons, the forward motion of which passes the rovings forwards to the winding stand, where they are wound on a jack-spool, while the traverse motion of the aprons condenses the flat ribbons of carded wool into round threads, or rovings. It must be remembered that the wool is rubbed together and not twisted.

This apron condenser is usually sold with and applied to the finisher card previously described.

COMBINATION CONDENSER

41. Fig. 13 shows a section of a combination roll and rub-apron condenser. It will be noted that each deck consists of a wipe roll *w*, five rub rolls *u*, and a pair of rub

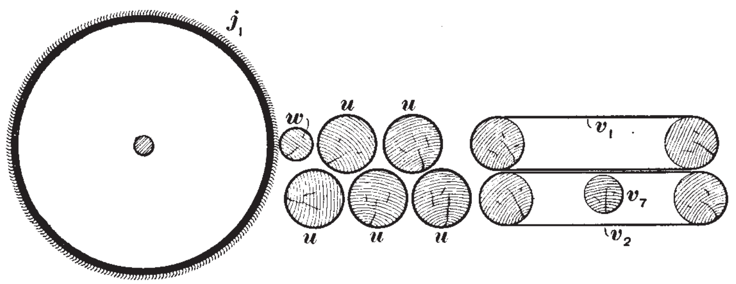

Fig. 13

aprons v_1, v_2. This type of condenser is built to combine the superior drafting action of the roll condenser with the excellent rubbing motion of the aprons. The roll v_7 is to keep the bottom rub apron from sagging away from the top apron. The finisher card shown in Fig. 8 is equipped with this type of condenser.

BOLLETTE CONDENSER

42. The **Bollette condenser** differs from other condensers in the fact that the finisher card is equipped with a single doffer that is entirely covered with fillet clothing, the stock being divided into ribbons by the condenser and not by the doffer. The stock is removed from the doffer by a comb instead of a wipe roll and in a continuous web the width of the card. This web is then divided by steel knives, or *separators*, into ribbons of the required number and size, which are then rubbed into rovings by means of rub aprons in the ordinary manner. Bollette condensers are but little used in America, although they are used to some extent in England and to a greater extent on the continent of Europe.

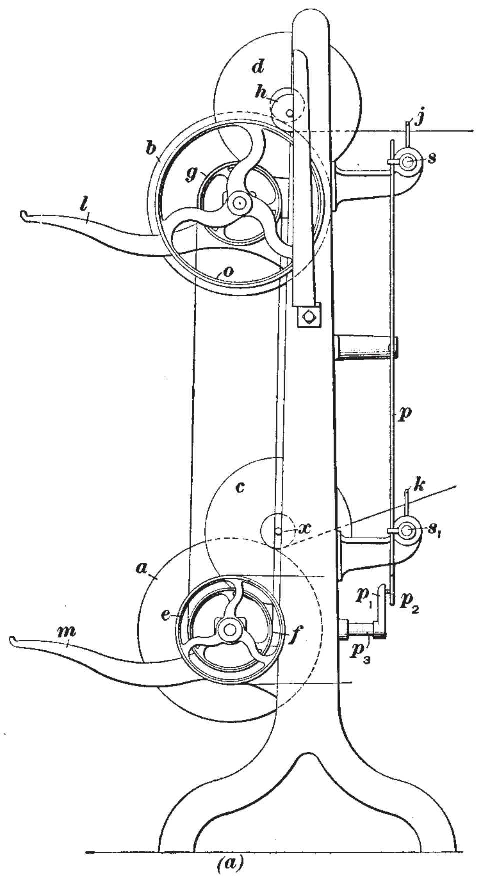

Fig. 14

WINDING FRAME

43. The object of the **winding frame** is to wind the condensed rovings on a jack-spool, which is then taken to the woolen mule, where the rovings are unwound and spun into yarn. The winding frame is usually driven from the condenser either by means of sprocket gears and a chain or by pulleys and a belt. The principle of the winding frame is simply that of surface contact with a revolving drum, on which the jack-spool rests and, being turned by the same, winds the rovings on itself as they are delivered from the condenser.

The winding frame or, as it is commonly called, the **spool stand,** is shown in Fig. 14 (*a*) and (*b*), the former being a side view and the latter a perspective view. It consists of two stands that carry the drums *a*, *b* on which the jack-spools *c*, *d* rest. The bottom drum is usually driven by a pulley on a stud driven from the condenser. This pulley drives the pulley *e* on the bottom drum shaft. A pulley *f* on the bottom drum shaft drives a pulley *g* on the top drum

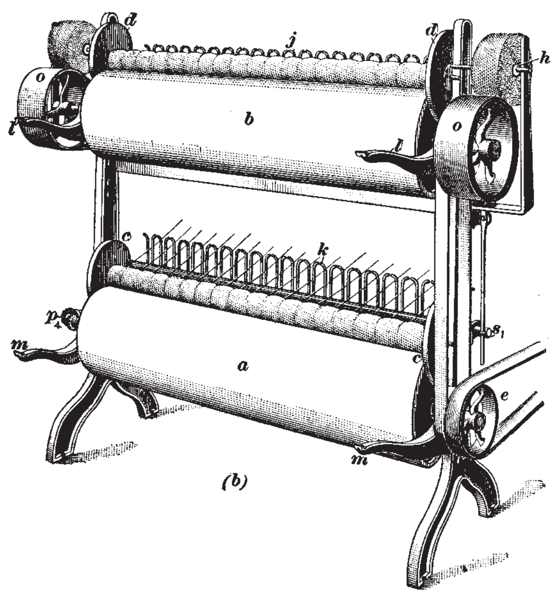

Fig. 14

shaft. Attached to each end of the top drum shaft are two short drums, or pulleys, *o*, on which small spools *h* are placed to wind up the waste end made on each side of the card by the doublings of the intermediate feed.

The rovings pass through guides before being wound on the spools. These guides *j*, *k* are fastened to rods *s*, s_1 that have a reciprocating motion imparted to them by means of a lever *p* attached to a crankpin p_2 and a crank p_1, Fig. 14(*a*), which are driven from the bottom drum shaft by a pair of bevel gears p_4, as shown in Fig. 14 (*b*), and a short shaft p_3,

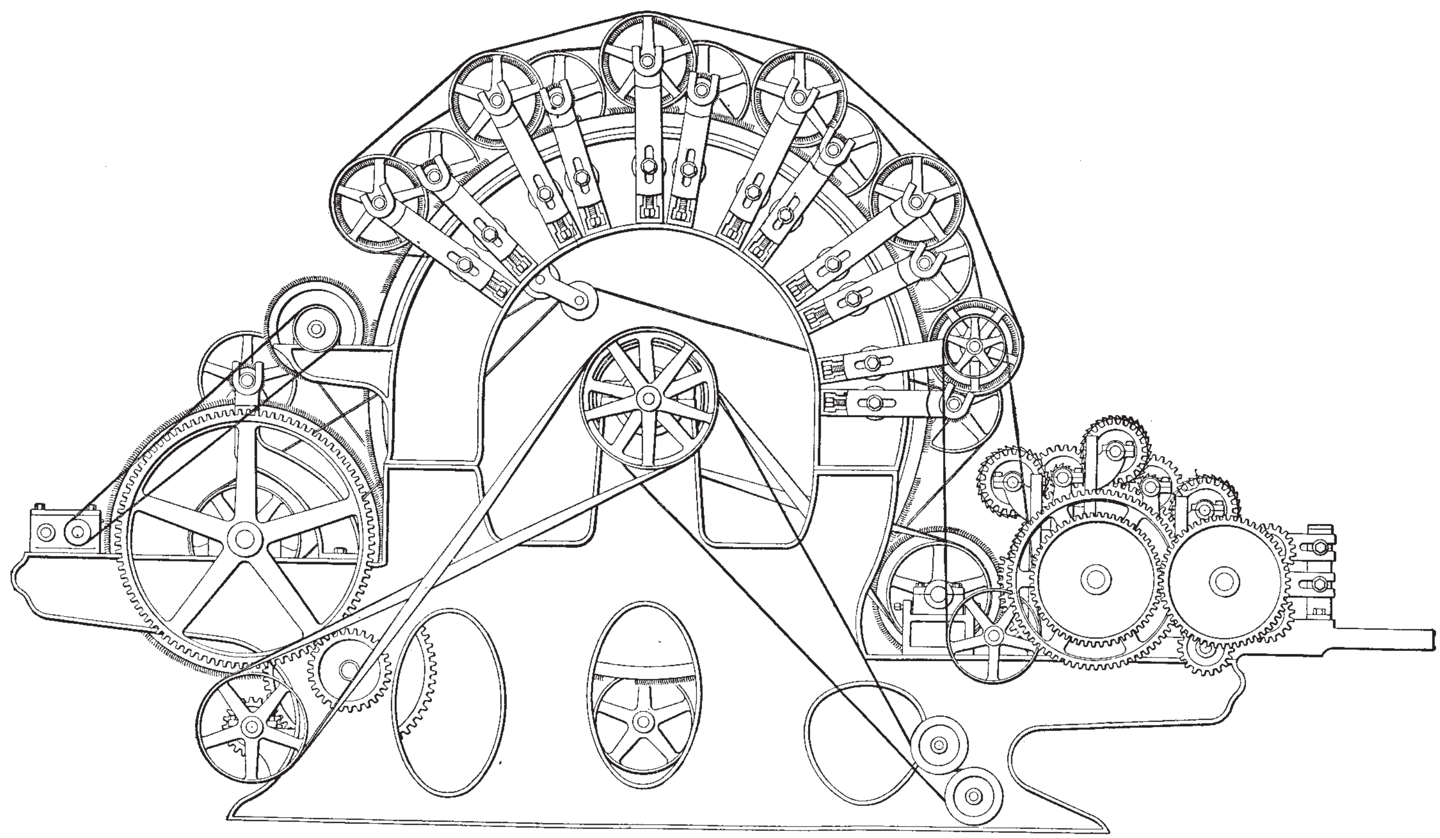

Fig. 15

Fig. 14 (*a*), on the other side of the frame. The reciprocating motion of the guides prevents the thread building up in one spot and winds the roving on the jack-spool without ridges. The two arms *l*, *m*, on each side of the spool stand, support the full spool while it is being doffed and an empty spool placed on the drum by the operator.

SMITH CARDS

44. The **Smith card** is shown in Fig. 15. The features in which this card differs from the Davis & Furber are mainly in gearing and belting the different parts of the machine, the principle of carding involved being the same. The frame of these cards also differs from the one described in that the bearing for the main cylinder is carried by the lower part of the frame, while the other is constructed with a straight-topped frame on which the arches rest. This may be seen by comparing Figs. 2 and 15. There are also minor details about the machine, such as the mechanism of the doffer comb and the method of setting the rolls, in which they differ.

