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TEXTILES

A · HANDBOOK · FOR THE · STUDENT · AND · THE · CONSUMER ·

WOOLMAN AND McGOWAN

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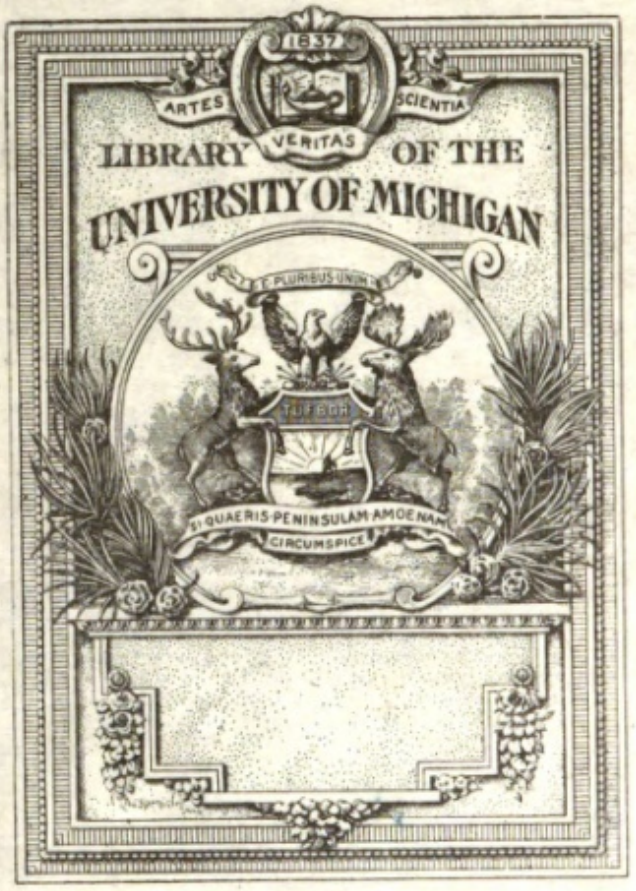

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The skins of animals were worn with the fur inside to make them comfortable. The felting of the wool of sheep as it touched the body led the way to the making of felt for clothing. The dried skin was later tanned to lessen its roughness. In some warm countries the soft, juicy inner bark of special trees was pounded into a flexible mass, soaked in water to ferment, and beaten again with mallets and rollers carved to give special effects. Patterns were made on these bark clothes in various ways, leaves and flowers wet with dye being sometimes laid on and pressed down. Bark material is still made. It is supposed to have been a forerunner of felted cloth. The cloth was beaten into large sheets, one being welded to the other, and was varnished with oil to render it waterproof.

Basketry was at first very simple, being made with splints, but it soon developed patterns in diagonals and diapers. The alternation of rigid with pliable materials gave a wide scope for design, and the twined and sewed basketry of some primitive people was an art (Fig. 1). Basketry and weaving have much in common, and improvements in one helped the other. Pottery soon developed, probably from the habit of lining baskets with clay in order to hold water. Some of the most primitive pottery shows the form of the weaving of the basket on the clay. (See Fig. 30.)

FIG. 1. — WICKERWORK BASKET.

The men were occupied in food getting, in fishing, hunting, and in war, while the women were working at the camp. The discovery of the use of fire tended toward further division of man's and woman's work, for she was the caretaker of the

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children, and naturally stayed by the fire. As the early people were wanderers, they needed carriers for transporting their young children and their household goods, and mats and baskets served many useful purposes in the life on the march, as well as in the tree, cave, or shelter homes. Inventions were adapted to numerous purposes; for example, a method of holding rigid material by softer fibers twined about it, now called wattling (Fig. 2), was used for shelters by fastening several heavy sticks together in a point, with their loose ends stuck into the earth, laying grass and rushes on top, and holding down this covering by laying sticks at intervals across the grass and rushes, and tying them down by intertwining pliable material around the sticks; for defenses, by holding together the great stakes used for stockades around primitive huts; for early weaving of soft materials, or for very coarse basketry, as well as the fine basket weaving of the Pacific Coast of the United States. Wattling is really a form of weaving. Such a principle once grasped by these awakening minds became a means of development as the environment offered new materials for use, and the many needs gave an impetus.

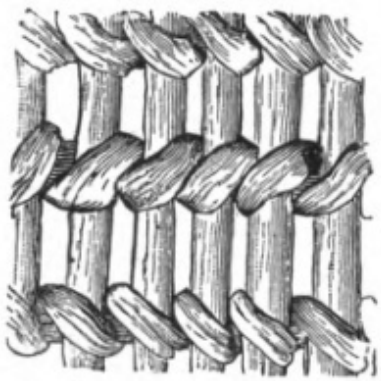

FIG. 2. — WATTLING.

The earliest beginning of the race has well been called the "Age of Fear," for man was afraid of his fellow, afraid of the animals, and afraid of nature. The individual was at first sufficient unto himself; there was little interdependence among the members of families. As family life increased, there arose a tendency to form into small groups. By degrees they entered into alliances with other nomads, thereby increasing their safety and bringing knowledge of new methods of fishing, hunting, and living. These social interrelations tended to decrease fear and to develop industries, for some families had made more progress in the crafts than others, and added comfort and beauty

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were found to come through new devices. Gradually those who excelled in textile work began to attain prominence, as did the great warrior or the great hunter.

Era of Hunting and Fishing. — During this time many crafts originated and devices to assist labor were invented. Work in metal had begun and was used to improve the textile tools. Although women did some planting, the homes were moved too

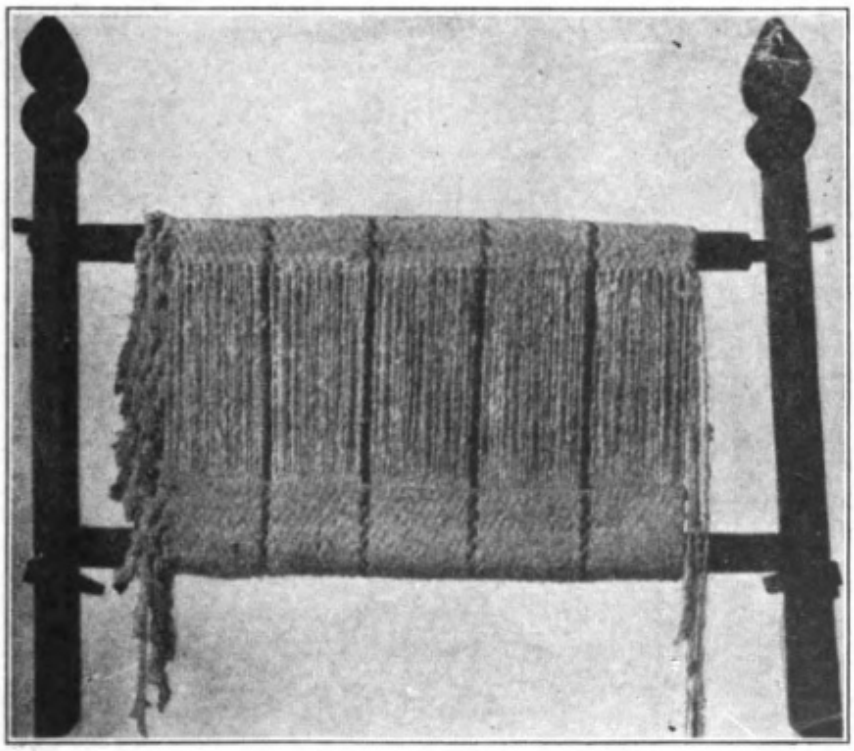

FIG. 3. — A PRIMITIVE TYPE OF LOOM.

frequently for the maintenance of a settled agriculture. There was little trade between people, and little providence for the future in storing food or in making covering, for all extras impeded travel.

During this wandering life the important industries passed their simplest form. Weaving was now done on looms, which were nothing more than two heavy sticks between which rushes were stretched so that the latter were held taut, while the weaver wove other rushes across these threads (Fig. 3). The value

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of weaving (Fig. 6). Tribes began to look to each other for exchange of products, and so tended to assume more peaceful relations.

By the close of the pastoral and the beginning of the agricultural era, many textile industries had passed their primitive

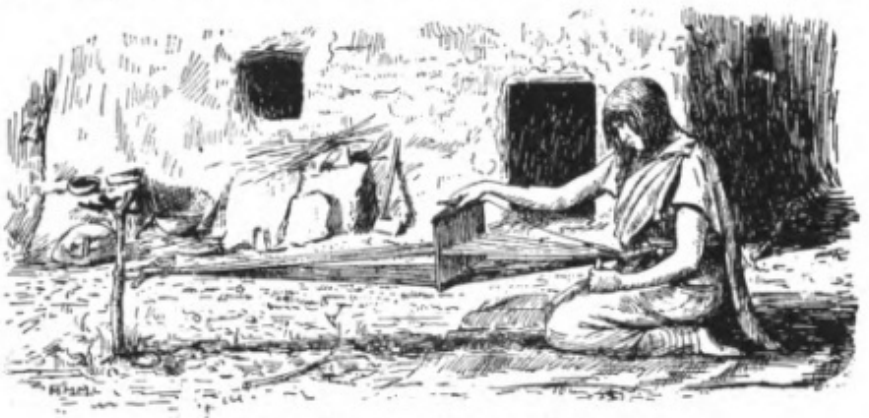

FIG. 6. — PUEBLO WOMAN WEAVING.

From Watson's *Textiles and Clothing*, by courtesy of the American School of Home Economics.

stages. Devices and even rude machinery to assist the hand were common. Beauty of design and skillful handling are evident from examples preserved in the museums. The most common of the textile crafts in use were: —

Braiding and looping.
Tying, wattling, and thatching.
Netting for fish nets, carriers, and clothing.
Weaving for shelters, mats, rugs, hangings, and garments.
Basketry, both woven and sewed, made into carriers, hats, traps, and household articles.
Knitting and crocheting.
Carding and spinning.
Reeling.
Needlework in sewing, embroidery, appliqué, repairing, box making, and clothing.
Lace making, by sewing, weaving, and knitting.
Skin drying and curing.
Dyeing and staining.
Decoration in bead work, stenciling, block printing, and picture writing.
Felting and beating.
Making tools for use in the various crafts.
Loom building.

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FIG. 13. — NAVAJO WOMAN SPINNING.

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the eye of the spindle. The flax passed smoothly under her second, third, and fourth fingers as she held it lightly between the first finger and thumb, which she slightly turned toward her as the thread was drawn down. She used her left hand to open up the mass of fibers next to the distaff, making them into a wedge shape with the narrow end running toward the right hand. She slightly twisted them, and threaded the yarn thus made through the needle's eye in the spindle, brought the thread over one of the hooks of the flyer and fastened it on the bobbin by means of a thread which had been left for this purpose. Beginners often found it difficult to keep the wheel revolving smoothly while drawing the flax evenly from the distaff to the spindle. It took time to become a good spinner. The threads of flax were kept moistened by the spinner in order to make a tighter and smoother twist. The spindle, the iron bar on the large wheel, and the crank connected with the treadle were kept well greased.

The Saxony wheel was more complex than the great wheel. The flyer (Fig. 17) on the spindle by which the thread was twisted (said to have been invented by Leonardo da Vinci) was a great step in advance of former spindles, and is utilized in power spinning even to the present day. The continuous motion of this wheel made it possible to spin more and stronger thread in a given time than had any previous invention. The bobbin revolved at a different speed from the spindle, consequently it was possible to wind up the yarn as it was being spun. The flax wheel was improved upon in various ways, and two spindles were later used on it at one time, enabling expert spinners to double the output.

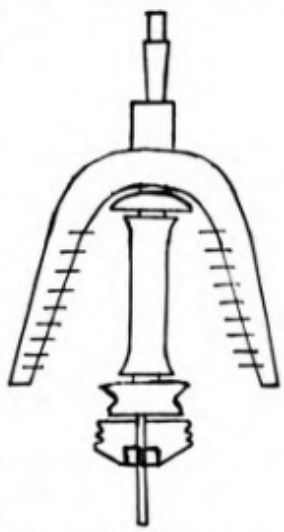

FIG. 17. — DETAIL OF FLYER.

Hand and Machine Carding. — The opening up, combing, or carding of raw fiber is probably as ancient as the art of spin-

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machine. The revolution of the swift carries the good carded cotton to a point directly opposite the licker-in, where it is stripped off by another revolving cylinder, called the "doffer cylinder," the teeth of which are so set that they take the cotton from the big cylinder or swift. An oscillating knife or comb, the "doctor knife," strikes the cotton from the doffer cylinder, and the soft lap is then delivered to a funnel or to two rolls which contract it into a ribbon or sliver and deliver it to a can. The great cylinder or swift often moves at a rate of 150 to 200 revolutions a minute. The doffer comb strikes the cotton about a thousand times a minute. The

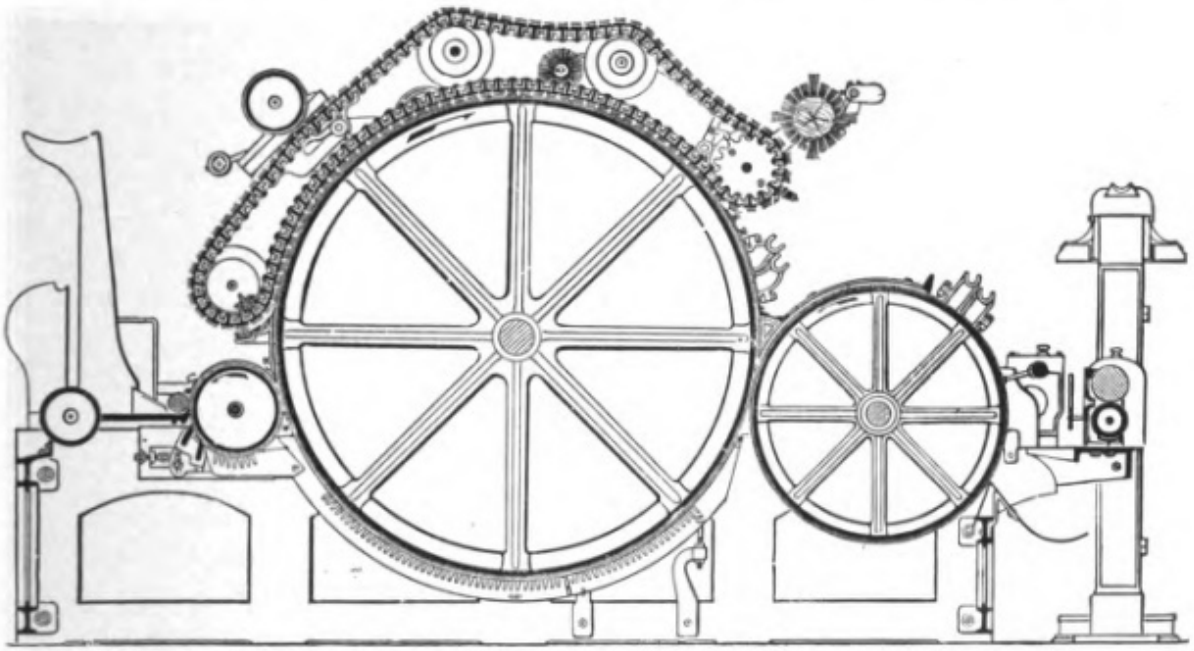

FIG. 19. — REVOLVING TOP FLAT CARD.