FURBUSH CARDS

45. Another well-known make of cards is the **Furbush card,** which is made with practically the same style of frame as the Smith card and is built with 8-inch workers and 4-inch strippers—an increase of 1 inch in diameter in each case over the Davis & Furber workers and strippers. The Furbush finisher card, however, is built with five 7-inch workers and five $2\frac{13}{16}$-inch strippers. The main features of the Furbush card are seen in Fig. 16, which shows a first breaker with Bramwell feed. It will be noticed that this card resembles the Davis & Furber cards more than the Smith cards. The Furbush cards are made in widths of 24, 30, 36, 40, 48, and 60 inches, while as a general rule the main cylinders are 48 inches in diameter. The general size of all makes of cards have cylinders 48 inches in diameter

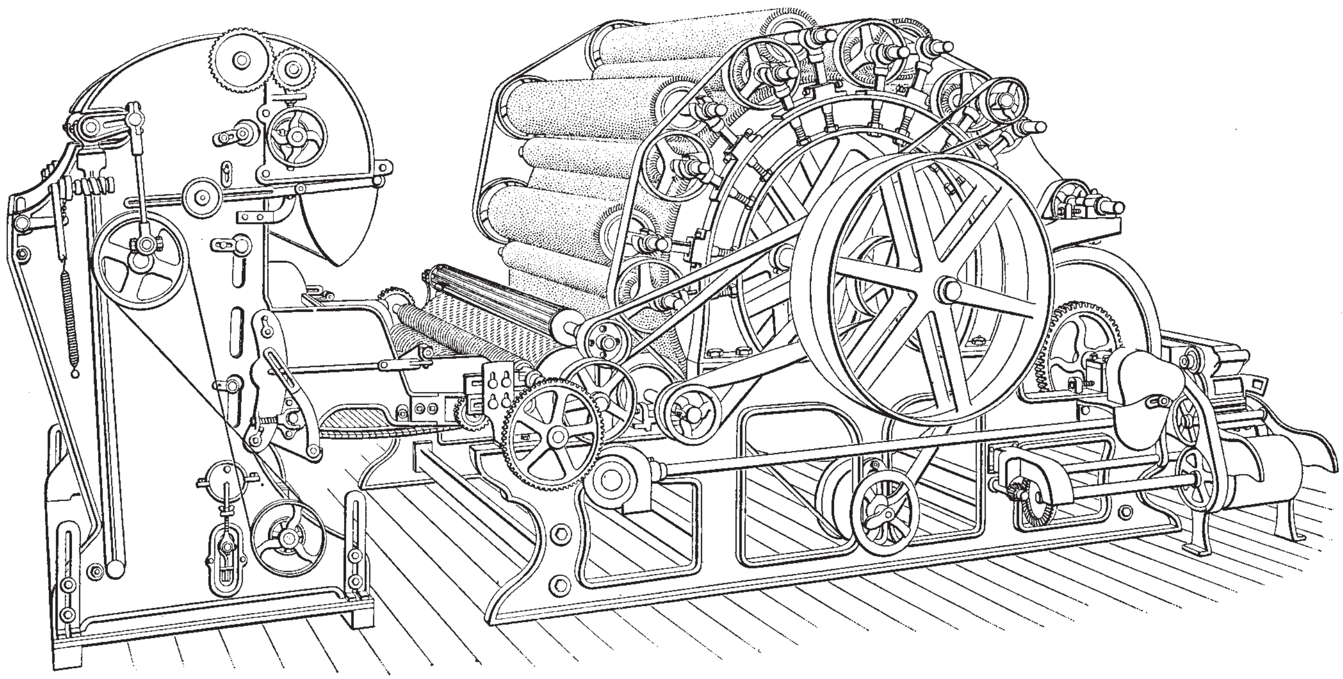

FIG. 16

and are 48 inches in width; that is, the width of the card clothing. There are some 60-inch cards in use, but owing to their width the workers, strippers, and other rolls are so long that they are much more easily sprung than the rolls on a card 48 inches wide. There is also a tendency for the long roll to sag in the center and thus be set closer in the middle of the roll than at its ends. Cards have been made 72 inches wide, but such a width is not often used. Occasionally cylinders 60 inches in diameter are met with; this size allows more workers to be used and gives a corresponding increase of carding surface. However, if the diameter of the cylinder is increased, the diameter of the doffer should also be increased; otherwise, the doffer will get out of condition much oftener.

WOOLEN CARDING

(PART 2)

CARD FEEDS

THE BRAMWELL AUTOMATIC WEIGHER AND FEEDER

INTRODUCTION

1. The question of feeding woolen cards is one of vital importance and should be accomplished in such a manner that the resultant yarn will have a definite size, or number. It is necessary that a constant weight be fed to the card and that the wool be uniformly spread, or delivered, in order that the best results may be obtained. Formerly, woolen cards were fed by hand, the operator being provided with a pair of scales in which to weigh the stock, and the feed-apron of the card being divided into uniform spaces by means of brass tacks or by painting certain slats black. A given amount of wool was weighed in the scales and spread over the area marked off on the feed-apron; the feeding was consequently often uneven and the carding poor. First breaker cards are now generally fed by a machine called an **automatic feed,** or **self-feed.**

The **Bramwell feed** is shown in perspective in Fig. 1, while elevations of each side are shown in Figs. 2 and 4. Fig. 3 shows the details of the device for controlling the motion of the elevating and stripping aprons of the machine. The principle on which the machine is constructed is that of automatically weighing the stock fed to the card, the mechanism being so devised that equal weights of stock are spread uniformly on equal areas of the feed-apron and fed to the card

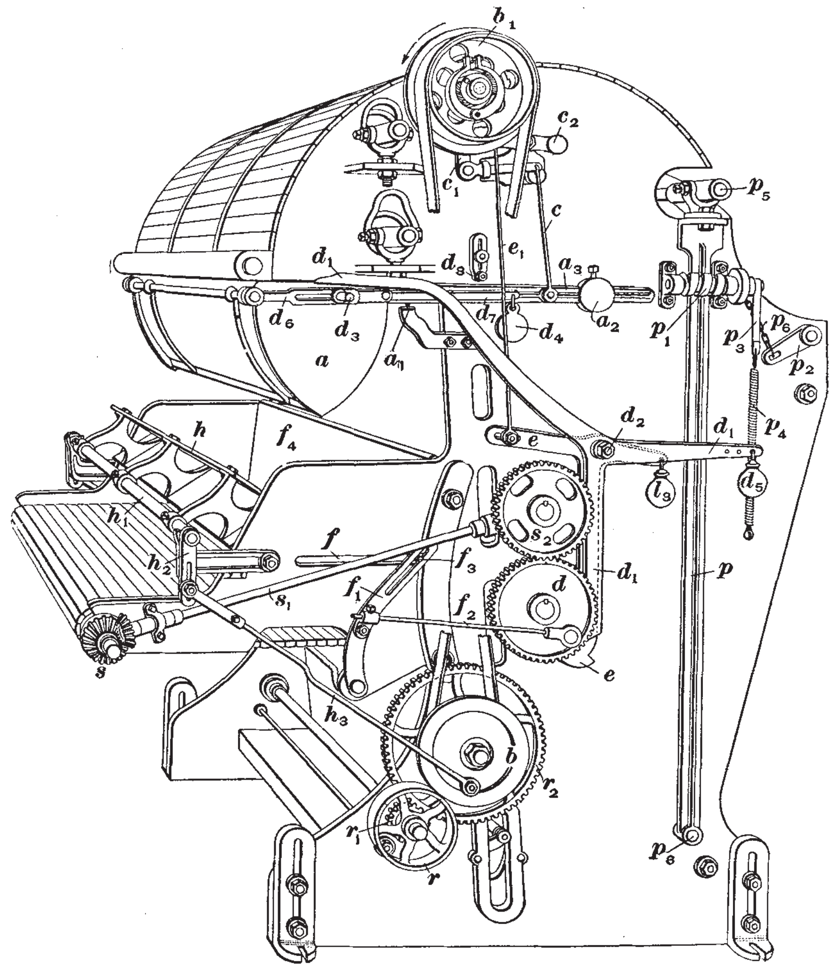

FIG. 1

during equal periods of time. This machine is used only for feeding first breaker cards and is built for cards of various widths, the standard sizes being 40, 48, 54, 60, and 72 inches.

CONSTRUCTION

2. Weighing and Dumping Mechanism.—The machine is constructed with a large hopper, or feed-box, in the rear of which is a spiked elevating, or lifting, apron for the purpose of lifting the stock from the hopper. As the stock approaches the top of the apron, it is brought under the action of an oscillating comb having a slow but long sweep, which combs off the surplus wool and leaves the rest evenly distributed on the apron. On the other side of the elevating apron is a short, fast-running, stripping apron provided with flexible strips of leather passing transversely across it. These sweep, or strip, the stock from the spiked apron and, acting in connection with a concave shell, or dish, deposit it in a weighing pan, or scale, a, Fig. 2 (a), which is suspended from the lever a_3 that is balanced on a knife-edge at a_1, and held in a raised position by the adjustable weight a_2. When a sufficient amount of stock has been deposited in the scale, the lever a_3 swings around its fulcrum at a_1, whereby the left end with the pan a will descend and the other end with weight a_2 rise until the lever strikes the stop d_8. By this motion it also raises a rod c attached to the elbow lever c_1, thus disengaging the pin c_8 from the notch in the end of the dog c_2, Figs. 2 (a) and 3 (b). When the dog c_2 is freed, its point rises, owing to the fact that the rear end of the dog is heavier, and engages with one of the teeth of the ratchet c_3, which by means of a clutch arrangement stops the delivery of wool to the scale a.

The construction and action of these parts are more fully shown in Fig. 3 in which (a) is a front view of the pulley b_1, (b) a view of the ratchet behind it, and (c) a side view of both in their true positions. As the pulley b_1 is not fast to the shaft b_4 it cannot drive the latter directly, but only by means of a sector c_5 that is keyed to the shaft. On the back of the sector and between the sector and the ratchet c_3 a small casting c_9 is fulcrumed. This piece has the shape of an elbow lever and is cast with a pin, or stud, c_6 on one end that projects through a curved slot c_7 in the sector. The other end of the piece c_9 engages with a gap, or cut-out, in the edge of the ratchet c_3, which is loose on the shaft b_4.

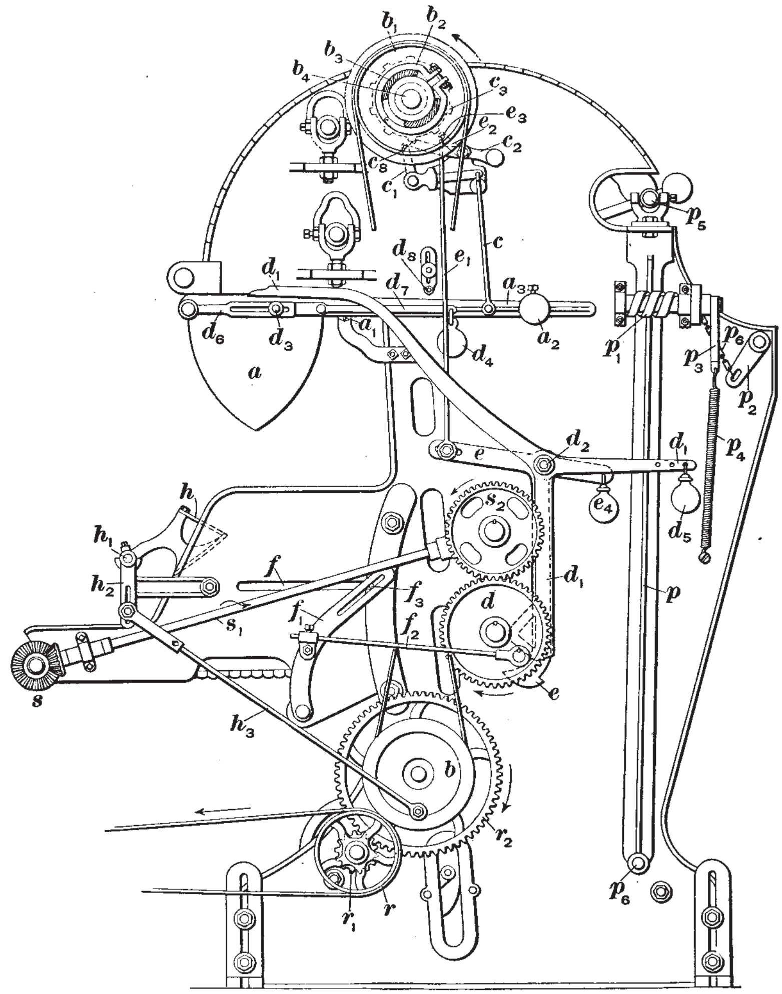

Fig. 2 (*a*)