Courtesy of the Whitin Machine Works.

card for wool does not aim to lay the fibers parallel, but simply to open them into a soft mass. A series of small cylinders, covered with card clothing, working over the top of the swift, take the place of the flat bars in the cotton card. These rollers or cylinders are in pairs called workers and strippers and alternately press the wool on the teeth of the swift and remove it again, thus opening the fiber. Three cards in a train are in general use in the wool industry. (See Chap. VI.) The fiber passes from one card to another in a transverse direction, to overcome the inclination to parallelism. The card in use in the worsted industry differs from the train of cards required in the wool, but the principles remain the same. The rapidity of movement in the swift depends upon the length of staple of the fiber. In the wool card the final stripping roller is called the fancy. It is larger

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brilliant idea in the use of drawing rollers to attenuate the yarn. This latter principle is important in power spinning. Richard Arkwright later used this principle in his water frame, but gave no credit to either Wyatt or Paul, and is generally given credit for the invention.

In 1764 or 1767 James Hargreaves, a spinner and carder, living in Blackburn, Lancashire, invented a spinning frame

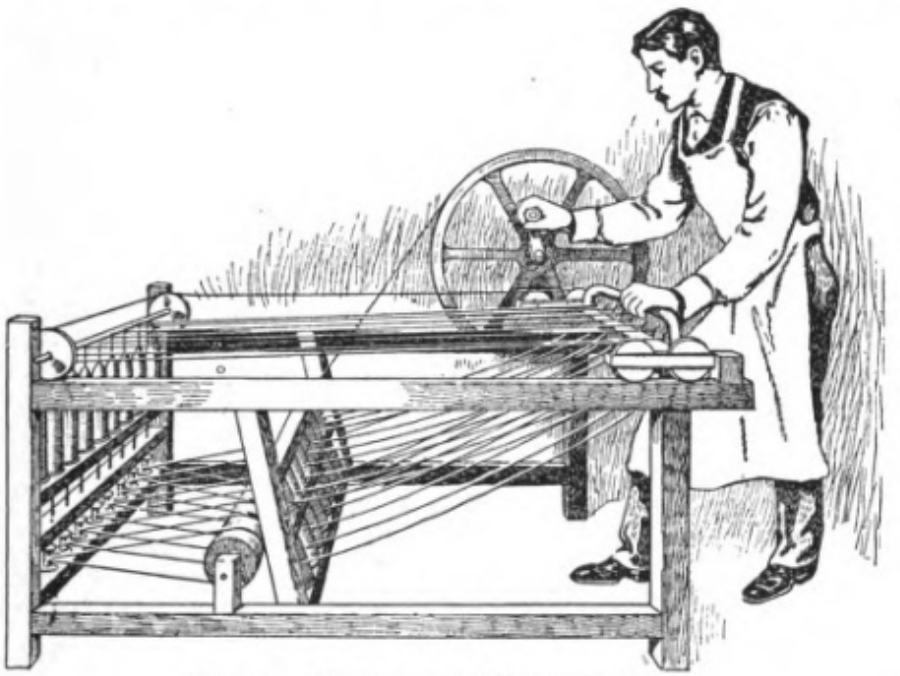

FIG. 20. — HARGREAVES' SPINNING JENNY.

From Robinson and Beard's *The Development of Modern Europe*, by courtesy of Ginn & Co.

(Fig. 20) which was the progenitor of the modern self-acting mule. (See Fig. 22.) His idea was evidently taken from the principle of the great wheel. For power he used one hand to control a traveling carriage, and the other to turn a wheel by means of a crank. The wheel was connected by a band with a cylinder under the framework, and bands went from the cylinder to the pulley or wharve of each spindle, thus setting them in motion as the wheel turned. This machine spun from eight to eleven threads at once. It was a great invention, but the fibers were not parallel, and the yarn was too softly twisted to

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poor of England. Credit for this invention is given by some to High of Leigh.

The spinning jenny was known to Richard Arkwright, a clever barber of Preston, who wandered about the towns of

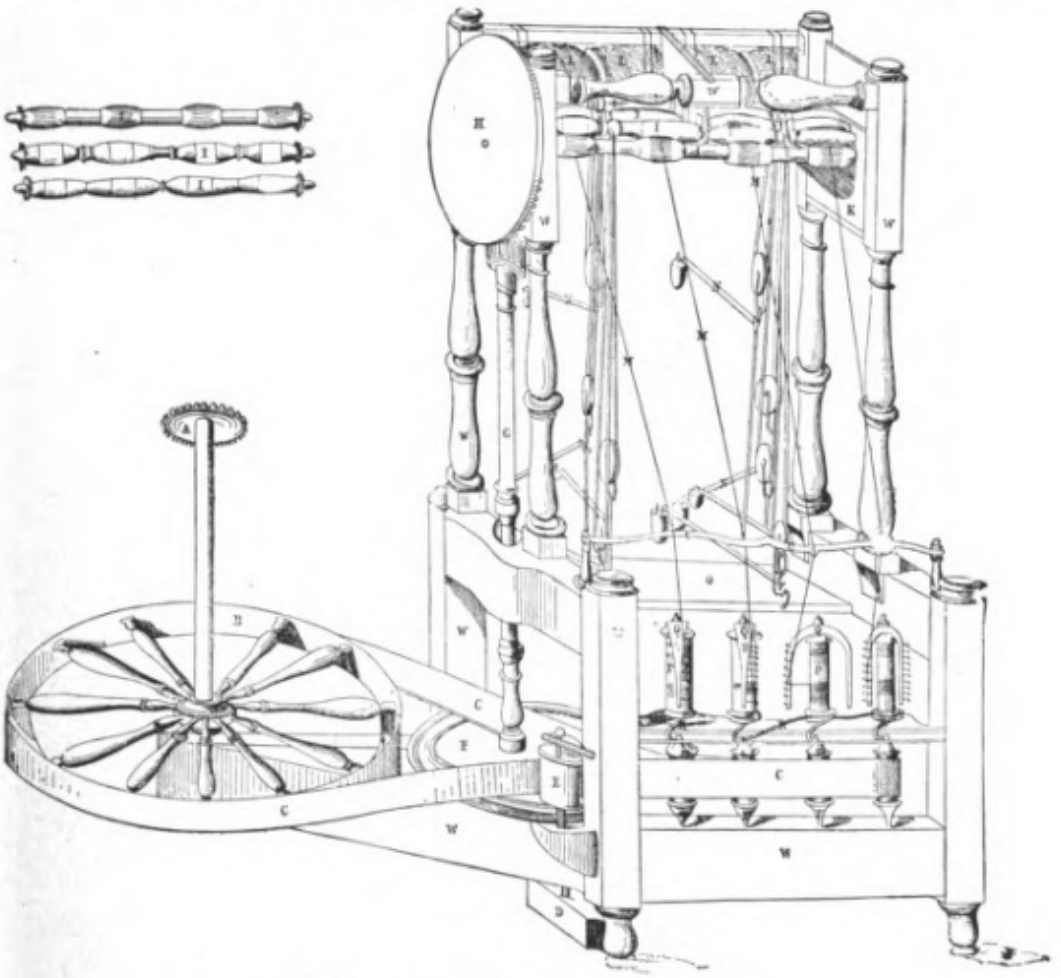

FIG. 21.—ARKWRIGHT'S WATER FRAME.
From Barker's *Textiles*, by courtesy of Constable & Co., London.

England in pursuit of business. He continually heard of the need of yarn and cloth, and probably improvements in devices were talked over with him, and new appliances shown him. About 1768 he brought out a machine founded on the principle of the Saxony wheel. It had an upright frame, a continuous motion, and the spindle and flyer of the Saxony wheel placed vertically (Fig. 21). The roving passed through twin drawing

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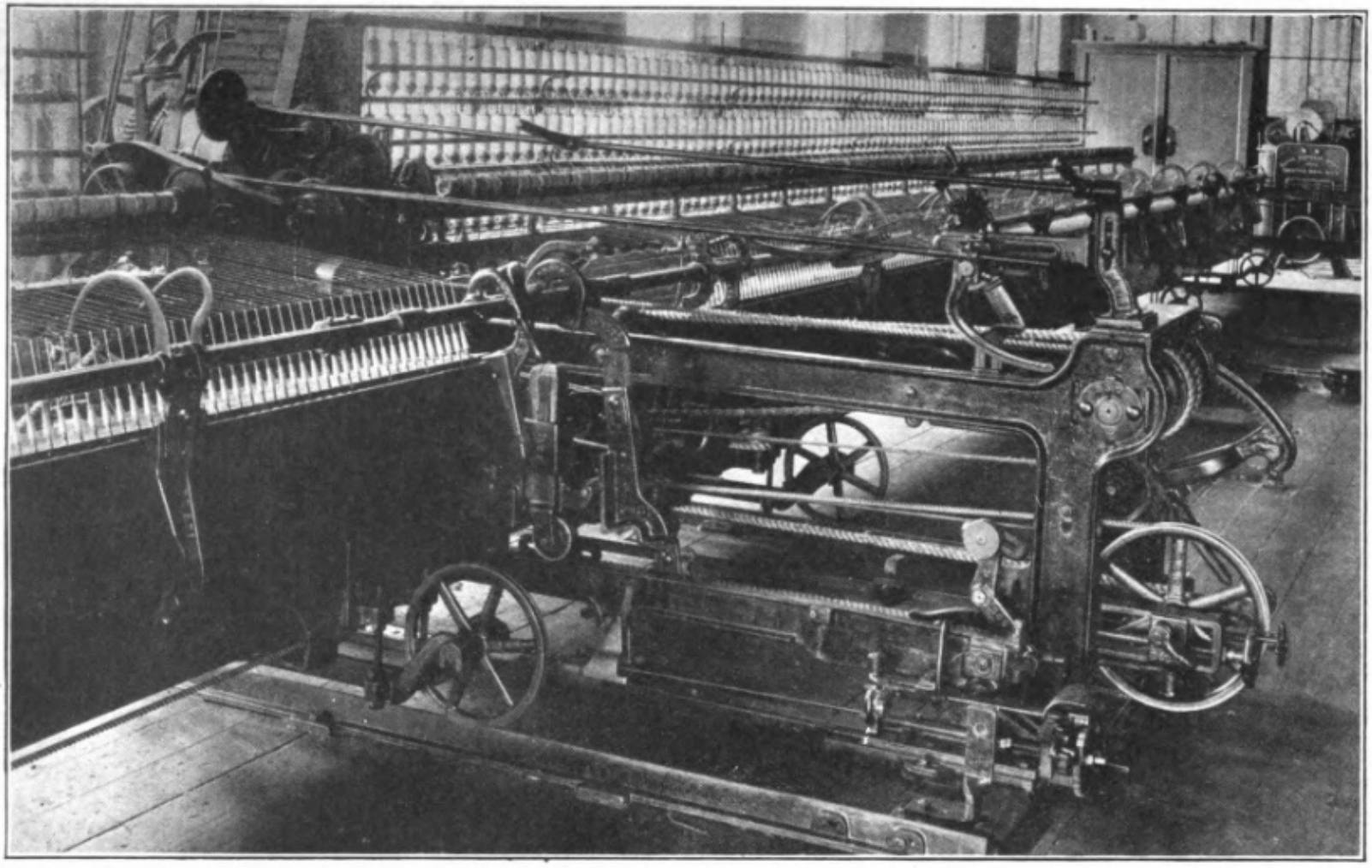

FIG. 22. — MULE SPINNING.
Courtesy of the Mason Machine Works.

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ning, utilizes this idea, and gives the spindle as much freedom as a spinning top, which running at full speed balances itself. Cap spinning is used in spinning worsted yarns, the principle at base being a stationary spindle with a stationary cap and a revolving bobbin. The latter has a whorl on it, and a band connected with the driving shaft makes it revolve. The yarn comes from the rollers above, the bobbin moves up and down, and the end of the cap keeps the yarn evenly winding on the bobbin.

In ring spinning (Fig. 26) the yarn is twisted immediately on leaving the rollers. In spinning frames there are usually

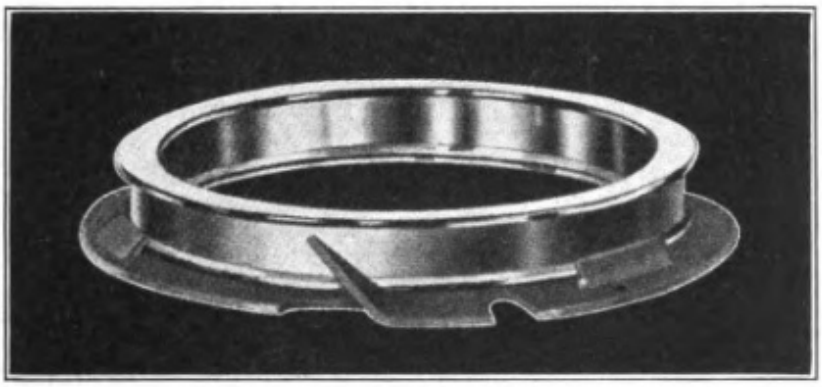

FIG. 27. — DETAIL OF RING.

two rails. In the lower the spindles rest, and through the higher, called a bolster rail, the tops of the spindles pass. In ring spinning there is a third rail. This rail moves up and down the spindle, causing the yarn to wind evenly. A series of rings (Fig. 27), each with a flange, are fixed on the rail, and move with it. The front of each spindle goes through a ring, but does not touch it. A traveler, which is a crooked piece of fine wire, is sprung on the flange. It can move easily, but cannot come off. The ends of the yarn come through the rollers and each passes through a traveler and is fastened on a bobbin which is on the spindle. The spindle and traveler revolve rapidly. The latter is held back slightly by the yarn and consequently winds the yarn on the bobbin. A traveler makes as many as 10,000 revolutions per minute. Separators of metal are often used between the spindles to keep the threads from interfering.

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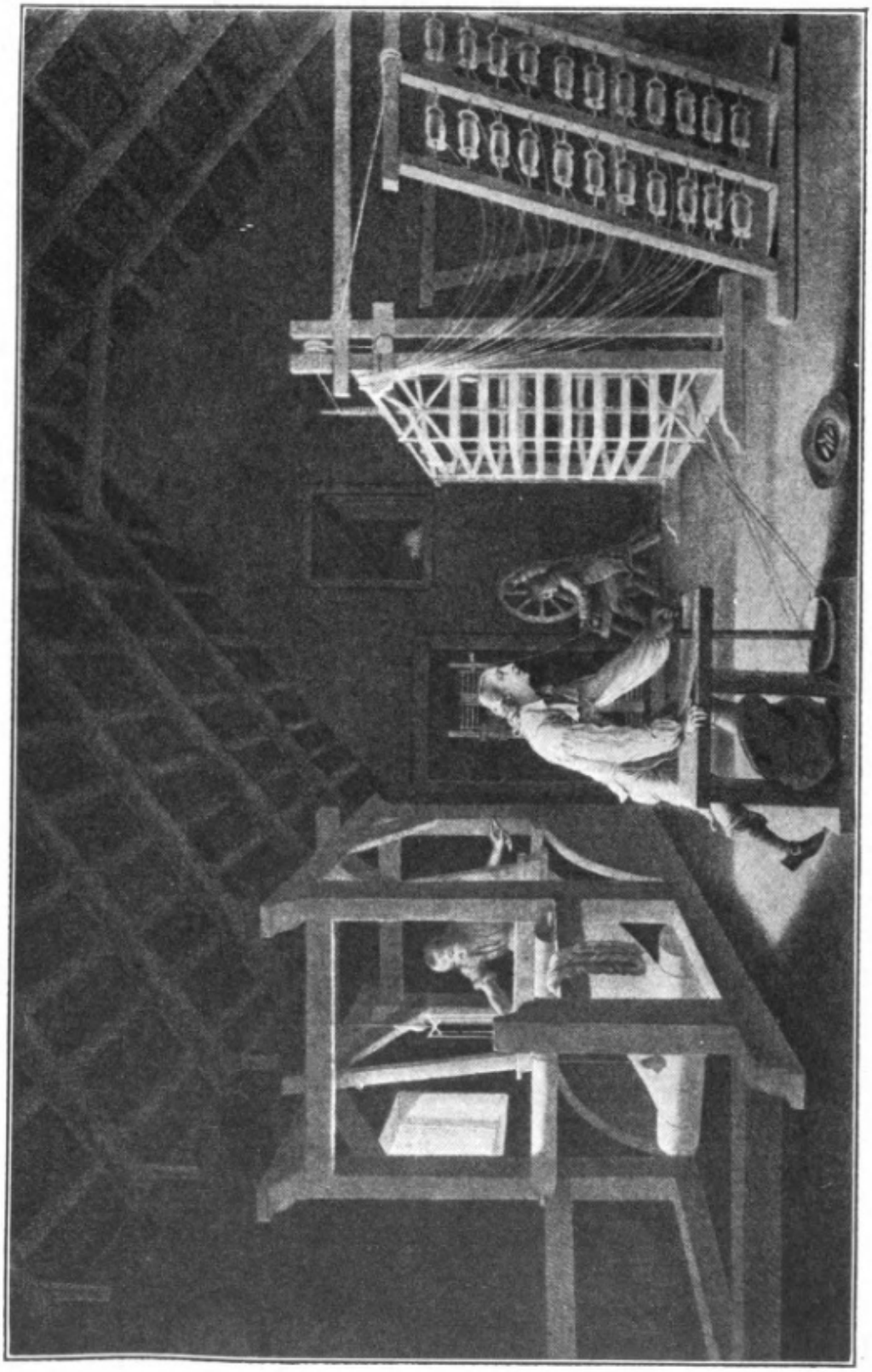

FIG. 28. — AN ANCIENT WEAVE ROOM.

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Our present knowledge of the beginnings of weaving comes (1) from the work of nations which are now in primitive conditions and whose work we can watch, such as the natives of the

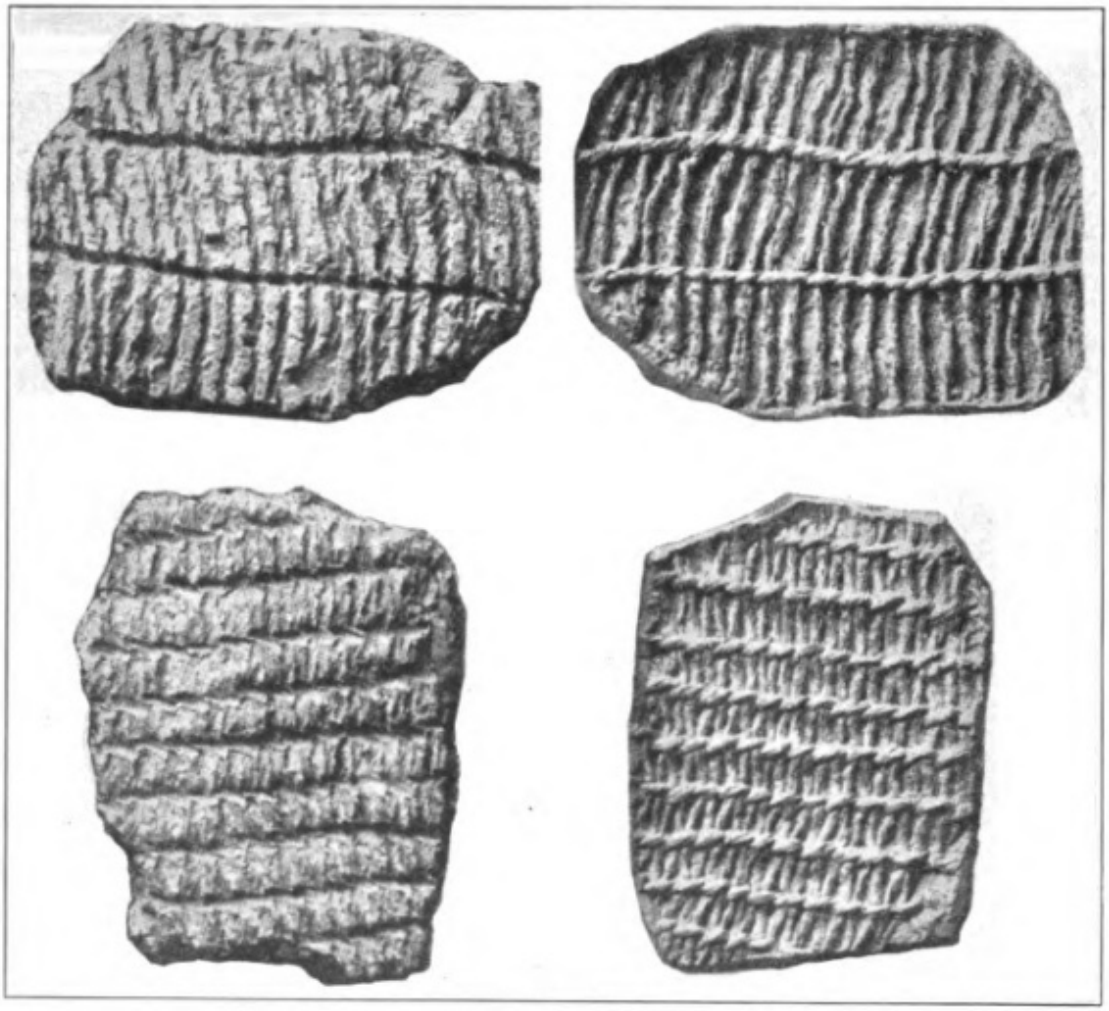

FIG. 30. — TEXTILE-IMPRESSED POTTERY.

A. Pottery. *B*. Weave used.

Philippine Islands, the American Indian, and African tribes; (2) from early pottery, which was frequently decorated with a textile design, and shows clearly that woven cloth was laid upon it when it was in a moist state (Fig. 30); (3) picture writing on tombs; (4) mats, rugs, and cloth which have been preserved in tombs. These ancient materials show the art from the coars-

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Primitive Looms. — Many kinds of looms were invented: (1) the upright or vertical, such as the Navajo Indian loom or some forms of the tapestry loom; (2) the horizontal loom, like those of the Moros of the Philippine Islands, and of the Zuni and Pueblos of America, a form also seen in the hand loom of colonial days and in the power looms, and (3) slanting looms, such as

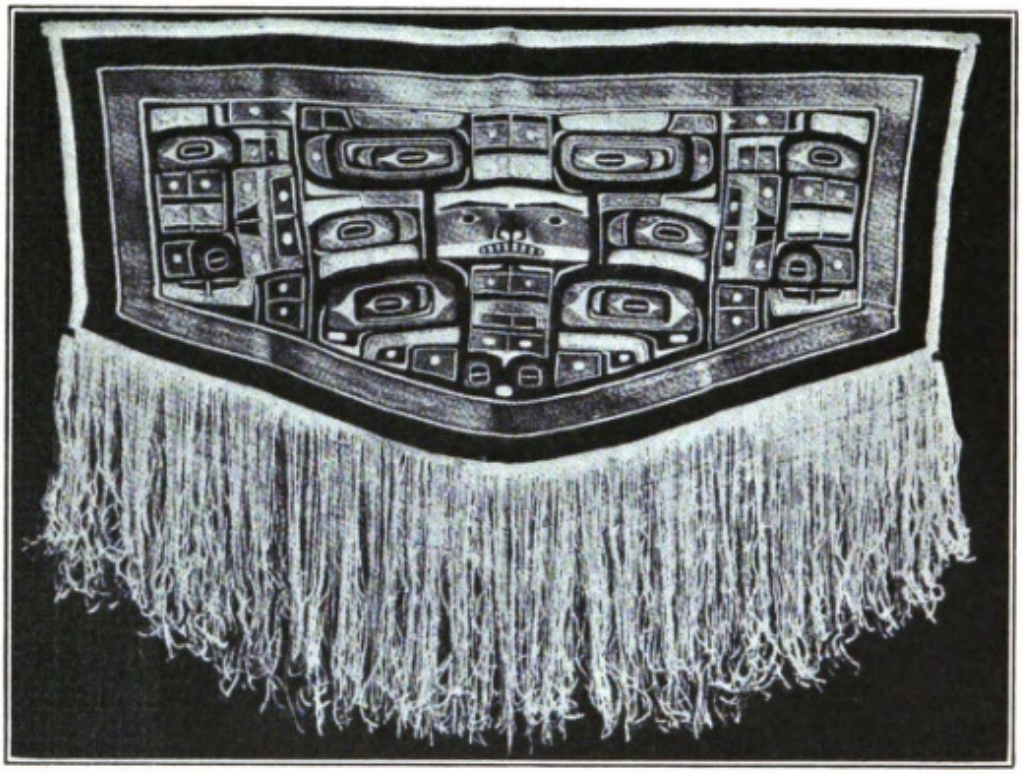

FIG. 31. — CHILCAT BLANKET.

are found among the rug makers of the East. A simple form of loom is found in British Guiana, in which the lower end of the warp is rounded by the use of a flexible reed, and the upper bar is straight. As the warp threads are put in they widen slightly. A rod laid across the warp is attached to alternate threads by a cord and is used as a simple means of drawing these threads out while leaving the others down, thus forming the shed. A slender stick on which some yarn was wound was used for a shuttle, and a wider stick with a flat edge beat the

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cession catching the yarn around each back thread in the lease and then around the rod. When all the back threads were thus connected with the rod, they could be drawn forward at one time, making a distinct shed. Through this the sword was thrust and turned over to make a wider opening of the threads, while the filling was inserted. A stick had been placed in the

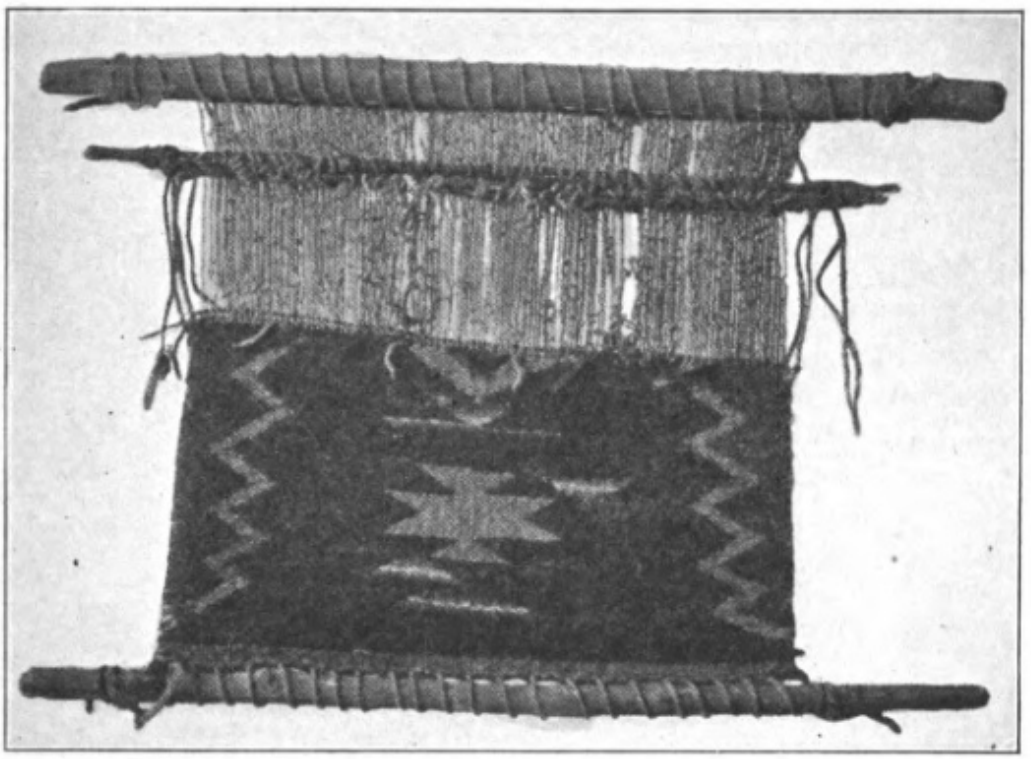

FIG. 33. — NAVAJO LOOM.

alternate shed, which preserved it. As the threads of this shed were forward in the crossing they were easily distinguished at any time. When this forward shed was to be used the sword or batten was placed in it and turned to its full width, as in the shed attached to the harness rod. The weaver usually began to work from the bottom up, but some worked from both ends, using a needle for the final weaving. She alternately opened the sheds, turned her batten in them, put her filling across, and drove it home with the batten by turning it flat and drawing it toward the finished weaving. She used a rude

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modern power loom (Fig. 47) is based. Continuous cloth was made, instead of the rug lengths of an earlier period. Our colonial loom was like the European hand loom, and the weaving was at first done in the homes. It is estimated that there were in this country one hundred twenty-five or more years ago about three and a half million spinning wheels, and a quarter of a million hand looms. When the inventions leading to power spinning and weaving made it more profitable to do the work in factories, a number of them were started in the East, and also

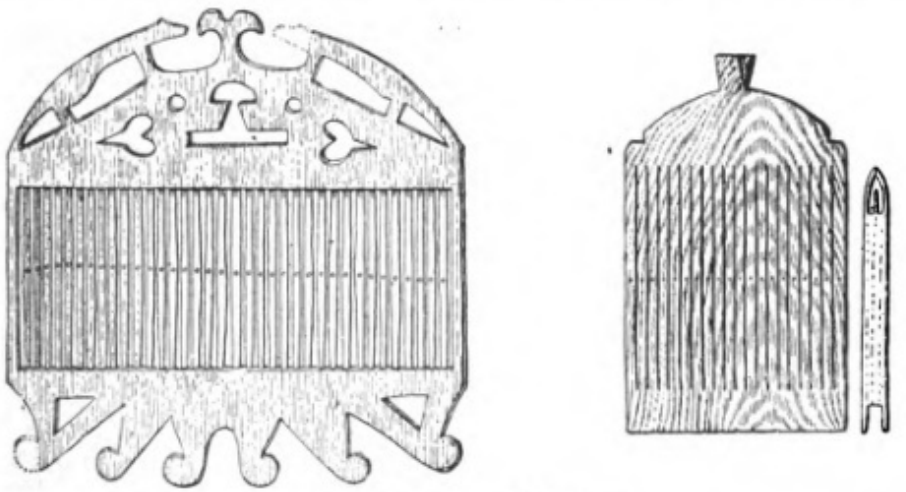

FIG. 35. — PRIMITIVE HEDDLES.