The driving power of the pulley b_1 is transmitted to the sector c_8 and thereby to the shaft of the lifting apron by means of a stud b_5 on the pulley that engages with the stud c_6 projecting through the slot c_7 in the sector. When these two studs are brought in contact, motion is imparted to the shaft; but if c_6 is moved out of the path of the stud b_5,

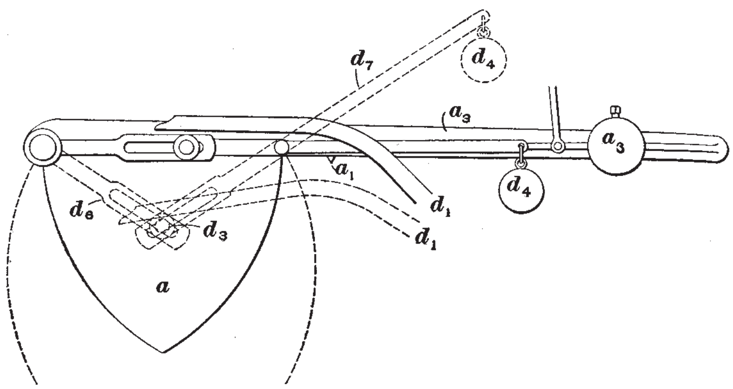

Fig. 2 (*b*)

as in Fig. 3 (*b*), the shaft will come to a standstill. When the dog c_2 is released and engages with a tooth of the ratchet c_3, the latter is stopped, but the sector c_5 will continue to revolve through a very small angle until the pin c_6 is withdrawn from the path of the pin b_5 on the pulley b_1. This is

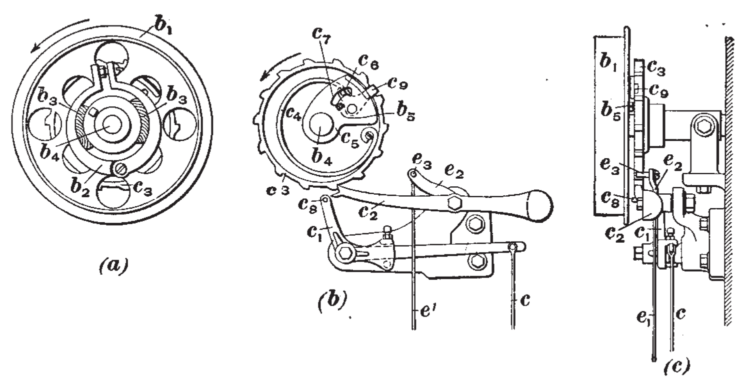

Fig. 3

accomplished by means of the gap in the rim of the ratchet with which the piece c_9 engages, because as the sector continues to revolve the elbow lever c_9 will be turned on its axis since one end is held by engaging with the gap in the ratchet. This will have the effect of drawing the pin c_6 in the curved slot c_7 away from the pin b_5 so that no motion will be

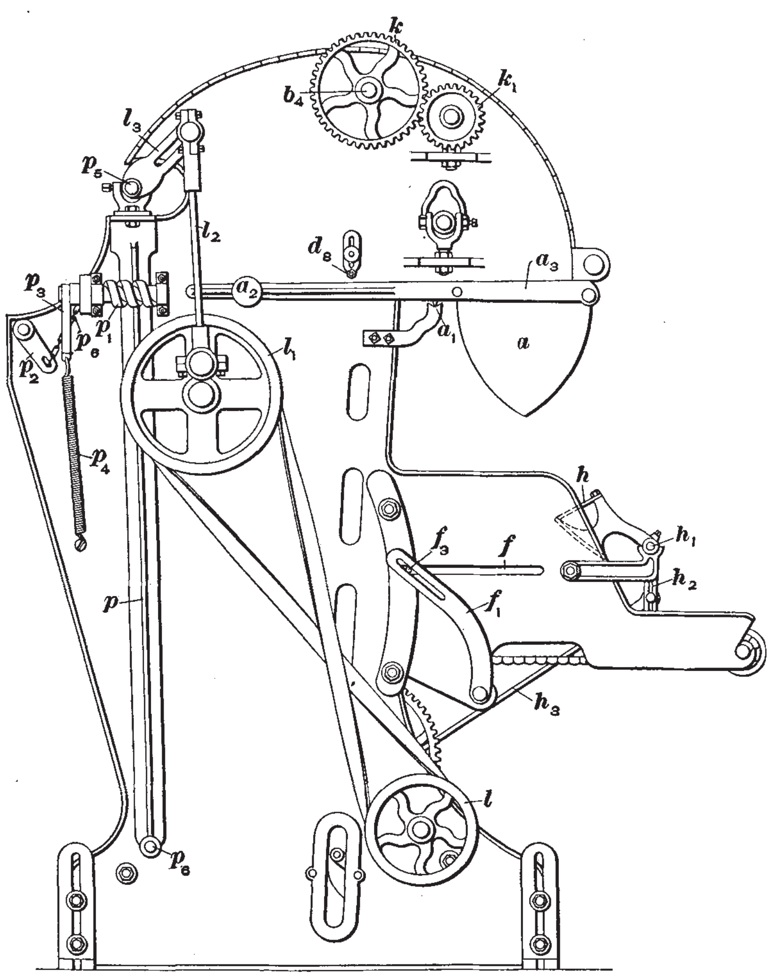

FIG. 4

imparted to the shaft; therefore, when the dog c_2 engages with the ratchet the lifting apron will be stopped. The pulley b_1 continues to revolve after the lifting apron is stopped and the friction of the pieces of wood b_3 keeps the ratchet constantly pressed against the dog c_2 so that the latter will not be liable to move from contact with the teeth of the ratchet. The tension of the spring c_4 tends to move the pin c_6 back again into the path of the stud b_5; but as long as the pieces of wood b_3 in the friction arrangement on the pulley b_1 continue to revolve, the pin c_6 is prevented from receding into its original position. This can only take place when the dog c_2 is removed from contact with the ratchet; then the spring will contract and move the stud c_6 inwards and in front of the stud b_5 on the pulley, thereby causing the lifting apron to start again.

After the scale is filled and the lifting apron stopped, it remains at rest until a pin on the inside of the gear d Fig. 2 (a), comes in contact with the lever d_1, which is centered on a stud d_2. As the lower arm of this lever is operated on by the pin attached to the gear, its upper arm is lowered and presses down the pin d_3, which works in connection with arms d_6, d_7 attached to the wings of the scale. As the pin d_3 is pressed down, the wings of the scale are opened, as shown by the dotted lines in Fig. 2 (b), and the wool allowed to fall on the feed-apron. After the pin on the gear d passes from contact with the lever d_1 the lever is returned to its original position by the weight d_5, while the wings of the scale are brought together by means of the weight d_4.

The stock having been emptied from the scale, the lifting apron is started again by means of the same pin on the gear d that opened the wings of the scale. After this pin passes from contact with the lever d_1 it engages with the lever e, which is also pivoted at d_2. The lever e, operating through the rod e_1, pulls down a dog e_2, attached to which is a pin e_3 that projects over the dog c_2. Thus, when e_2, Fig. 3, is pulled down, the dog c_2 is disengaged from the ratchet c_3, allowing the pin c_6 to spring into the path of the pin b_5 in the pulley b_1 and the lifting apron to be started. When the dog c_2 is drawn down by the pin e_3, the pin c_8 on lever c_1 again engages with the notch at its end, preventing it from coming in contact with the ratchet c_3 until the scale is again overbalanced. The lever e, Fig. 2 (a), is returned to its proper position, after the pin on the gear d is disengaged, by means of the weight e_4.

3. Stripping Apron.—Referring to Fig. 4, it will be seen that the **stripping apron** is driven from the lifting-apron roll shaft b_4 by means of the gears k, k_1. Thus, the stripping apron is stopped at the same time as the lifting apron; i. e., when the scale is overbalanced and the delivery of wool stopped. On the older machines the stripping apron was driven by means of a pulley and belt from the main shaft of the machine. This was a disadvantage, as wool was thrown into the scale after it had overbalanced and the lifting apron had been stopped, thus making uneven weighing. In case any pressure is applied to the scale before it becomes sufficiently filled with stock to overbalance, the lifting apron will be stopped exactly as though the scale were full, and in consequence a light dumping and correspondingly uneven place in the feed will result. To guard against interference of this kind on the part of careless persons, the words "Hands Off" are usually printed on each end of the scale.

4. Push Board.—After the stock has fallen on the feed-apron it is pushed forwards by a **push board,** so as to close up all inequalities, as the wool is liable to scatter somewhat when it drops from the scales. The device consists of a wooden board f_4, Fig. 1, extending across the feed-apron and carrying on each end a pin f_3. This pin extends through the slot f in the side of the machine and also through the slot in the lever f_1. The lever f_1 is given an oscillating motion by means of the connecting-rod f_2 that is connected to a crankpin on the gear d. The push board moves forwards, pushing the wool over the feed-apron to the previous weighing, closing up all irregularities, and then returns to its former position, at each revolution of the gear d.

5. Evener Motion.—There is also an **evener,** or **dabbing, motion** that strikes the wool lightly as it is spread on the feed-apron. This serves finally to even up the stock on the feed-apron before it passes forwards to the feed-rolls of the first breaker card in an even sheet. This motion consists of a long dabber h, Fig. 1, which is connected by arms to a shaft h_1 extending across the feed-apron. The shaft and dabber are given an oscillating motion by a crankpin on the pulley b by means of the arm h_2 and connecting-rod h_3.

6. The **oscillating comb,** which evens up the wool extracted from the hopper, is driven by the pulley l, Fig. 4, on the main shaft of the machine that drives a pulley l_1 on a stud. A connecting-rod l_2 attached to the pulley l_1 by means of a crankpin gives an oscillating motion to the arm l_3, which is fastened to the comb shaft. The comb has a slow but long sweep.

The mechanism for regulating the proximity of the comb to the lifting apron is constructed as follows: The bearings of the comb shaft p_5 are carried on two vertical arms p that are pivoted at the points p_6 on each side of the machine. A small projection on the arm p works in the thread of the screw p_1, the position of which is controlled by an arm p_2 that is attached to the shaft of a wooden rack, or **comb regulator,** similar to the one used on the picker feed. This arm is attached by means of a chain p_6 to a boss on the shaft of the screw. A strap p_3 is attached to the screw and a spring p_4 is attached to this strap.

When the rack in the hopper is pressed down by the wool placed on it in the feed-box, the arm p_2 is also pressed down. This tightens the chain attached to the screw, causing the screw to be turned in such a direction that the arm p will be moved forwards and carry the comb nearer to the lifting apron, thus striking off a maximum amount of wool. As the amount of wool in the hopper is decreasing, the tension on the chain attached to p_2 is relieved, and the spring p_4 and strap p_3 turn the screw p_1 in the opposite direction, thus moving the arm p backwards and increasing the distance between the comb and the lifting apron. The amount of wool in the hopper is the element that regulates the distance of the comb from the lifting apron, thus rendering the amount of wool on the lifting apron evenly and uniformly distributed.

The comb blade is made flexible and may be set nearer the apron in the center than at the sides. This is usually advisable, as the friction of the sides of the hopper is apt to make the apron more lightly loaded at the sides than in the center.