From Watson's *Textiles and Clothing*, by courtesy of The American School of Home Economics.

a few fulling mills were opened. Thus began our textile industry of to-day. The hand loom was used until about 1850.

The Parts of the Hand Loom (Fig. 34) were as follows: (1) *For the management of the warp:* The framework, *C*, usually of wood, and clumsily made, contained a warp beam, *A*, on which the yarn was wound, and a web, cloth, goods, or merchandise beam, *B*, for the finished cloth. These two beams were held in slots at each end of the framework; the warp, *W*, was stretched between them, passing through the harness, *H*, and the reed on the way. Weights on the beams or rollers kept the warp stretched. When the weaving was going on, and the weaver desired to wind up the woven cloth, and at the same time

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9. The threads must now be attached to the warp beam. They are slipped over a thin, flat stick which is attached to a piece of cloth fastened to the warp beam. Holes are punched at intervals in the cloth, and strings through these holes are tied to the stick. The warp threads or ends are stretched the required width on the stick.

10. The warp threads are distributed evenly on a raddle (Fig. 41) to a couple of inches wider than the cloth will be. The raddle is placed near the warp beam, that the ends of warp may pass through it and wind smoothly on the beam.

11. The warp beam is slowly revolved by one worker and the chain is let out by the other, who stands on the other side of the raddle. The threads

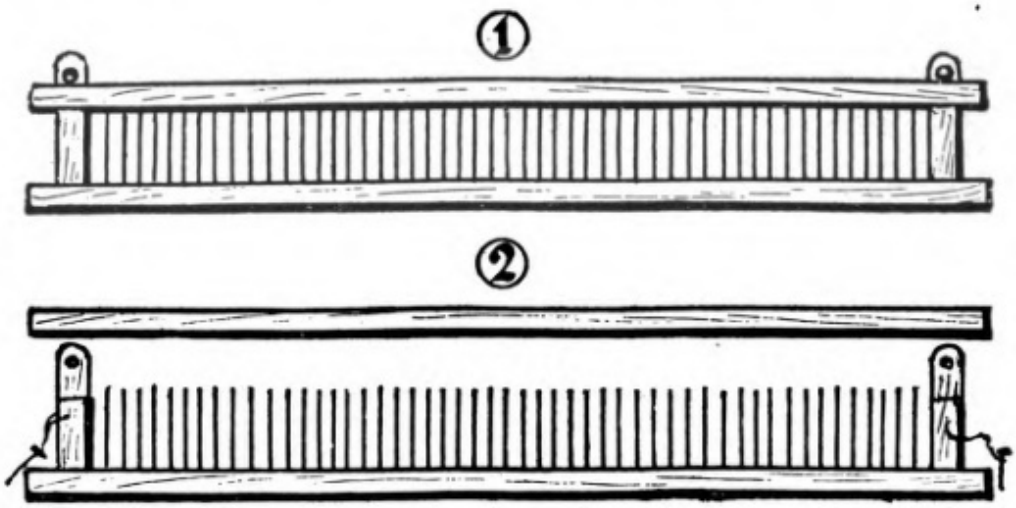

FIG. 41. — RADDLE.

From Hooper's *Hand-loom Weaving*, by courtesy of John Hogg, London.

pass through the raddle and the lease and are wound up evenly on the beam until the end of the warp is reached. A coarse brush is often used to lay the threads parallel.

12. Two sticks are placed through the lease in place of the cords. They are tied together at each end to keep the threads from slipping off. The raddle is removed, the threads of the warp are cut through and tied in bunches of ten or twenty on the harness side of the lease. It is extremely important that the threads shall go through the harness in the exact order that they come from the lease.

13. The ends of warp are now threaded carefully through the eyes in the healds of the harness. The order in which this shall be done depends upon the particular pattern required, and is indicated by a draft. (See Design and Draft.)

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14. When the threading of the harness is complete, the warp threads are taken one by one through the correct dents in the reed (Fig. 42).

15. The warp threads are passed over the breast beam and fastened evenly to the cloth beam in the same way as on the warp beam.

In general, when a warp comes to an end in a loom the threads are not pulled through the harness, but are left hanging in small groups and are tied together so that they cannot slip through. When that arrangement of harness is needed again, the new warp threads are tied to the old by a flat or weaver's knot, or twisted one by one to each of the former threads. This method saves much time. A good worker can twist in seven thousand new threads in a day. Machinery which does this work as well and more rapidly

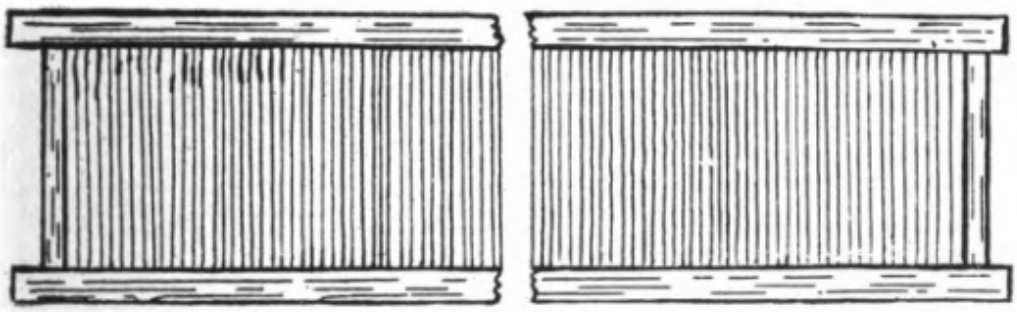

FIG. 42. — REED.

is on the market. It is expensive and not found in the smaller mills. Hand threaders are generally employed. Two workers are usually found sitting on either side of the harness. One pushes the warp thread through the mail eye with a little metal device, and the other receives it. Single warp threads are sized before weaving and after they are on the beam, to give them strength to bear the strain. Filling threads are not sized. For numerous details of warping and drawing in, see *Hand-loom Weaving*, by Luther Hooper.

Several processes mentioned in the above outline are given in greater detail below.

The creel (see Fig. 9) is an upright frame with a number of wire rods across it on which bobbins filled with yarn may be slipped. Threads are drawn from all the bobbins at once. The creels used by hand workers are of various sizes, carrying from ten to eighty bobbins. Those used for power warping frequently hold many hundreds. In hand warping the creel filled with its bobbins is placed beside the warping bars or

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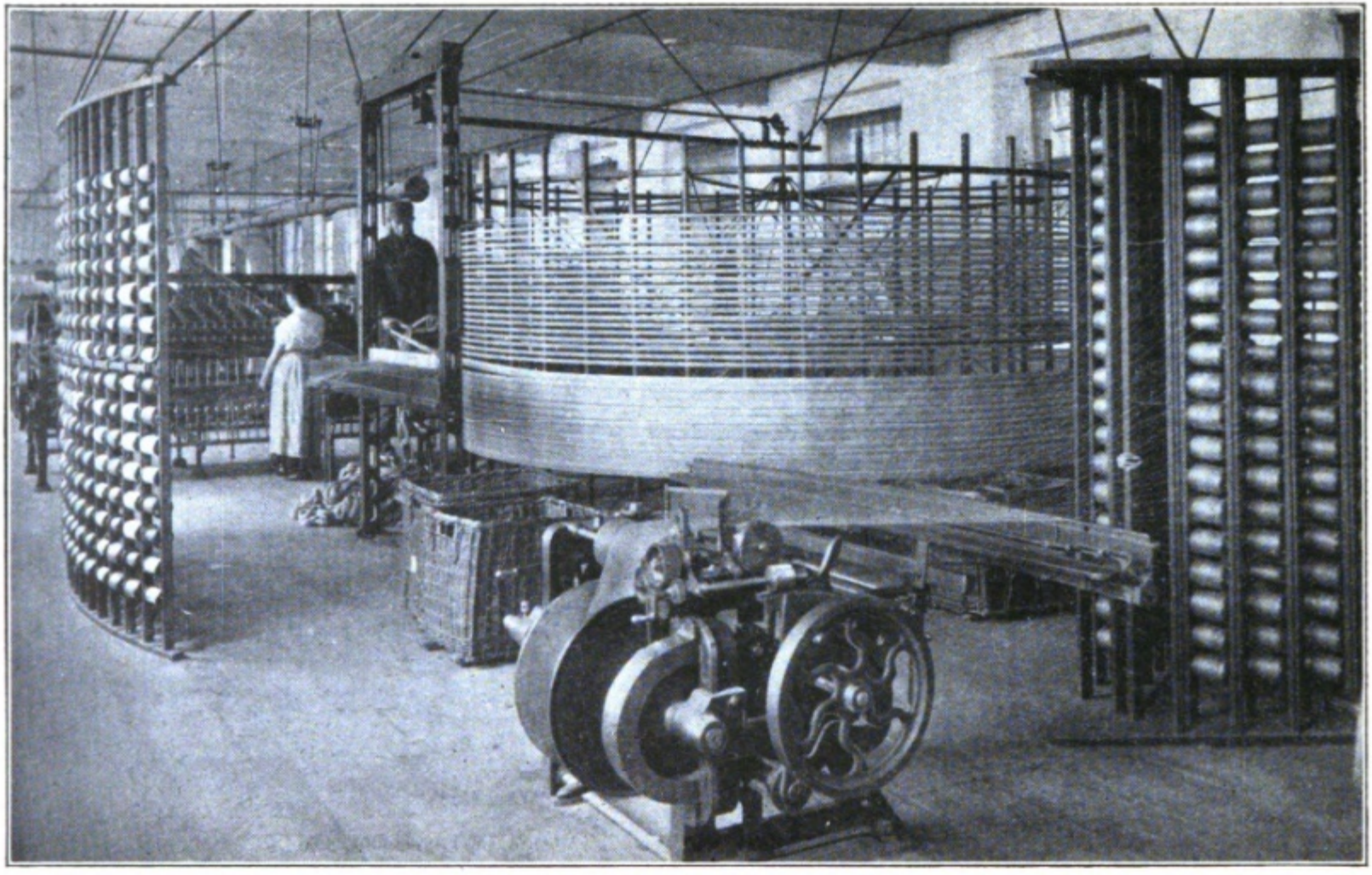

FIG. 43.—HAND AND SECTIONAL WARPING. THE ATTENDANT IS REMOVING A WARP IN CHAIN FORM FROM THE DRUM.
Courtesy of The York Street Flax Spinning Co., Belfast.

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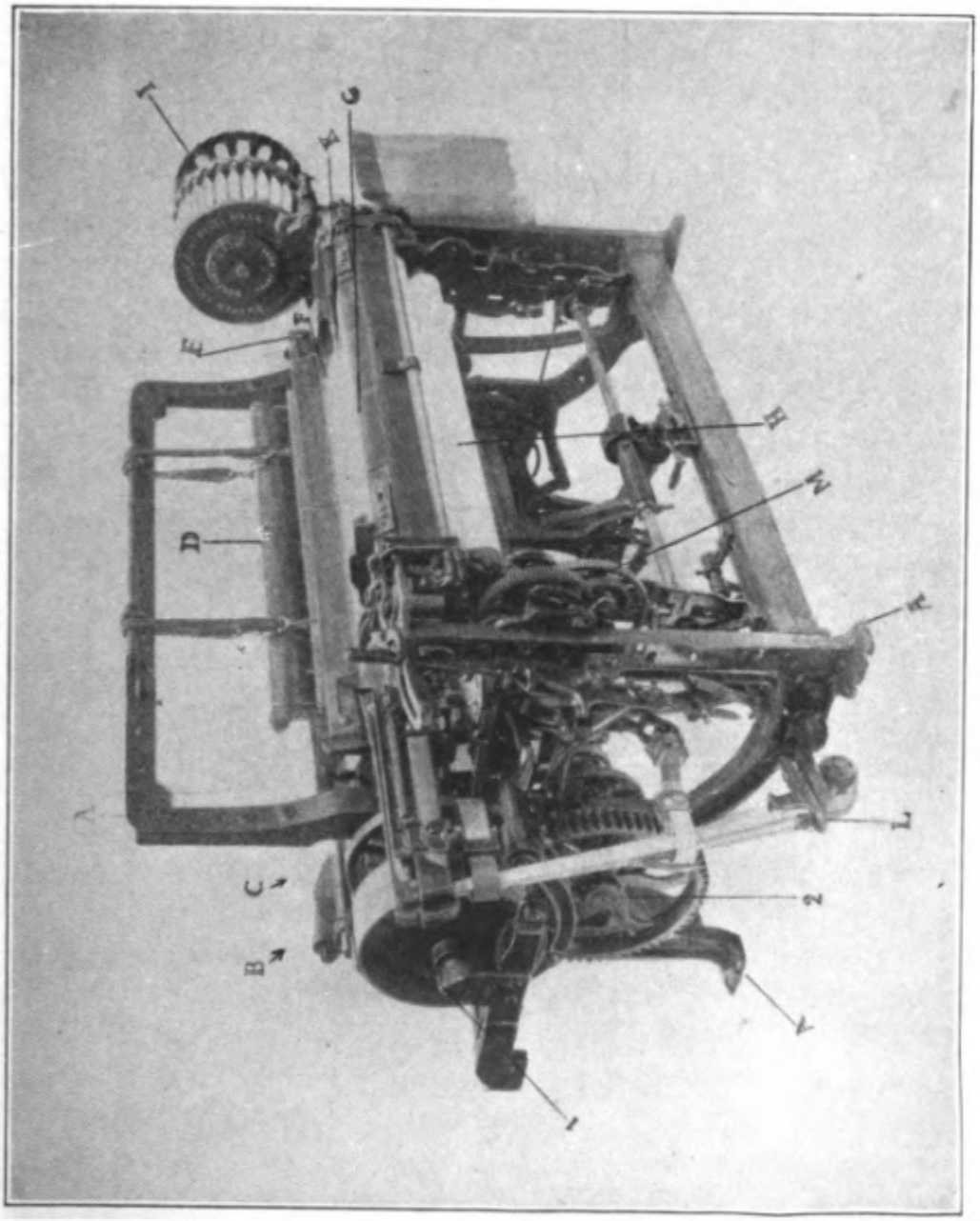

FIG. 47. — POWER LOOM.
Courtesy of The Draper Company.

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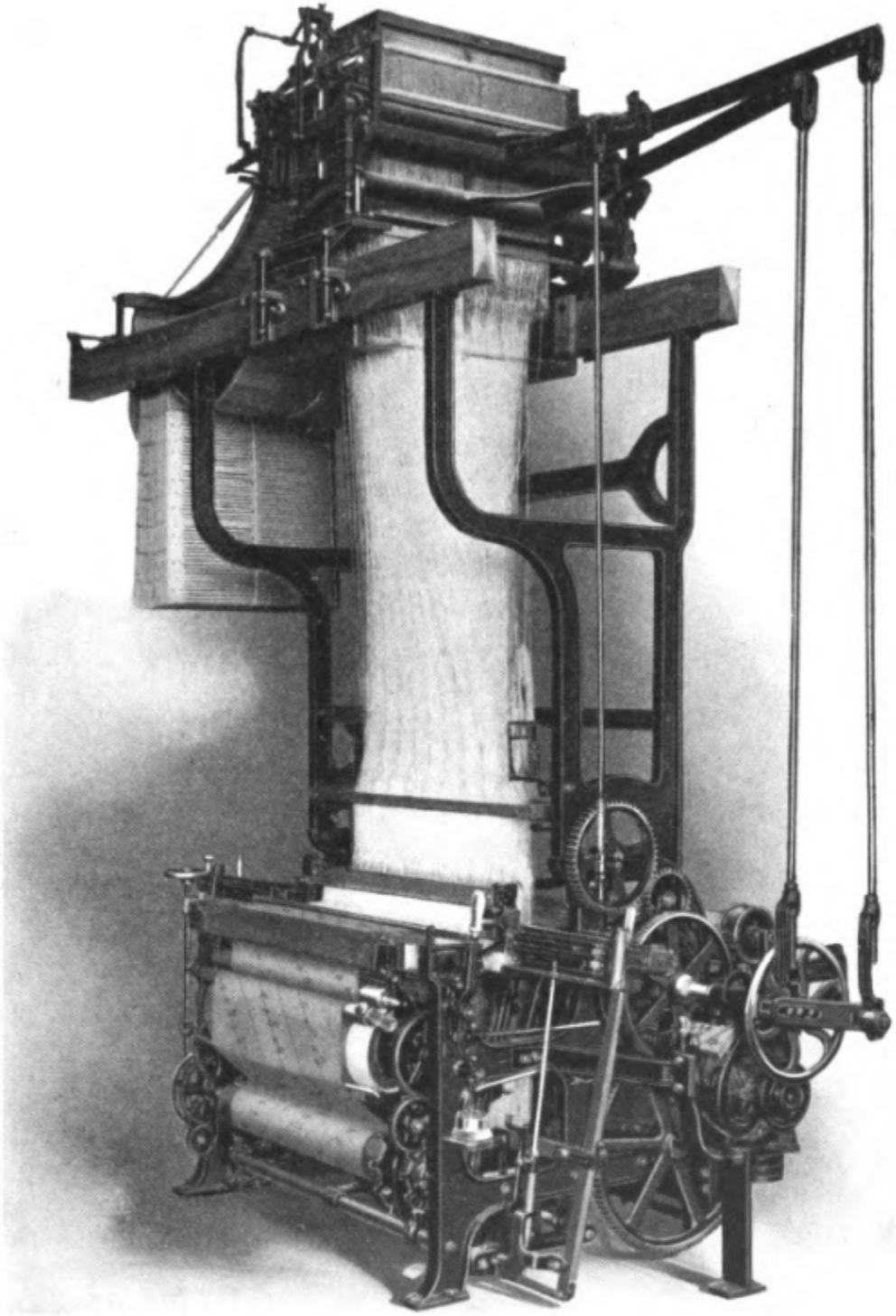

FIG. 48. — JACQUARD LOOM.

Courtesy of Crompton and Knowles Loom Works.

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the shafts attached to the hooks and make the shed. A second chain controls the shuttle. Multiplier chains duplicate the pattern and save time which would otherwise be taken in preparing the lags. The modern dobby offers almost unlimited possibilities.

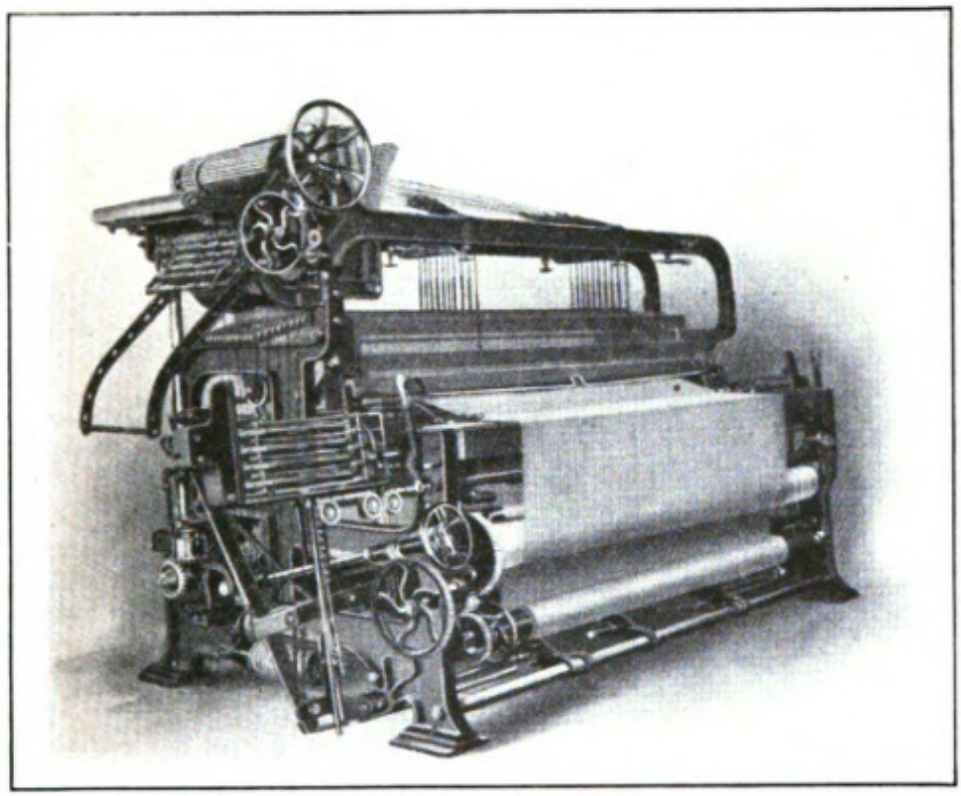

FIG. 53. — LOOM WITH DROP BOX AND DOBBY ATTACHMENT.
Courtesy of Crompton and Knowles Loom Works.

Another method of weaving intricate patterns without the use of the Jacquard harness is by the *head motion* attached to the harness loom (Fig. 54, showing detail). This is an American invention and is used extensively in the United States. The heald shafts in the loom are elevated or depressed by pulleys, but the series of mechanical devices which actuate the pulleys is quite different from the English dobby system. It is claimed that the head motion is simpler and more steady than the dobby. The pattern chain consists of high and low links, which control the elevation and depression of the shafts.

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The chain is made of a series of rods on which bowls or small

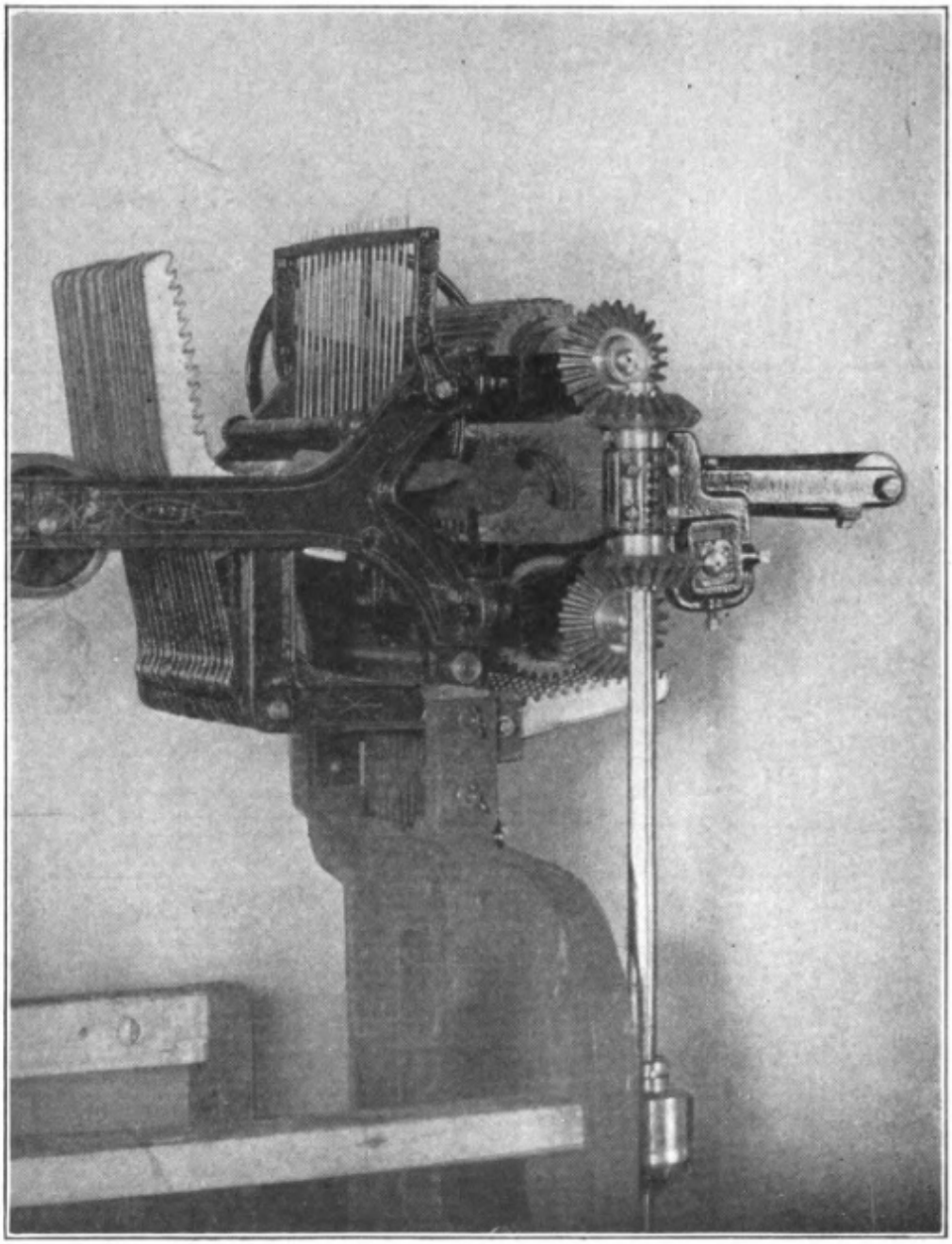

FIG. 54. — HEAD MOTION.

Courtesy of Crompton and Knowles Loom Works.

pulleys and lifters or risers and tubes called sinkers are arranged according to the requirements of the design. The chain lifts

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woven as double cloth, and are cut between the cloths, leaving a pile on each side (Fig. 58). Cotton velvets, corduroys, velveteens, and filling plushes are really varieties of double cloth. They are woven in a rib pattern, the cord being along the filling. The surface loops are cut by hand with a long cutter in the direction of the length. Cotton velvets require a great deal of finishing to make them look well. (See Finishing Cotton Goods,

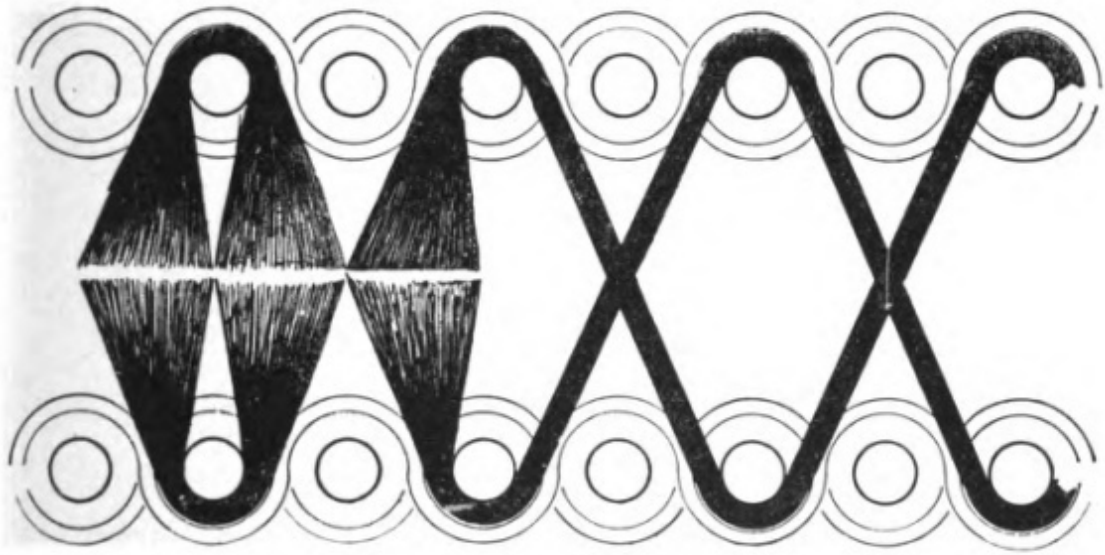

FIG. 58. — PLUSH WEAVE.

From Barker's *Textiles*, by courtesy of Constable & Co., London.