DRIVING

7. The lifting and stripping aprons of the machine are driven from the main cylinder of the first breaker by a cross-belt, Fig. 2 (*a*), which drives the pulley *r* on the main shaft of the machine. This shaft should make about 150 revolutions per minute. A gear r_1 attached to the main shaft drives a gear r_2 compounded with the pulley *b*. From the pulley *b*, the various parts of the machine are driven as previously described, the pulley b_1 being driven from it with a crossed belt. The feed-apron, push board, dumping motion, and release motion for the dog c_2 are driven from a gear on the feed-rolls of the card that drives a gear on the front feed-apron roll shaft. A bevel gear *s* on the front apron roll shaft drives a gear s_2 on a stud through a side shaft s_1; the gear *d* is driven from the gear s_2, as shown.

The dumping arrangement being controlled from the feed-rolls of the card, which are in turn controlled by the gear on the doffer shaft, any change made at the doffer changes the speed of the feed-rolls of the card and of the dumping arrangement in proportion. The weight fed to the card may be changed in three places; viz., change gear on doffer, gear on feed-roll shaft, and weights a_2, which change the amount of the wool deposited in the pan.

TORRANCE BALLING MACHINE AND CREEL

8. The **Torrance balling machine** is a device for winding the side drawing from the first breaker card into flat balls, which are placed in a creel and fed to the second breaker card. One of the chief advantages of a balling machine is that the balls are made flat, or thin, which enables a large number of slivers to be fed to the second breaker, With balls of wool formed by the first breaker card in the ordinary manner, fewer slivers can be fed to the second breaker, since the size of the balls requires a large and ungainly creel in order to allow the same number of ends to be manipulated. The more ends, or doublings, fed to the second breaker, the evener will be the rovings and the better

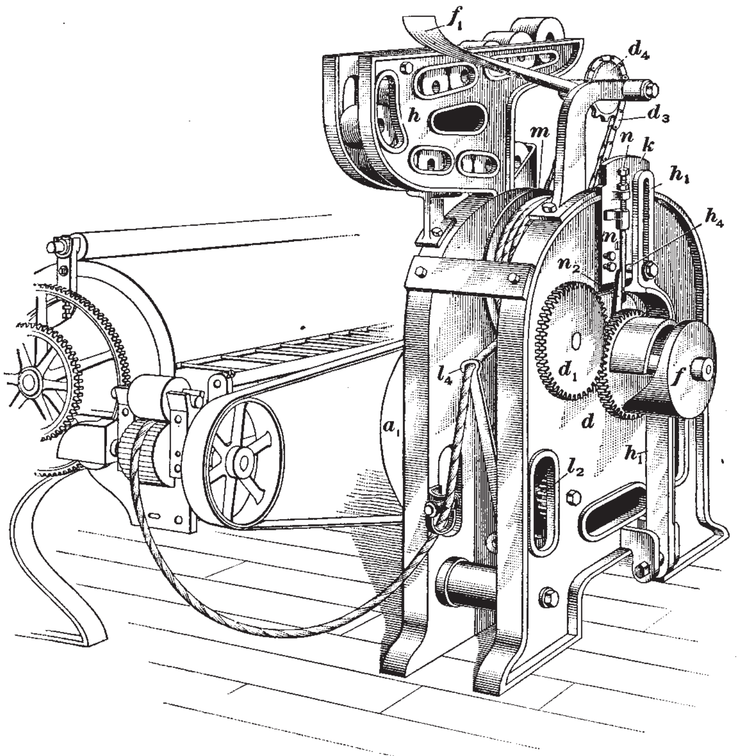

Fig. 5

the resulting yarn. Doublings are necessary in making an even and uniform thread and the more doublings used the more perfectly is the wool blended. Another advantage is apparent when small or sample lots of wool are being run through the cards. By means of the balling machine the balls can be made of any desired diameter; and if a small lot of wool is being run through the cards, small balls of wool can be made and the same number of ends fed to the second breaker as with large lots of wool. The usual number of doublings for a five-bank creel with a 48-inch card at the second breaker is eighty, but this of course may be varied to suit any requirements.

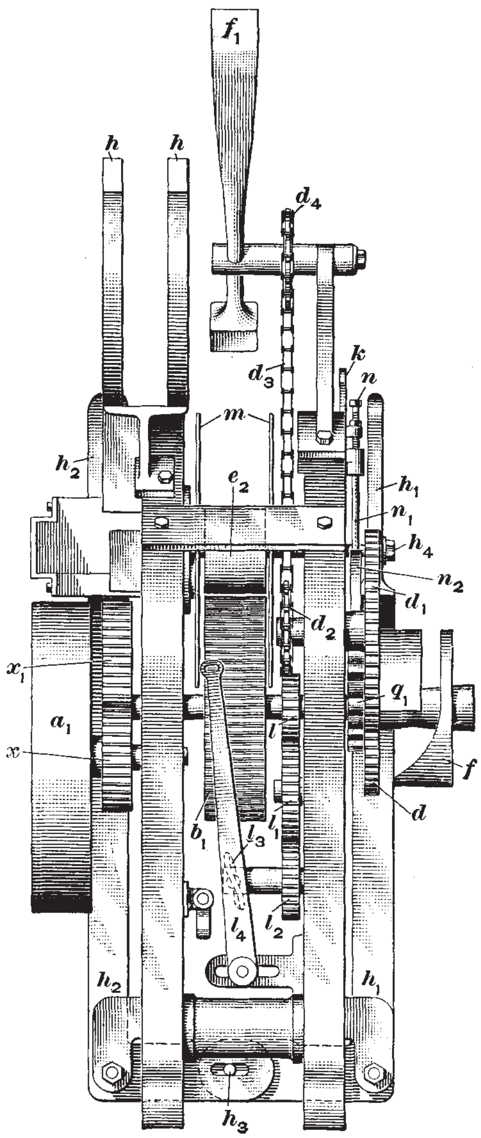

FIG. 6 (*a*)

The general features of the Torrance balling head and the method of attachment to the first breaker card are shown in Fig. 5; an end view is shown in Fig. 6 (*a*), while Fig. 6 (*b*) shows a side elevation of the balling machine.

Fig. 6 (*a*) shows the machine in its position immediately after the discharge of a full ball of wool and the reception of an empty spool e_2. The card end is wound on this spool by frictional contact with the large

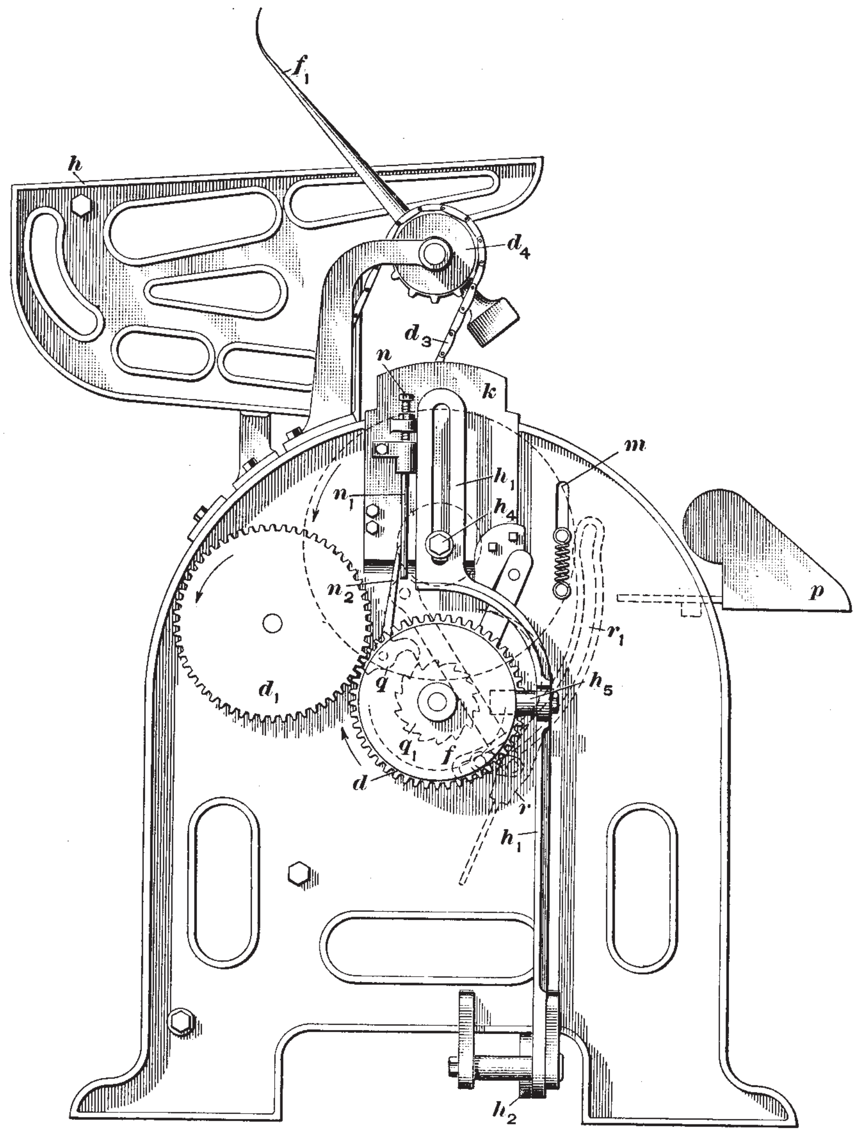

FIG. 6 (b)

fluted-iron roll b_1 on the central shaft of the machine, which derives its motion from the pulley a_1 through the gears x, x_1. The pulley a_1 is driven from a pulley on the bottom drawing-off-roll shaft of the first breaker card. Sometimes a large gear is used instead of the pulley a_1 and the machine geared from the first breaker card.

The operation of the machine is automatic; the empty spools are carried in a hopper, or magazine, h that holds twelve spools, which when filled are thrown out of the machine automatically into an iron box. This box is fitted with castors and is furnished with the balling machine and creel. The spool turns on a pin, or spindle, h_4 that is attached to the arm h_1. A corresponding arm h_2 on the other side of the machine is attached to a pusher slide. When a full ball of wool sets the doffing mechanism in motion, the arms h_1, h_2 are drawn back from each side of the machine. The arm h_1 withdraws the spindle from the spool, while the ball of wool is knocked into the box by the batten arm f_1; the arm h_2 meanwhile moves the pusher slide (which is not shown in the illustrations) and allows an empty spool to drop from the hopper h. The arms h_1, h_2 are moved out and then returned to their original positions by the cam f; in returning, the arm h_2 operating the pusher slide pushes the empty spool e_2 in place, as shown in Fig. 6 (a), while the arm h_1 thrusts the spindle through the hole in the center of the spool. An oscillating lever l_4, having at its top a ring through which the side drawing from the first breaker is passed, guides the sliver on the spool from side to side, while the two circular guide plates m insure that the sides of the ball are squarely built. The guide lever is driven by a gear l on the central shaft of the machine that drives an intermediate gear l_1. The gear l_1 drives a gear l_2 on the same sleeve as the disk cam l_3, which imparts the oscillating motion to the guide lever.

The batten arm that knocks the ball of wool from the machine into a receptacle on the floor is driven as follows: The gear d, set in motion when the full ball is ready to be discharged, drives the gear d_1. A sprocket d_2 attached to the same shaft as the gear d_1 drives, through a chain d_3, a sprocket d_4, which is attached to the same sleeve as the batten arm f_1. The mechanism for discharging the full spool and replacing the empty one is necessarily intermittent and is controlled by means of the pin n_1, which is attached to the slide k. As the wool is wound on the spool, the slide k is raised by the increased diameter of the ball of wool and carries with it the pin n_1. When this pin slides by the finger n_2, a pawl q that is loose on a stud on the gear d engages with a ratchet q_1 on the main shaft of the machine and imparts motion to the cam f, and the gear d. By means of the cam f, the arm h_1 is drawn out; this draws the pin from the spool and at the same time the batten f_1 works around and knocks out the full spool, being driven from the gear d. The arm h_2 is operated by the arm h_1 by means of the pin h_3 and slot, shown in Fig. 6 (a), the motion being a reciprocating one.