Chap. VII.) In their weaving the backing threads are brought forward to form part of the pile, and also to connect the two rows of warp threads. Different weaves are used to form the face and the back respectively, but the two must be designed to work in harmony with each other, or the finish will be defective. Crêpe or other crimped fabrics are woven in a variety of ways, plain, ribbed, or twilled. Some are made by using a sateen twill for the filling and a satin twill for the backing, the aim being to confuse the surface of the material by the way the stitches from the back break the face. Crêpe is also woven with the warp yarn twisted in one direction and the filling in the opposite. In the dye vat these yarns are differently affected

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make reversible material for heavy coating and rugs. Backing yarn is frequently made of much cheaper fiber in order to decrease the cost while adding to the weight. Shoddy, coarse wool, and cotton are used for backing threads.

Design, Pattern, Draft, and Drawing-in. — Weaving may be very simple, with only an alternation of two sets of threads, as in cheesecloth (see Fig. 4), or it may be so complex that hundreds of changes are needed to complete the pattern, as when coats of arms or portraits of noted people are woven on Jacquard looms. When the hand loom could produce the intricate designs which we see in the Spanish, Italian, Sicilian, and Oriental cloths of the thirteenth century, a system of design was used to indicate the pattern, called drafting. A draft showed the weaver: first, the manner in which the filling should cross the warp; second, the entering or drawing in of the warp threads into the harness; third, the tying of the heald shafts; fourth, the treadling or succession in working the treadles. Figure 59 shows a common way of indicating to hand-loom weavers one variety of the diaper, bird's- or fish-eye pattern. The draft has therefore the following meaning: There are four heald shafts; *i.e.*, there are four straight lines representing the shafts, and four treadles are attached singly to each shaft. The method of entering, drawing in, heddling, or threading the heald shaft is shown in Fig. 59 *B*.

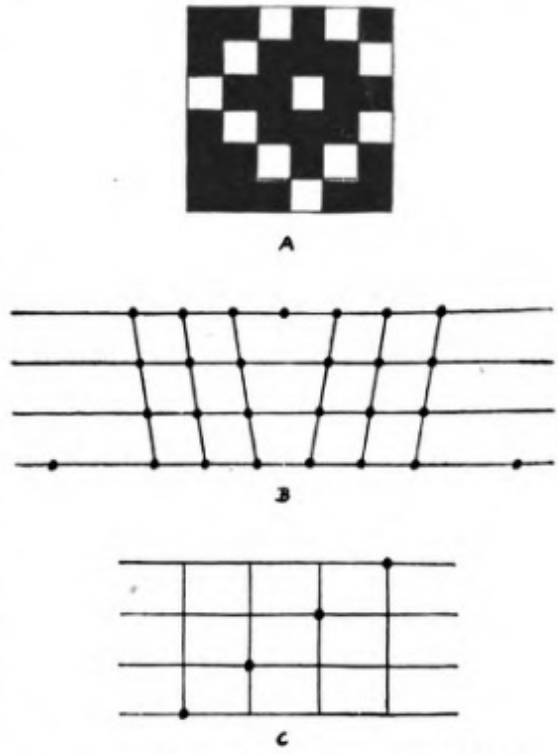

FIG. 59. — FISH- OR BIRD'S-EYE PATTERN.
A, Draft. *B*, Entering. *C*, Treadling.

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(Fig. 60). The Jacquard design usually requires ten by ten or twelve by twelve. These papers also come lined to represent coarser threads one way than the other, which condition is often found in weaving by having a heavy filling and fine warp. In general the squared paper is preferred. Ways of indicating the method of procedure on the paper in the draft differ slightly. In the accompanying illustrations the shaded blocks represent the warp threads and the white blocks show that the filling is on top with the warp underneath. The numbers when given at the side indicate the number of shafts or leaves required by the weave.

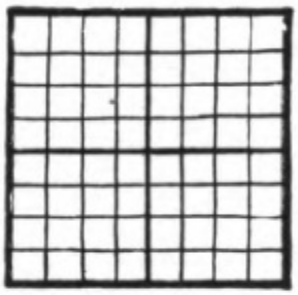

FIG. 60. — DESIGN OR POINT PAPER.

The simplest alternation of threads is called the plain, tabby, or cotton weave. It is found in muslins, ginghams, prints, Panama cloth, and in some canvasses and broadcloths. India and taffeta silks and crash toweling also use the tabby weave. See Fig. 61 for the draft, which looks like a checkerboard. The numbers at the side show that under the first heald shaft a warp thread is up and then a filling thread, followed again by a warp thread. In the second shaft the filling thread rises first. Two alternations complete the pattern. When coarse yarns are in use, a two-heald shaft is sufficient. (See Fig. 62.) In finer yarns, four or even eight shafts are used (Fig. 62), as a better distribution of the warp threads can be made, thus lessening the strain and liability to break. The threads are so inserted and the shafts connected that they act as two, the odd numbered threads being raised at one time and the even at the other. There are variations of plain weaving which give considerable latitude in design. Basket or Panama weaves (Fig. 63) have two or more warp threads crossed by

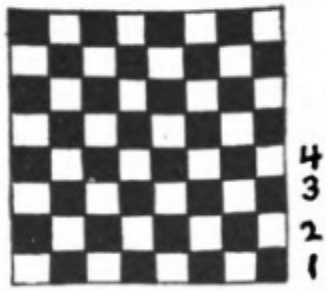

FIG. 61. — PLAIN WEAVE.

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forming a diagonal line across the material. In the three-shaft twill, the pattern begins to repeat itself in the fourth line. Twills may run to the right or to the left or both ways. In the latter case the design is called chevron, herring-bone, diaper, bird's- or fish-eye. Twills may be so made that either warp or filling may be thrown on the face of the material. In the four-shaft twill (Fig. 67 *A*) the filling is on the face, for three filling threads are up and one down. In *B* the warp is on the face, as three warp threads are on the surface and one below; consequently the twill is made by the filling. For the warp-faced twill there would be three risers and one sinker on the chain of a head motion loom, expressed as 3/1. If it were a four-shaft twill, filling face, there would be three sinkers and one riser, throwing the filling on the face, and expressed by 1/3.

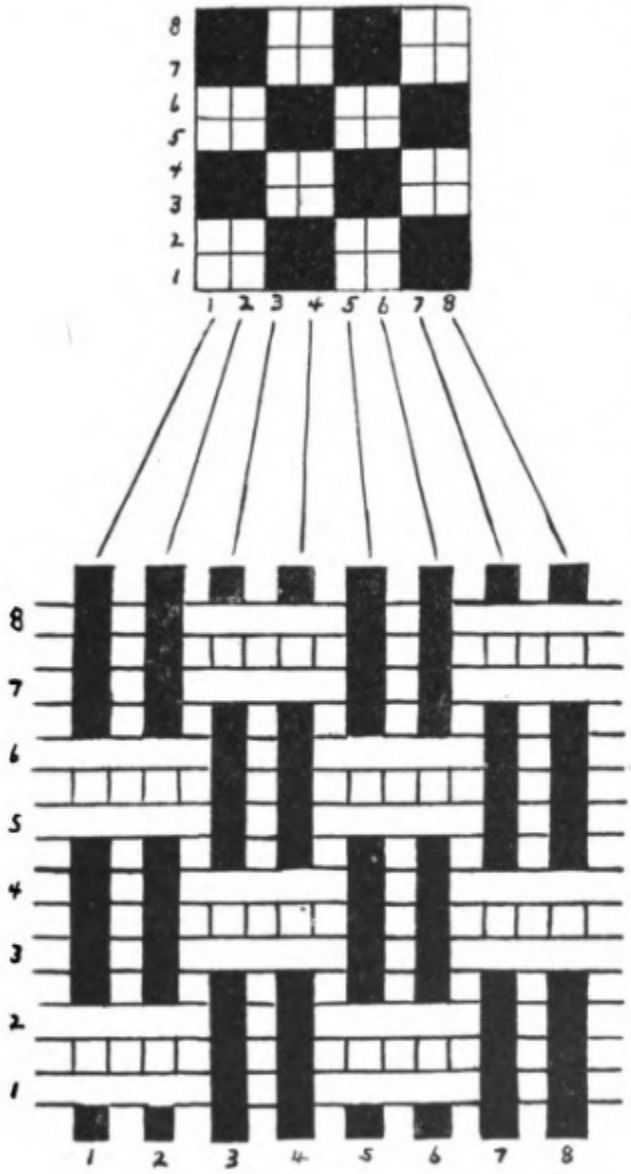

FIG. 63. — BASKET OR PANAMA WEAVE.

Drillings and jeans are often made on the three-shaft twill. Twills are among the most popular weaves. They may run

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as high as forty-eight or fifty shafts, each added number of shafts allowing a greater number of variations in the designs;

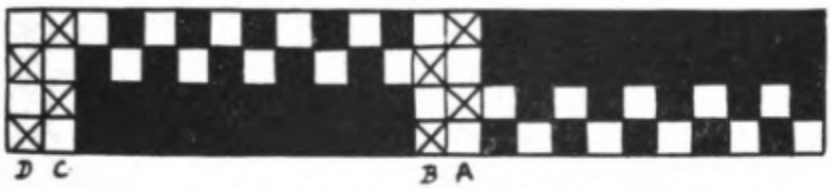

FIG. 64. — BEDFORD CORD.

A, *B*, *C*, *D*, plain weave throughout, forming line effect.

therefore it may be said that there is an almost unlimited possibility of pattern. Twills may be even-sided, filling and warp balancing; or uneven-sided, filling and warp uneven, each additional shaft having its own advantages and variations. The principle of designing for the twill can be understood from the simplest ones. The following varieties are in use: broken, skip, corkscrew, double, curved, combination, steep, wide-waled, entwining, checker-board, pointed, and fancy. The four-shaft twill is very useful in woolens and worsteds, being found in blankets, cassimeres, and shepherd's checks. It is much employed in double-backed and stitched cloths for the backing weave. The five-shaft twill is used extensively in heavy materials, in doeskins, satins and sateens, Venetians, drillings, diapers, and damasks.

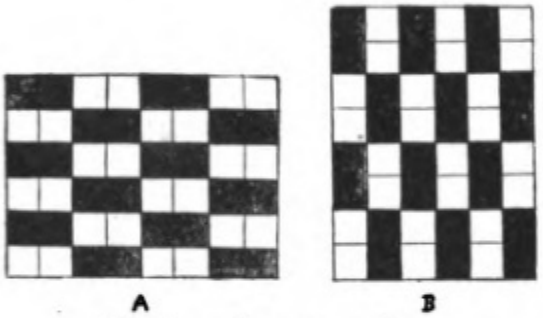

FIG. 65. — POPLIN OR REP.

A, Warp ways. *B*, Filling ways.

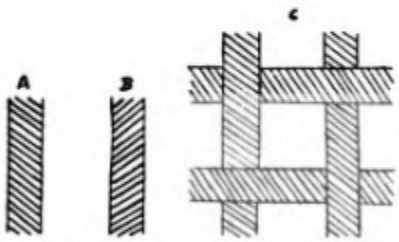

FIG. 66. — SHOWING TWIST OF YARN.

A, Left twist. *B*, Right twist. *C*, Combination.

Satin weaving combines the characteristics of the twill and the figure, and may be included under twill weaving as well

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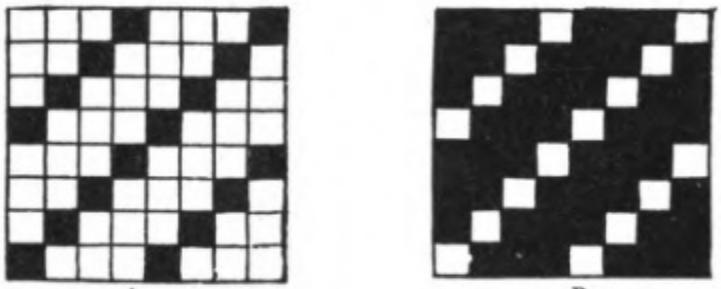
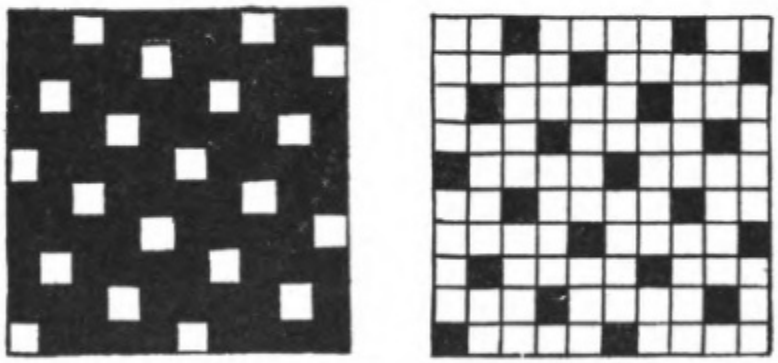
as figure weaving. The term satin or sateen (Fig. 68 *A* and *B*) is used to designate certain classes of design, such as five-shaft or eight-shaft satin. These same terms are often used inter-



A *B*

FIG. 67. — FOUR-LEAF TWILL.
A, Filling for face. *B*, Warp for face.

changeably, but according to some authorities the warp-faced design, *A*, is the real satin and the filling-faced is the sateen, *B*. The expression often seen, " weft-faced satin," would according



A *B*

FIG. 68. — SATIN WEAVE.
A, Real satin: warp face. *B*, Sateen: filling face.

to these authorities refer to sateen, and " warp-faced sateen " would be satin. The word sateen was first used for cotton satin made to look like silk satin. Damasks are often woven with the background sateen and the figure satin, that is, the figure weave is a lengthwise twill and the background a cross-wise one. The corkscrew weaves are on one of these principles;

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they are a steep twill. The twill effect is made clearer to the eye if it runs in the direction of the twist in the yarn. Smooth-faced serges are woven in this way, and the effect of clear light

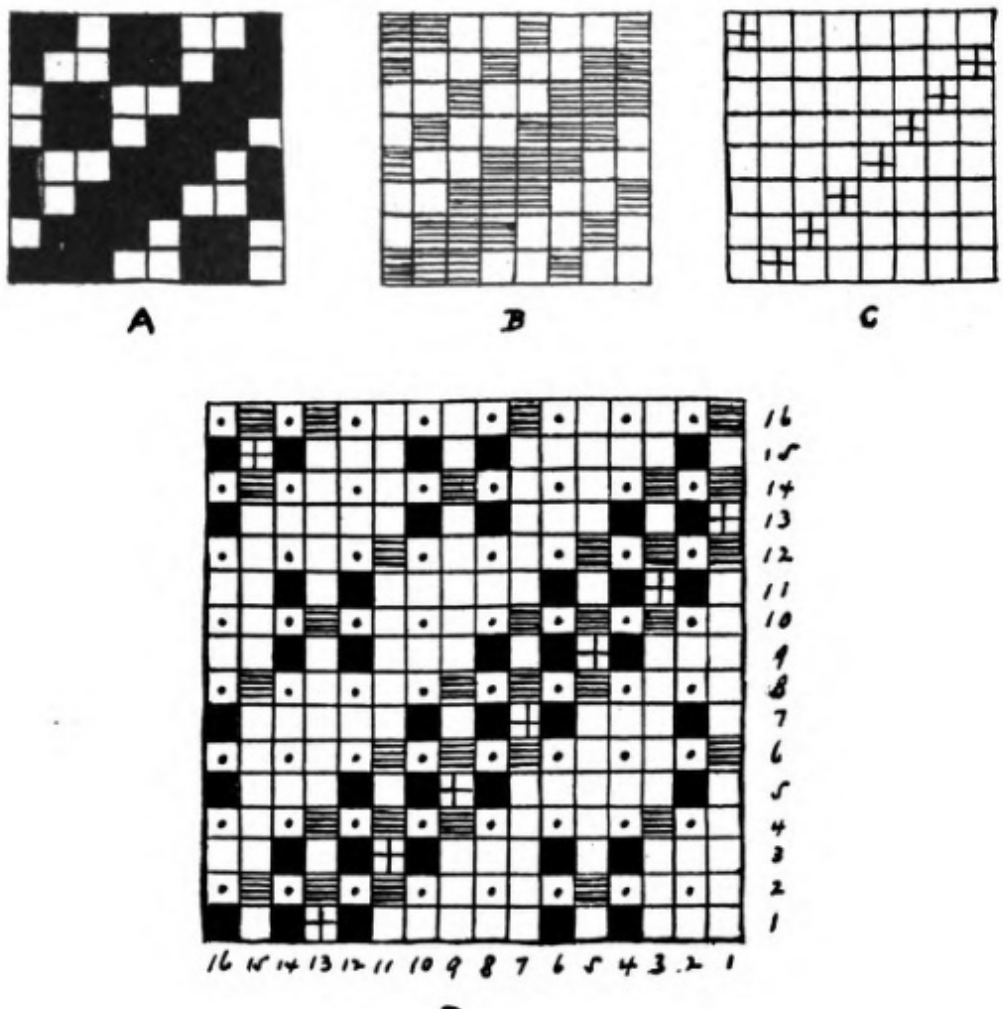

FIG. 69. — DOUBLE CLOTH WEAVE.

A, Weave for the face. *B*, Weave for the back. *C*, Arrangement for combining back warp with face filling. *D*, The complete weave. Repeat: 16 ends; 16 picks.

is increased by the finish. Rough twills are often woven with the twist of the threads running opposite to the pattern. Twills of various kinds are used extensively in elaborate floral figures and conventional designs, as a binder or stitch to hold together the warp and filling threads, that too long floats will not be on

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the surface. Elaborate combination twills look like Jacquard weaving, but are really only clever repeats, alternations, or reversals of pattern.

The stitches used to hold together double cloths are usually twills which come at intervals to the surface. (See Fig. 69 for explanation of the method of drafting.) In some classes of worsted goods the binder is frequent. The stitching requires care in planning, so that it does not make itself evident on the face of the cloth. The stitching stitches are now frequently employed in all classes of patterns. Cheap stock is often used for them, as it gives weight and does not show on the face. Cloths backed with shoddy or poor wool are usually rough on the wrong side.

Satins or Figured Weaves. — The step between twills and figured weaves is short. Satin really belongs to both, for it is a broken or skip twill. The object in satin or sateen is to throw a series of closely twisted threads on the face of the material, with a cross thread at intervals, that the floats of warp or filling may reflect the light. When the warp is constantly crossed by the filling, the reflection of light is interfered with. In the satin the cross thread binds sufficiently to hold, yet it is not noticed. Cotton-backed satins save expense, and the cotton thread coming to the surface is not seen. When well woven of good materials this class of satin is enduring. An odd number of shafts is preferred for the satins; the five-shaft is much used, but the seven shaft is considered a perfect satin. Diaper patterns (Fig. 70) and spots are illustrations of simple figure

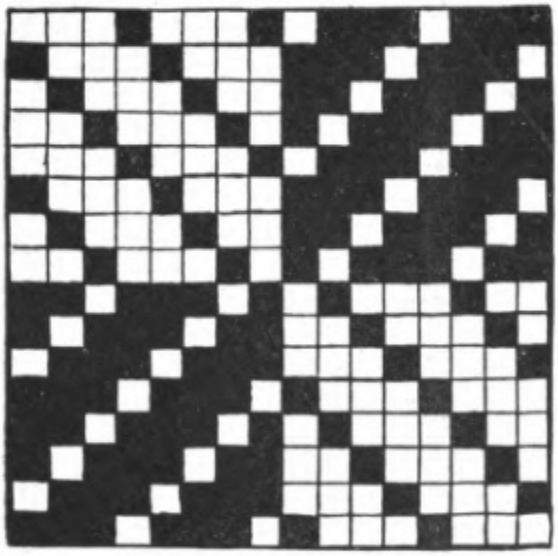

FIG. 70. — DIAPER PATTERN.

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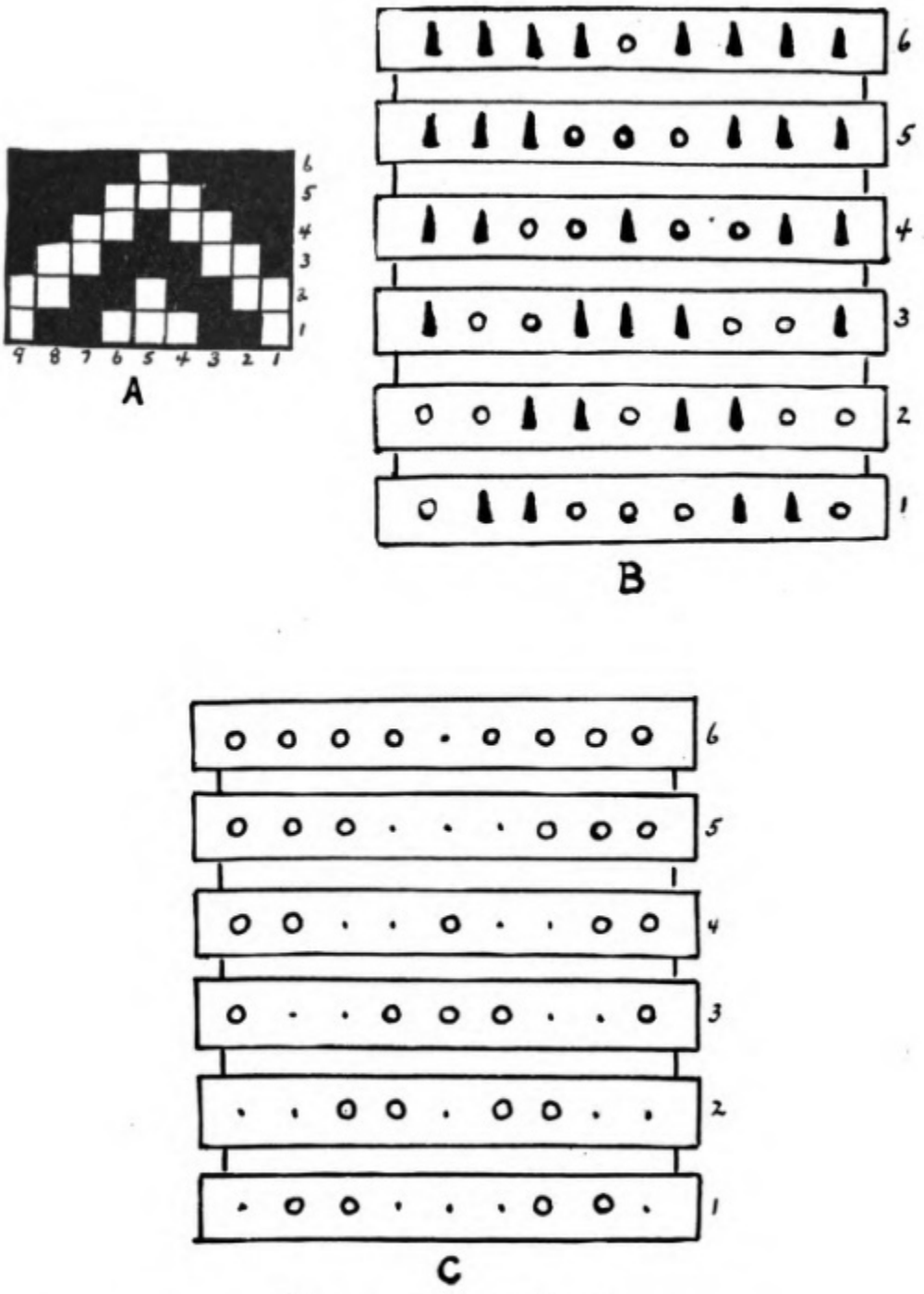

FIG. 71. — LOZENGE DESIGN.

A, Draft. *B*, Arrangement of pegs in the lags for the dobby. *C*, Arrangement of cards for the Jacquard harness.

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touch, and have a fair finish. Mercerized and lisle thread yarns are used widely for knitted goods.

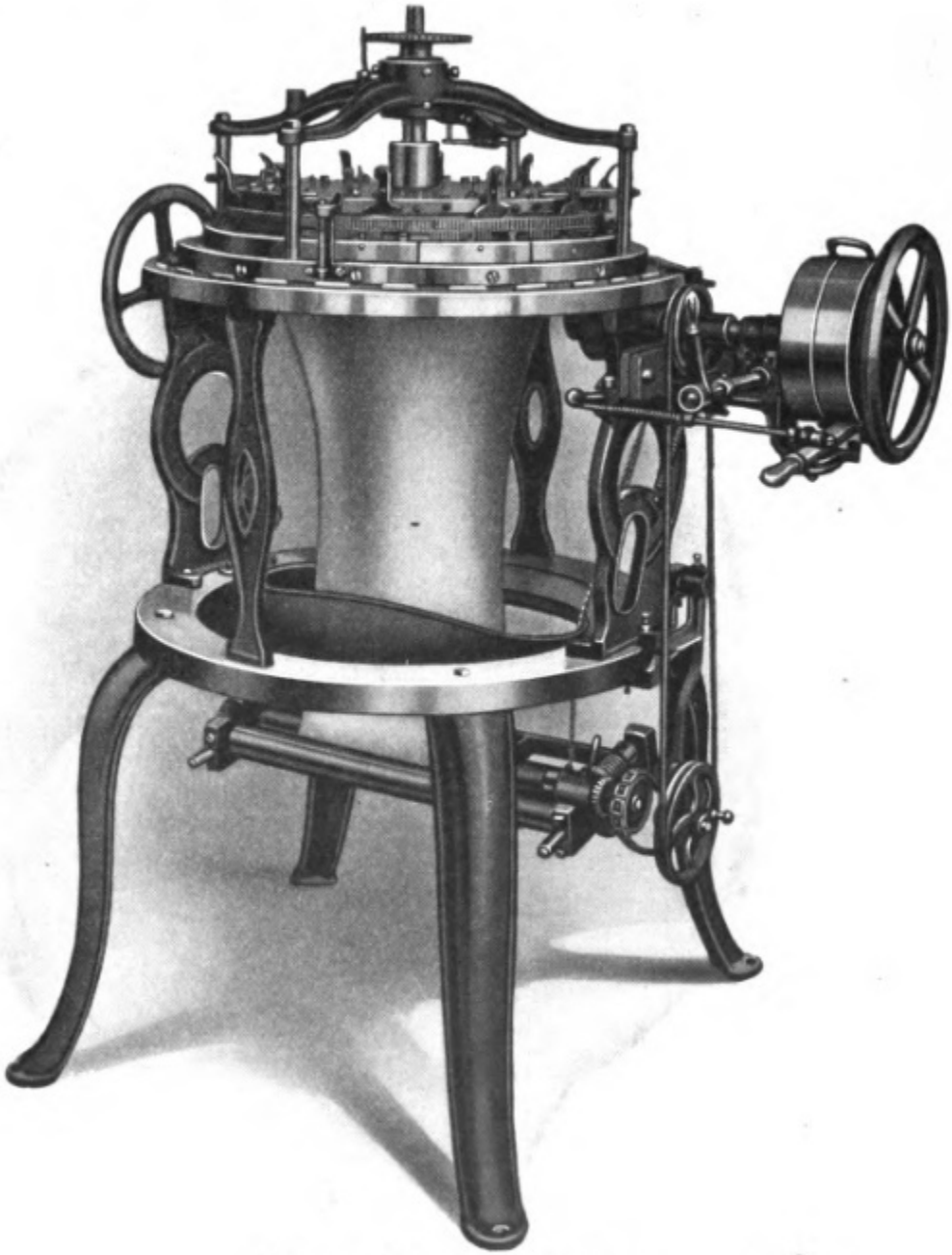

FIG. 72. — KNITTING MACHINE.

Knitting machines are circular in shape to make a circular article, or of a form to knit a specially shaped garment which

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The difference between woolens and worsteds was originally quite marked, for the short, serrated wools were used for the former, and the long, brighter varieties for the worsteds, but modern machinery can now comb the shortest staple wools, hence the difference is principally in the yarn preparation. The fibers which compose the woolen yarn are carded, but not

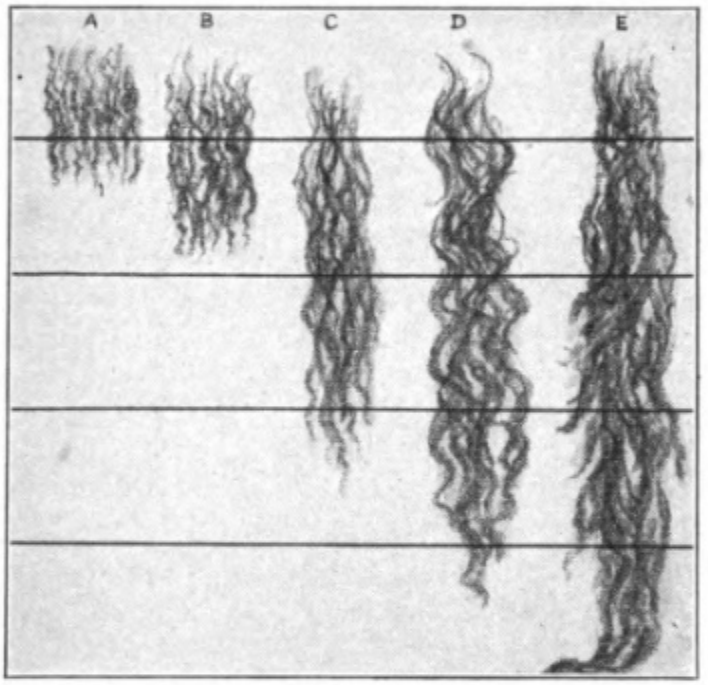

FIG. 74. — RELATIVE LENGTH OF STAPLE.