9. The size of the ball is governed by the pin n_1; the lower this pin is, the larger will be the ball of wool, because of the longer time that elapses before the pin slips past the finger n_2. The pin may be raised or lowered by means of the threaded end n, which is provided with a check-nut that locks it in place, thus rendering all of the balls of wool of a uniform size. A breaker, or knife, r moves in a slot r_1 and laps the sliver of wool around the empty spool to start the new ball of wool after a full spool has been knocked out by the batten arm. The edge of this knife is provided with serrated teeth that part the sliver and release the full ball at the same time that the sliver from the card is wrapped around the empty spool.

The motions of the fluted-iron roll b_1, on which the ball of wool rests while forming, of the ratchet q_1, and of the oscillating lever l_4, that guides the sliver while it is being wound on the spool, are constant, but the other motions are intermittent and are controlled by the pin n_1, as previously explained. The guide plate p shown in Fig. 6 (b) is for the purpose of guiding the ball of wool as it is thrown from the machine and preventing its being thrown on the doffer comb of the card.

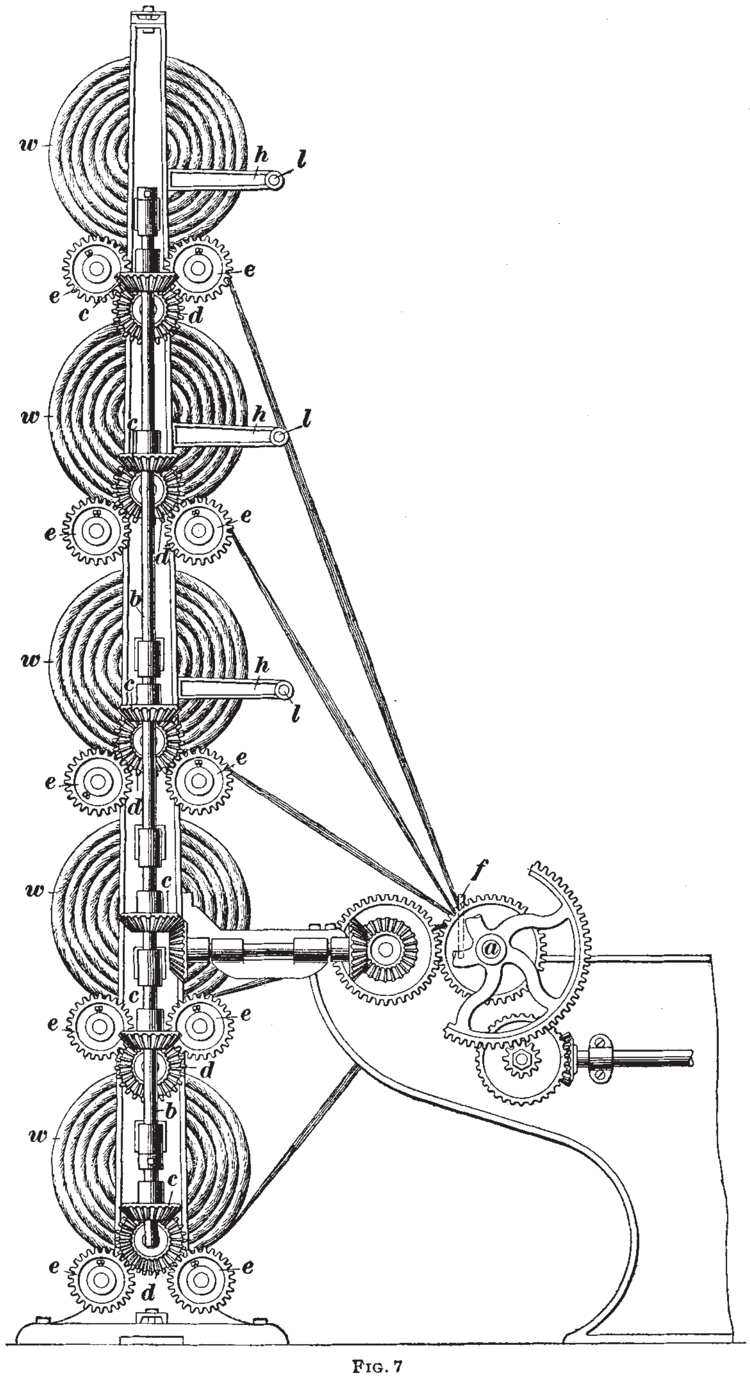

Fig. 7

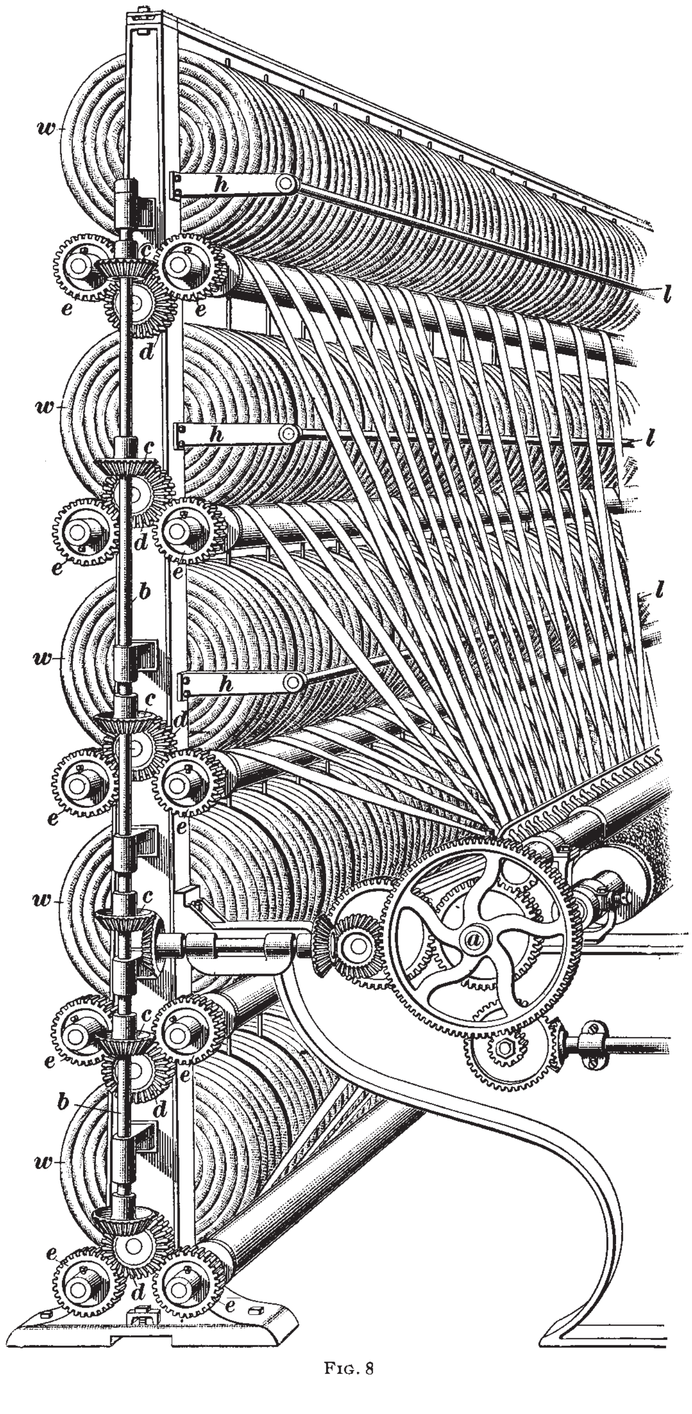

Fig. 8

CREEL

10. The balls of wool that are prepared from the side drawing of the first breaker by the balling machine just described are placed in a **creel** at the rear of the second breaker card. The creel, shown in Fig. 7 in elevation and in Fig. 8 in perspective, consists of five sets of rolls on which the balls of wool are resting; it is known as a **five-bank creel.** The rolls are given a rotating motion and the balls *w* resting on them are thus unwound; the sliver of wool is delivered to the feed-rolls of the second breaker, being passed through a perforated steel guide plate *f*, the details of which are shown in Fig. 9.

The creel consists of two vertical stands that carry the bearings for the rotating rolls on which the balls rest; the rolls are driven, as shown in Figs. 7 and 8, from the feed-roll shaft *a* of the second breaker. Motion is imparted to an upright shaft *b* on one end of the creel by means of bevel gears. This upright shaft carries bevel gears *c* that impart motion to each set, or bank, of rolls on which the balls rest, by means of intermediates *d* and the gears marked *e* on the ends of the rolls. The balls of wool are separated from one another by means of iron rods passing from the top to the bottom of the creel between the rolls, as shown in Fig. 8. On each side of the creel, and opposite the three top banks, brackets *h* support iron rods *l* passing across the creel in front of the balls of wool; these prevent the balls of wool from being thrown out of the creel and falling into the card.

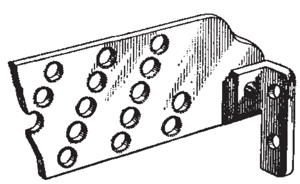

FIG. 9

APPERLY FEED

11. The **Apperly** is an intermediate feed that is usually attached to a finisher card but in some cases is used between the first and second breakers. Its object is to feed the stock continuously to the card and at the same time to secure a sufficient number of doublings of the stock to insure the evenness and uniform character of the rovings, this latter end being attained by laying the sliver from the second breaker so that it is fed diagonally on the feed of the finisher, thus allowing the ends of a number of slivers to pass into the card at once.

12. Operation.—The general features of an Apperly feed, feeding a finisher card continuously from the second breaker, are shown in Fig. 10, which also shows the overhead carrier rolls that support and transfer the second-breaker sliver. Fig. 11 shows a plan view of the feed, in which parts of the doublings have been omitted to show the aprons better, while Fig. 12 is a front elevation showing the mechanism for placing the sliver on the feed-apron. The wool as it is taken from the doffer by the comb of the second breaker is twisted by being passed through a rotating tube; this gives the sliver sufficient strength to be carried to the feed, which rests on the end of the finisher frame. The sliver, as shown in Fig. 12, is passed between two rolls m, supported by a carrier y that slides back and forth on a rod t extending diagonally across the machine. As the carrier y travels back and forth, the sliver is laid on a series of woven-cotton carrying aprons p that have a forward motion. Two latches r, Fig. 12, are lifted by the carrier each time that it reaches the side of the feed, and fall back in the loop formed by the sliver, thus holding it from drawing back as the next layer is placed on the aprons. The outside carrying aprons p_1 are called retention bands and are studded with short wires projecting through the apron only a sufficient distance to hold the sliver of wool from drawing back. In addition, as the successive layers of wool are carried

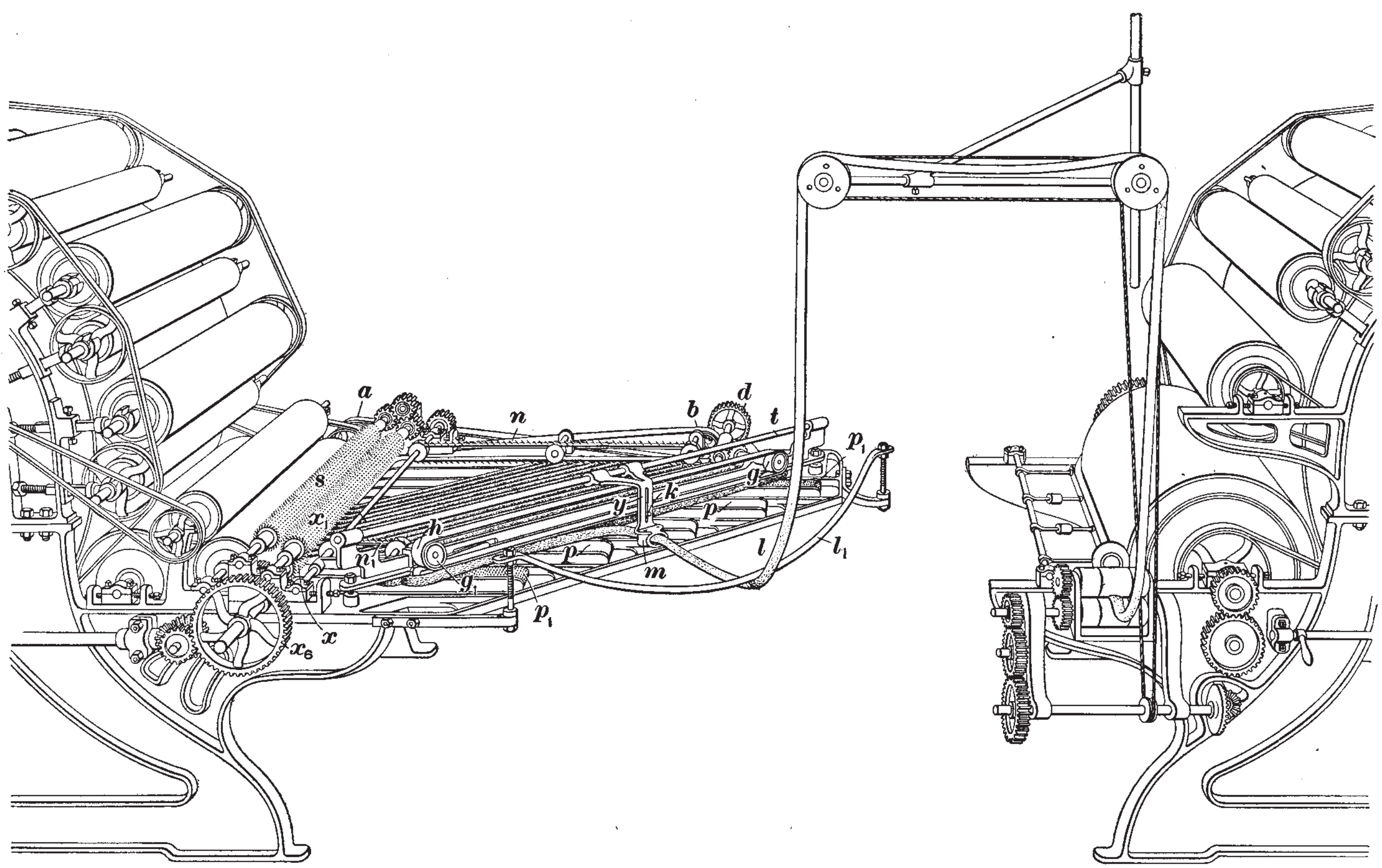

Fig. 10

forwards by the carrying aprons p, they are taken by spiked straps n, n_1, Fig. 11, which hold the slivers and do not allow them to contract after being released by the latches r. The spiked straps are filled with short wires about $\frac{1}{2}$ inch in length and travel in the same direction as the carrying aprons and with the same velocity. The stock is carried forwards to a pair of feed-rolls x, x_1, Fig. 10, which deliver it to the licker-in of the card.

The stripping roll s keeps the stock from winding around the top feed-roll x_1 by stripping the wool from it and delivering it to the licker-in. The feed-rolls and stripping rolls are a part of the feed instead of being a part of the card, as in other instances.

13. Driving.—A large gear x_6, Fig. 11, driven from the side shaft of the finisher card is fastened on the bottom feed-roll shaft of the feed. On the same shaft a gear x_4 drives an intermediate gear x_5, which in turn imparts motion to a gear o_1 that is fast to the shaft of the front apron roll o. By this means motion is imparted to all the carrying aprons p and to the retention bands p_1. The spike straps n, n_1 are driven by grooved pulleys on a shaft z that receives motion from a gear on the shaft of the roll o that drives a gear z_1 on the shaft z. The top feed-roll x_1 is driven by a gear fastened to the shaft of the bottom feed-roll that drives the gear x_2 fast to the shaft of the top feed-roll. The gear x_2 also drives an intermediate x_3, which drives a gear s_1 on the shaft of the stripping roll. The driving of the carrying device for placing the sliver on the carrying aprons is as follows: A pulley a on the licker-in shaft of the finisher drives a pulley b by means of a crossed belt; attached to the same shaft as the pulley b is a gear c that drives a gear d on a shaft on the other end of which is a bevel gear e driving a bevel gear f. On the same shaft as the bevel gear f is a pulley g that drives a belt h, which also passes over a pulley g_1 at the other side of the feed. Attached to this belt is a projecting finger, or dog, k, also shown in Fig. 12, working in a slot of the carrier y, which slides easily on the rod t. The belt gives

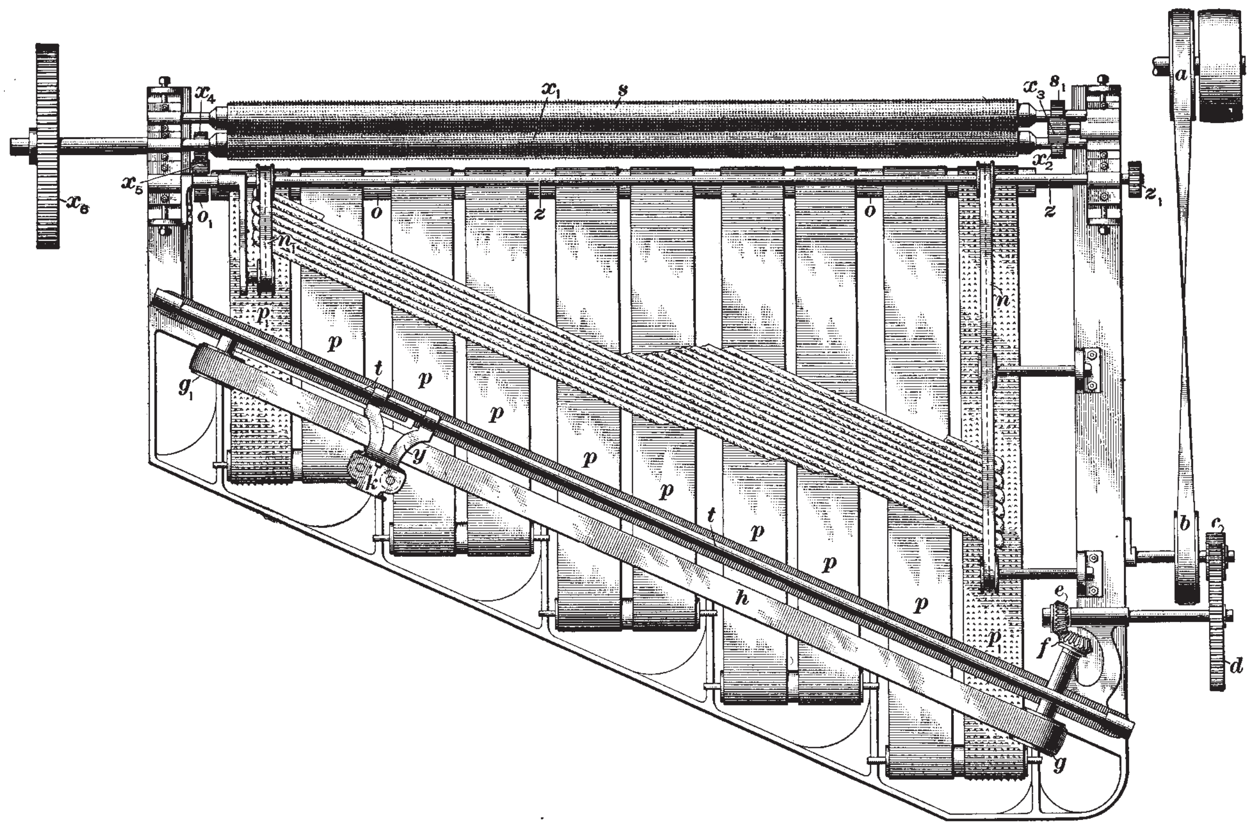

Fig. 11

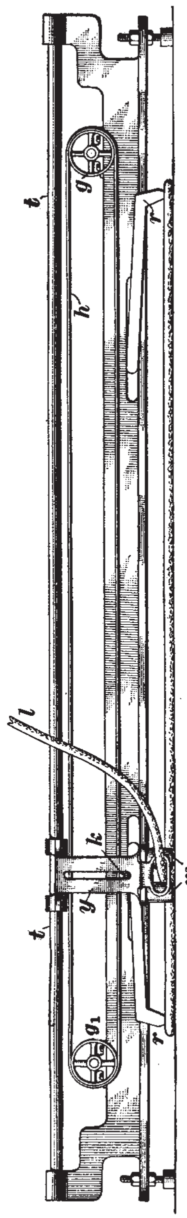

FIG. 12

the carrier a reciprocating motion and the sliver of wool *l* is passed between the rolls *m* and laid on the feed apron as the carrier moves back and forth.

Although the number of doublings obtained is not so great, an Apperly feed is more desirable for a finisher than the creel feed in general use on the second breaker cards, since there is no danger of the ends running out and making imperfect spools of roving. The number of doublings obtained with an Apperly feed varies according to the width of the card, owing to the diagonal position of the slivers on the feed-apron. The average number of doublings is about 40, although with a smaller sliver and a 60-inch card as many as 60 ends may pass into the finisher at once. In using the Apperly feed, it is very important that the speed of the carrying aprons shall be so regulated that the sliver will be laid evenly and uniformly on them. If the aprons travel too slowly, the slivers will be crowded and will ride over each other, but if the speed is too fast, the feed to the finisher will be too light and rapid. In case the sliver is crowded, the fault may be remedied by placing a larger gear on the doffer shaft, which will drive the feed-rolls and aprons faster. A smaller gear on the doffer shaft will have the opposite effect and will make the slivers lie closer. It must be remembered that this change does not alter the amount of wool fed to the finisher or the size of the rovings, but simply makes the feed lighter and more rapid or slower and heavier, according to whether a larger or smaller gear is used; the same amount of stock is fed to the card in a given time in either case. Sometimes the feed will not keep up to the second breaker but will allow the sliver to lie in coils on the floor. This is usually due to the slipping of the belt on the finisher and may be remedied by shortening the belt. Any great difference may be remedied by changing the speed of the carrier. A guide rod l_1, Fig. 10, is sometimes used to guide the sliver l; it is made in a curved shape so as to keep the tension on the sliver the same, whether the carrier is in the center of the feed or at either side.

BATES FEED

14. The **Bates feed** is very similar to the Apperly, the only difference being that the feed is positive and the sliver of wool is laid on the apron without any tension. In the Apperly, there is apt to be some tension on the sliver as it is laid on the carrying aprons, since the rolls *m*, Fig. 12, are simply driven by the friction of the sliver of wool, but in the Bates feed these rolls are given a positive motion by means of a rack extending across the feed.

SCOTCH FEED

15. Another feed that is sometimes used in this country but finds an extensive use on the continent of Europe is the **Scotch feed.** It operates on a principle somewhat similar to the Apperly, but does not twist the sliver into a rope. When using the Scotch feed, the sliver is taken off the doffer of the second breaker by an oscillating comb in the usual manner but, instead of being twisted by a rotating tube, it is simply passed through a pair of delivery rolls that press the side drawing into a flat ribbon from 3 to 5 inches wide, depending on the weight of the sliver. This ribbon of wool is carried overhead in the same manner as the sliver for the Apperly feed and is taken by a carrier that passes back and forth across the feed-apron of the finisher card, laying the ribbons of wool on the same, each ribbon overlapping the previous one about one-half its width. The carrier passes back and forth parallel to the feed-rolls instead of diagonally, as with the Apperly feed; thus, the ribbon is only laid at an angle to the extent that the apron travels forwards while the carrier is making one traverse, the angle being first in one direction and then in the other.

The Scotch and Apperly feeds give excellent results with low stock and handle fine grades of wool in an equally satisfactory manner. With any feed of this description it is necessary to have two waste ends on the card, owing to the doubling of the sliver at each end, which naturally makes it heavier; thus, the two end rovings on the side of the card would be so heavy as to make the yarn spun from them a good deal heavier as well as uneven.

LAP FEED

16. Another method of feeding the product of one card to another is by means of **lap feeds,** which are rarely used in America although often met with in England and on the continent of Europe. The wool is taken from the second breaker in the form of a continuous roll, or lap, the width of the card; one or more of these laps are placed on the feed-apron of the finisher, where they are allowed to unwind and pass into the feed-rolls.

The disadvantages of a lap feed are the large amount of floor space required and the lack of continuity, the laps having to be doffed from one card and placed on the feed-apron of the other by hand. One advantage, however, of having all the cards of a set separate is that when stopping for grinding or stripping there is no loss of time by stopping the other cards.

OPERATION OF WOOLEN CARDS

17. The passage of stock through the set of cards and intermediate machines from the hopper of the Bramwell feed to the jack-spool is as follows: The wool is placed in the hopper of the self-feed, which deposits it in an even sheet on the feed-apron of the first breaker, from which it is taken by the feed-rolls and passed to the burr cylinder. This cylinder and the burr guard working in connection with it are identical in their action with the burr rolls and guards of the burr picker; the wool is drawn into the crevices of the metallic burr cylinder, and as the burrs remain on the surface they are knocked into the burr pan by the burr guard. The object of a metallic burr roll on the first breaker is also to open out the wool before it comes in contact with the card clothing, the first opening action naturally requiring a stronger and coarser-covered roll than the subsequent operations. From the burr cylinder the stock passes to the tumbler, from which it is stripped by the main cylinder, which carries it to the first worker where, meeting the points of the worker, which operate against the points of the cylinder, it is opened out and carded. The wool is taken from the teeth of the worker by the stripper, which operates point against back of the teeth on the worker; it is then taken by the main cylinder and again passed forwards so that other workers and strippers may operate on it, until it finally comes under the action of the fancy.

The function of the fancy is neither to card nor strip the wool but to raise it to the points of the teeth on the cylinder so that it can be readily taken by the doffer. To accomplish this the fancy wires are made long and flexible and are generally bent back from the direction in which the roll rotates. Sometimes, however, fancy wire is made straight; i. e., without any bend, or *knee.* It is usually set into the cylinder wire about $\frac{1}{32}$ inch; thus the fancy acts as a brush. The fancy is the only roll of a card that touches another, all other rolls being set a definite distance apart by means of gauges.

The wool having been raised to the points of the cylinder teeth by the fancy and the cylinder working against the points of the teeth on the doffer results in the wool being deposited on the latter. From this it is removed by the oscillating doffer comb and passes through the rotating tube to the drawing-off rolls, from which the sliver passes to the balling machine, where it is formed into flat balls. These balls are placed in the creel and the sliver unwound and passed to the feed-rolls of the second breaker.

The action of the second breaker on the stock is the same as that of the first breaker, with the exception that the burr cylinder is replaced by a licker-in covered with card clothing. There is also a feed-roll stripper for keeping the top feed-roll clean and a licker-in fancy for keeping the licker-in clear.

The wool is taken from the doffer of the second breaker in the usual manner and passed overhead to the Apperly feed, by which it is fed diagonally to the finisher card. The carding action of the finisher is similar to that of the second breaker, but the direction of rotation of the workers is reversed; this prevents a large amount of flyings and also produces evener rovings. The wool is raised on the cylinder by a fancy and is then divided into narrow ribbons by the ring doffers. These ribbons are taken from the ring doffers by the corduroy-covered wipe rolls and passed to the rub rolls, or aprons, which condense them into round rovings, or roping. These rovings pass through reciprocating guides on the winding frame and are then wound on a rotating jack-spool, ready to be spun on a mule.

METALLIC BURRING MACHINES FOR FIRST BREAKER CARDS

18. Instead of having only a single burring machine, consisting of a burr cylinder and guard on the first breaker, for removing the burrs before the stock passes to the card clothing, some cards are equipped with double burring machines or even a metallic breast. The object of such devices is not only to remove the foreign matter in dirty stock but also to open out any snarls or bunches and not allow them to pass forwards to strain the card clothing. On certain classes of stock, burring machines are a benefit, especially for very fine wools, which tend to cling together in small lumps and bunches. Devices of this kind are never

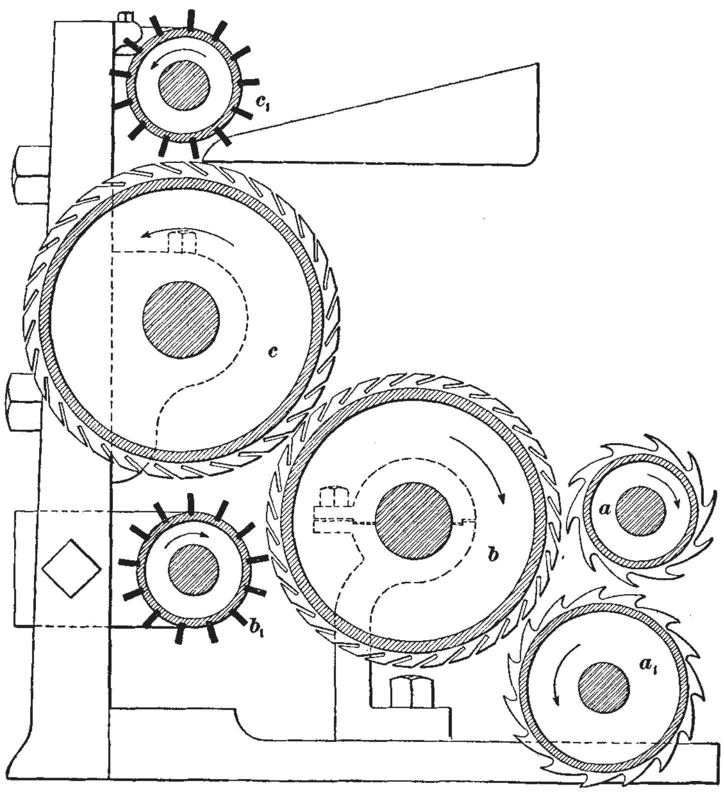

FIG. 13

attached to the second breaker nor to the finisher cards, as after the stock has passed through one carding process there is no necessity for metallic rolls.

19. The **Parkhurst double burring machine,** shown in section in Fig. 13, is often applied to first breaker cards. It consists of a pair of steel-ring cock-spur feed-rolls a, a_1, two steel-ring burr cylinders b, c, and two burr guards b_1, c_1 with thirteen blades each; these parts are supported by a frame carrying the necessary bearings, which is readily bolted to the end of the first breaker frame.

In operation, the wool is taken by the feed-rolls and passed to the first burr cylinder, which, in connection with the burr guard b_1, frees it from burrs and dirt that have not been removed in the previous operations. The stock then passes to the second burr cylinder c, which, running up, receives on its surface the side of the wool already cleaned, completely turning over the lock of wool and presenting to the guard c_1 all burrs, etc. that are on the side not cleaned. The stock passes from the burr cylinder c to the tumbler of the first breaker card. The burr guard c_1 throws the burrs into a burr pan placed over the burr cylinders and the guard b_1 throws burrs and other refuse on the floor under the card. The top feed-roll a is stripped and kept clear by the burr cylinder b, which, running down, combs the wool through the teeth of the lower feed-roll a_1 and removes a large amount of shives, which are dropped under the card. A wipe roll is sometimes necessary for keeping the bottom feed-roll clear.

20. Smith Double Burring Machine.—Fig. 14 shows a form of double burring machine that contains burr cylinders of slightly different diameters. In the operation of this machine the stock is taken by a pair of feed-rolls a, a_1 and delivered to the first burr cylinder b, which strips the lower feed-roll a, while the top roll a_1 is kept clear by a stripper a_2. The burr cylinders are similar to those in the previous machine, the burrs being removed by two guards b_1, c_1 that knock them into the pans b_2, c_2. The tumbler t takes the wool from both burr cylinders and passes it to the main cylinder of the card.

21. Metallic Breast.—Occasionally, when very fine work is run, a **metallic breast** is used in connection with the first breaker. This operates on the same principle as the card, but owing to its slower speed is more gentle in its action and

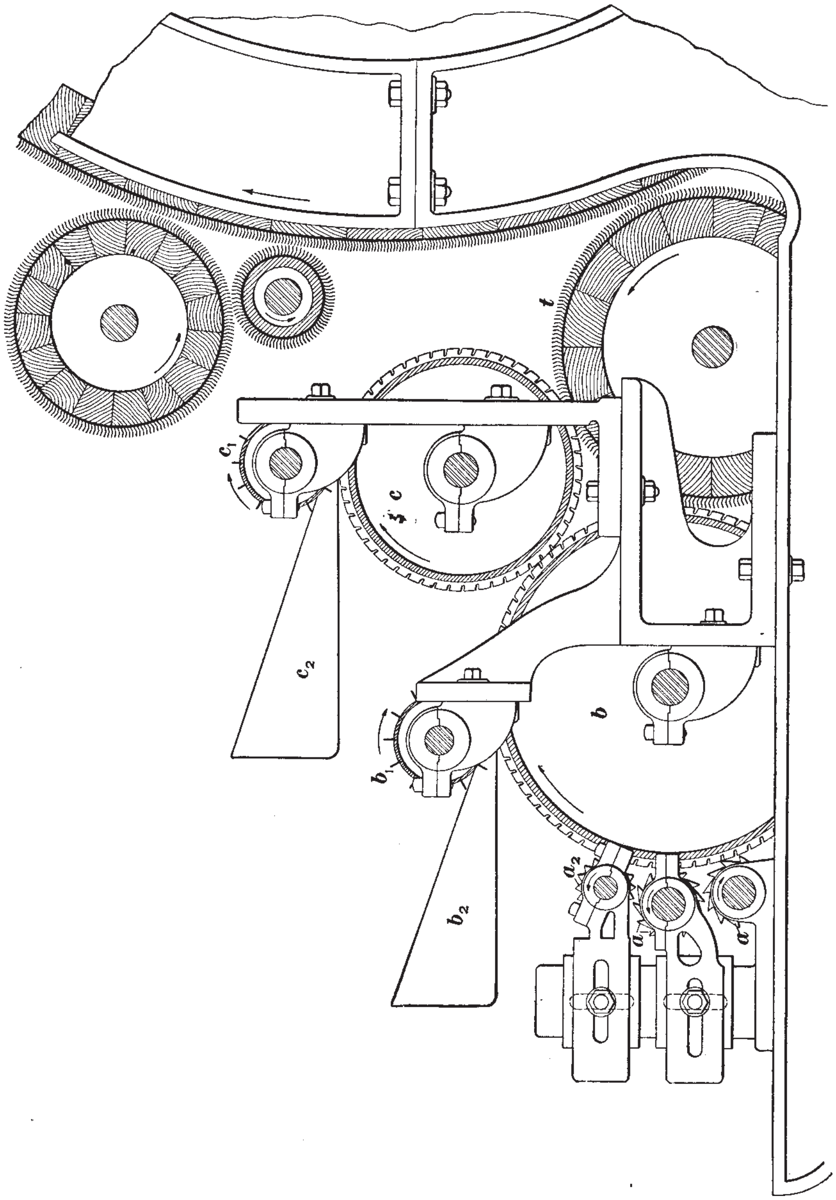

FIG. 14

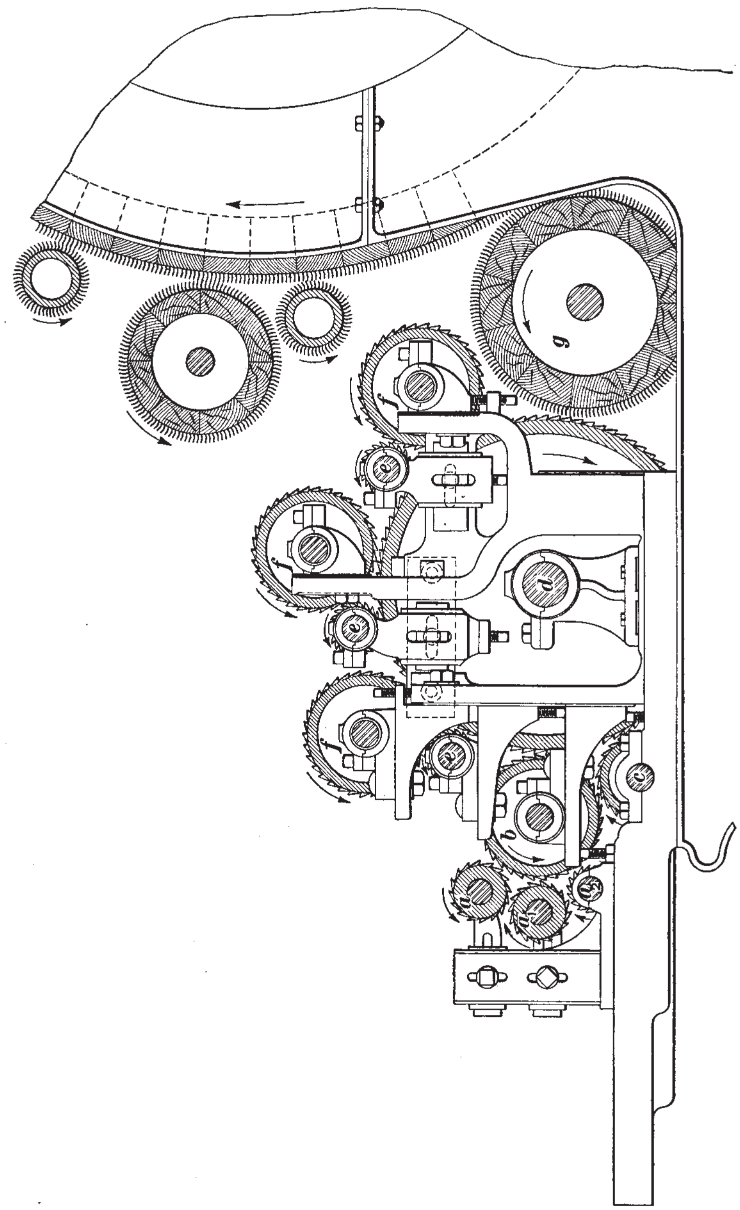

Fig. 15

gradually opens the wool, so that none of the fibers are broken when taken by the swiftly revolving main cylinder of the card.

The metallic breast shown in Fig. 15 consists of two metallic feed-rolls a, a_1, which take the stock and pass it to a licker-in b, which is covered with Garnett wire and passes the stock to the metallic breast d. A small stripper a_2 keeps the bottom feed-roll clear, while a roll c, called the *breast roll*, cards the wool on the licker-in b and delivers such as is not retained by the licker-in to the breast, which is 16 inches in diameter and works in connection with three 6-inch workers f and three $2\frac{1}{4}$-inch strippers e in the same manner as the main cylinder works with the workers and strippers of the card. The stock is then taken by the tumbler of the card g and passed to the main cylinder. A breast cylinder should run at about one-fourth the surface speed of the main cylinder of the card. This metallic breast is also shown on the card, Fig. 15, *Woolen Carding*, Part 1.

EUROPEAN METHODS

22. The **European system** of carding wool for the production of woolen yarn differs somewhat from the American, especially in England, where it is the custom to use but two cards for this kind of carding; namely, a first breaker, or as it is there called a *scribbler*, or *breaker scribbler*, and a finisher.

The **breaker scribbler** in the English woolen trade takes the place of the American first and second breakers and consists of three distinct parts: First, a metallic breast, over which are placed two workers and two strippers and also a fancy; second, a large main cylinder, or *swift*, over which are placed four workers and four strippers and a fancy; and third, another cylinder with the same complement of rolls. There are also, in connection with the breast and with each of the swifts, doffers that take the wool from them after it has been operated on by the complement of workers, strippers, and fancy working in connection with each. A small stripper, known as an *angle stripper*, takes the wool from the doffer and passes it to the next cylinder, where the operations of carding and stripping are repeated until the stock is finally removed from the last doffer by means of an oscillating comb.

The finisher card used in the English system of carding is similar to that used in America with the exception that a single ring doffer is generally used where the ring system is used at all. This doffer is of large diameter and is clothed with rings, the spaces between the rings being only about $\frac{3}{16}$ inch in width. In order that the wool shall not be left in strips on the main cylinder of the card when using a single doffer, the last worker, or perhaps the last two workers, are given a slight traversing motion so that they will pick up the stock on the cylinder not taken by the doffer and distribute it over the entire width of the card.

23. Difference Between European and American Systems.—It will be seen that the main difference between the American and European systems of carding is in the construction of the first breaker; the English and other European carders use a double first breaker and do away with the second breaker used in most American mills, although in some English mills on fine work they insert an extra card between the breaker scribbler and the finisher, but keep the first card as before.

A modification of the English system is sometimes used in American mills and consists of doing away with the intermediate balling head and creel between the first and second breakers and backing the second breaker up to the doffer of the first breaker, the transfer of the stock from one to the other being effected by means of the angle stripper. For carding low stock this makes a good arrangement and also causes a great saving in labor and floor space; but for fine stock it is not to be recommended, because with this method of coupling the cards there are no doublings between the first and second breakers, and in making fine yarn, or in fact any yarn, the more doublings there are, the evener and more uniform will be the resultant thread. This is, however, not important in coarse yarn, as a slight variation will not be noticed.

WORSTED CARDING

24. Difference Between Woolen and Worsted Carding.—It is unnecessary in these Sections to deal fully with **worsted carding,** as that subject would be out of place in the treatment of woolen carding, but a brief reference is made to worsted carding, so as to explain the principal points of difference between carding in the woolen and in the worsted trades. Wool is carded on two systems for the production of two classes of fabrics; namely, the worsted system of carding, for the manufacture of worsted yarns and fabrics, and woolen carding, for the manufacture of woolen yarns and fabrics. The two systems are different both in the machines used and the results obtained, although the principle of carding remains the same.

Worsted carding tends toward the parallelization of the fibers, while woolen carding is more for the purpose of making a uniform mix, or blend, of the fibers, than to parallelize them. The tendency of any carding process is to lay the fibers parallel, but upon a woolen card the stock is removed from the card by means of a side drawing, which tends to mix and cross the fibers; at the same time the side drawing is twisted by being passed through a rotating tube, which also has a tendency to mix the fibers of wool. From the worsted card the stock is removed in a web, passed directly through a stationary trumpet, and wound into a ball without twist, which tends to lay the fibers parallel to the direction of the drawing. This is the beginning of the parallelization of the fibers.

Again, the worsted carder deals generally with a longer fiber and this requires a slower speed, in order to guard against breakage and the consequent shortening of the fiber, while the woolen carder in dealing with a shorter fiber, which is more easily opened out and disentangled, can use higher speeds. Even if the fiber is broken, the deterioration of the stock is not of so much consequence in the manufacture of a woolen as in the making of a worsted yarn, since all short fibers are removed by the comb in worsted-yarn manufacture and are, consequently, a dead loss so far as worsted is concerned, although they may be (and are, under the name of noils) used in woolen manufacture. Wool that is carded for worsted yarn is afterwards combed and put through various operations of drawing before spinning, while a woolen thread is spun on the woolen mule directly after the carding process. A woolen yarn is a thread spun from wool, the fibers of which are mixed and crossed in every conceivable direction and which presents a rough, although uniform, surface appearance. A worsted yarn is a thread spun from wool, the fibers of which lie smoothly in the direction of the thread and parallel to each other. From these definitions it will be seen that a woolen yarn differs from a worsted in the arrangement of the component fibers; also, generally speaking, in the length of the fibers and in the process of manufacture, which in woolen spinning tends to an even artificial mixing and in the worsted to parallelism of the fibers. Worsted carding is customarily performed on one card, which may be considered as a double card, being composed of two cylinders with their complements of workers, strippers, etc. The worsted card also usually carries, before the first cylinder, four licker-ins (or three licker-ins and a burr cylinder), and several other rolls. This, of course, makes a long card, which has a large amount of carding surface.

WOOLEN CARDING

(PART 3)

CARD CLOTHING

1. Card clothing, the material with which the various rolls of the card are covered and by means of which the wool or other stock is opened out and prepared for the spinning, consists of wire teeth set in leather or some other suitable foundation and having a bend, or forward inclination, from a point called the **knee** of the tooth. The foundation employed for woolen cards is generally leather, but on cotton and worsted cards various woven combinations are used.

Flexifort, a foundation largely used for worsted card clothing and frequently for woolen cards, consists of a woven fabric, generally cotton or cotton and wool but sometimes composed of cotton and linen, the face of which is covered with a veneering of india rubber. The india rubber gives a firm yet elastic foundation and is especially adapted for worsted carding, as this fiber is carded while moist; any dampness would rot either a cotton or a leather foundation for the clothing. On cotton cards combinations of wool and cotton are generally used for the clothing. Leather is generally used as the foundation of clothing for woolen cards. Rubber clothing cannot be used for woolen cards, as the oil that is applied to the wool will quickly weaken the rubber.

2. Wire.—Besides the foundation, several points in regard to the wire should be carefully noted: (1) Its character as to shape and preparation; (2) the angle at which it passes through the leather; (3) the angle at the bend, or knee; (4) its size; (5) its setting in the foundation.

Card clothing is set with many kinds of wire—iron, steel, tempered steel, brass, tinned, etc.—but the best wire to use for woolen carding is the tempered steel, which makes a springy, elastic tooth that is not easily bent out of place. The wire is better if tinned, as then there is no liability of the clothing rusting during damp weather or if water is applied to the stock. *Round wire* is generally used, although another kind, known as the *elliptical wire*, which is made by

TABLE I

Birmingham		American	
No. of Wire	Diameter Inch	No. of Wire	Diameter Inch
28	.014	28	.012641
29	.013	29	.011257
30	.012	30	.010025
31	.010	31	.008928
32	.009	32	.007950
33	.008	33	.007080
34	.007	34	.006305
35	.005	35	.005615
36	.004	36	.005000

passing round wire through heavy rolls and slightly flattening it out, is sometimes used. *Triangular wire* has also been used, as well as the *diamond-point wire*, which is used for licker-in and feed-rolls.

Fine wire is more elastic than coarse wire and has a gentler action on the stock and also allows of a more open set of the clothing with the same number of points per square foot. If nothing but the wool to be carded comes in contact with the wire, fine wire will be found to be as durable as coarse, but the fine clothing will necessitate more careful handling and grinding. When a uniform quality of