A, Merino.	Average length		$2\frac{1}{4}'' - 2\frac{1}{2}''$
B, Fine Crossbred.	"	"	$3''$
C, Alpaca.	"	"	$7\frac{1}{2}''$
D, Mohair.	"	"	$8''$
E, Lincoln.	"	"	$10\frac{1}{2}''$

combed, and cross and intermix irregularly, the appearance being soft and fluffy, and the preparation usually taking but a short time. The fibers, however, of worsted yarns are repeatedly carded and combed until they lie parallel and smooth, and are then closely and tightly twisted to make the yarn look regular and lustrous (Fig. 75). The preparation takes much longer than the carded woolen yarns, sometimes ten times as long. Woolen materials are usually soft, elastic, and of dull finish, and

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hair-bearing animals are used in the manufacture of woolen and worsted cloths (Figs. 79, 80). In a very general way wool or hair (the term wool is used to cover both) may be divided into two groups: short staple wools, the fiber being from two to

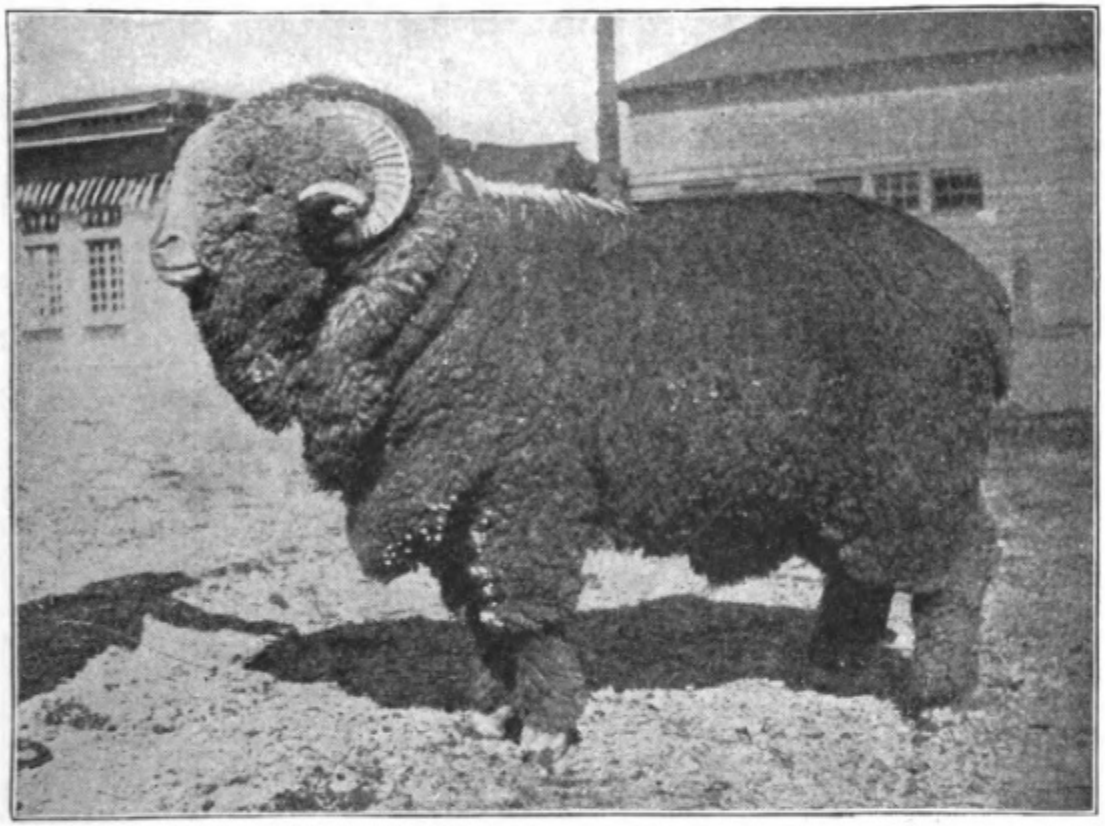

FIG. 79. — AMERICAN MERINO RAM.

From Collins' *Woolen and Worsted Spinning*, by courtesy of the American School of Correspondence.

four inches, and long staple wools, the length of fiber being from four to ten or even twenty inches. (See Fig. 74.) Some wools occupy a middle ground.

The various wools and hair now used in the wool and worsted industries of the United States fall fairly well under the following headings: —

1. Merino (Rambouillet breed is used extensively in the United States).
2. Crossbreeds from the merino and other sheep, notably the Lincoln.

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3. Pure blooded coarse- and long-haired sheep such as the Lincoln and Leicester.
4. Coarse wools from the sheep of China, East India, Turkey, Russia, and other countries.
5. Hair. Mohair, alpaca, camel's hair, and others.

The Domestic Clip. — The United States in 1912 grew about two thirds of the wool used in its woolen and worsted mills.

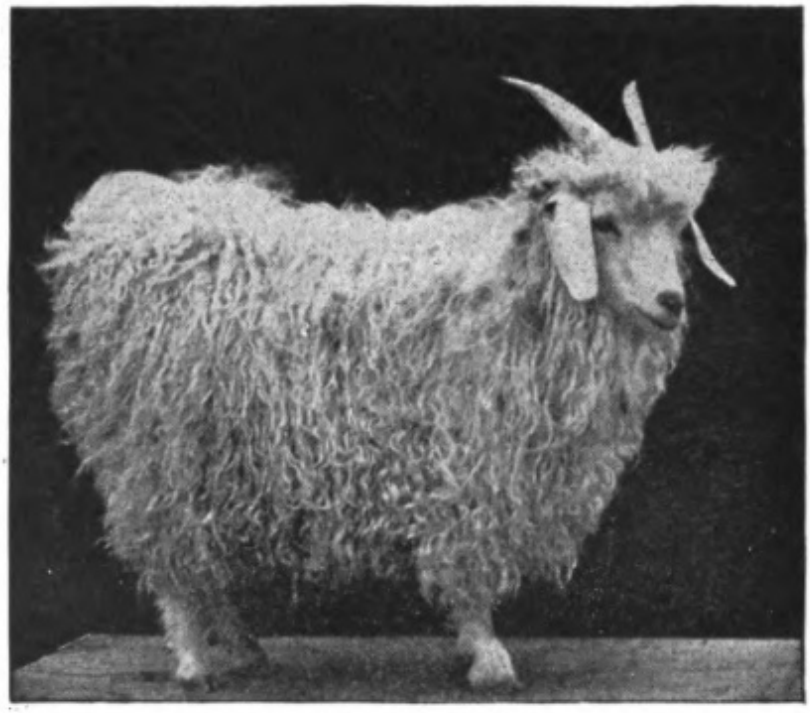

FIG. 80. — ANGORA GOAT.

From Collins' *Woolen and Worsted Spinning*, by courtesy of the American School of Correspondence.

Sheep are raised in most of the states, the mutton industry being often more important than the wool. New England breeds most of its sheep for food; the Middle States, of which New York had 625,000 sheep (April 1, 1912,[1]), subordinates its wool to its mutton. The South also inclines more to mutton breeds. The upper Ohio valley grows some of the finest merino wool equal to the Saxony, but the expense of raising is great, and mutton grow-

[1] Bull. National Association of Wool Manufacturers, 1912.

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sheep in a complete fleece. The shearer rolls it in a bundle. In large flocks the sheep are next branded on the back or side with the owner's mark. Complaint is constantly made by wool buyers of the careless use of paint in branding, which injures the wool, making some of it worthless for spinning. After branding,

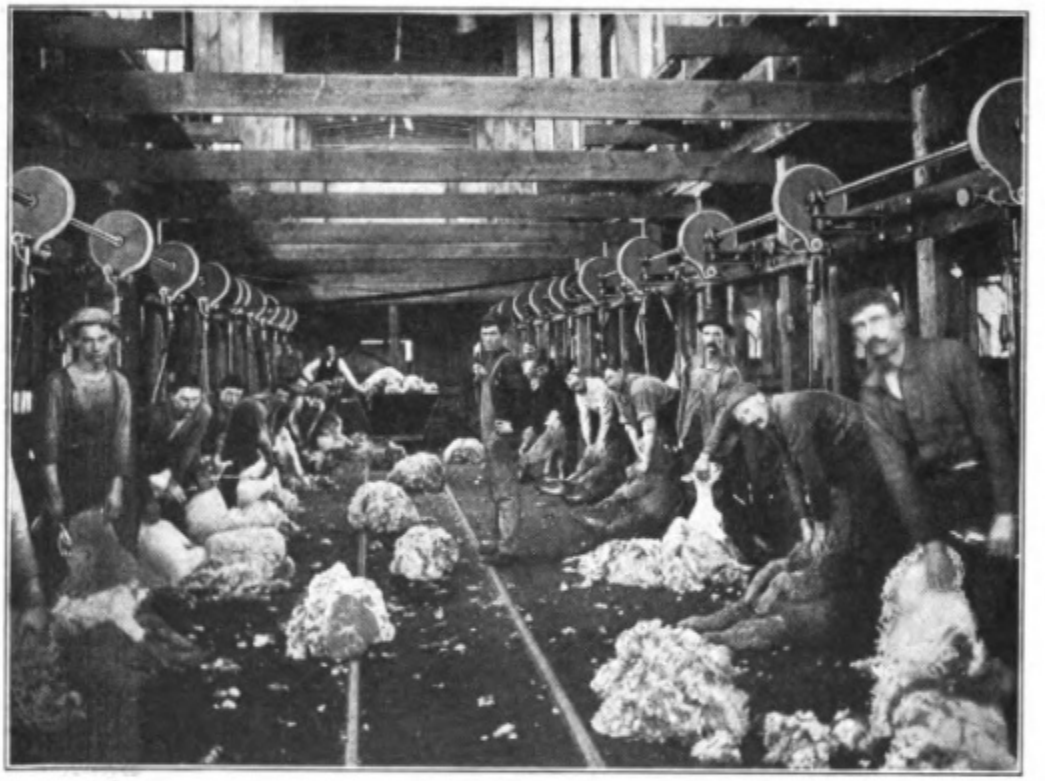

FIG. 81. — MACHINE SHEARING.

Courtesy of the Chicago Flexible Shaft Company.

the sheep are often dipped in an antiseptic solution to free them from parasites and disease. In some of the western states this is required by law.

The fleeces are taken to the wool packer (jamber) who sits on top of a wooden rack or framework (like a very high stool) which has a long bag hanging down in the middle of it, and a shelf at one side to hold the wool thrown up to him. The packer drops the fleeces into the bag and treads them down. One bag holds about forty fleeces, and weighs from 250 to 300

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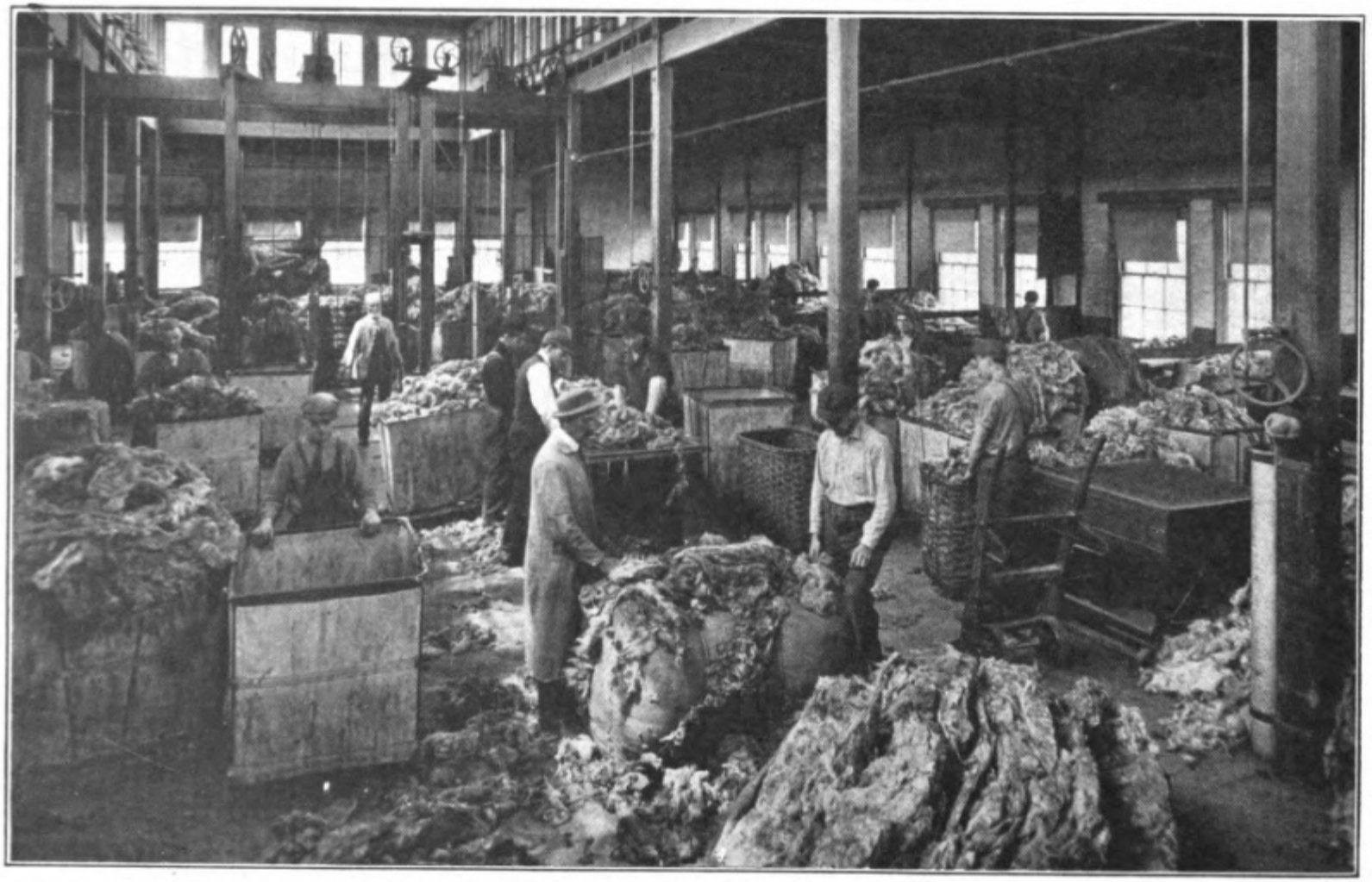

FIG. 82. — WOOL SORTING.

Courtesy of M. J. Whittall.

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the trouble by placing wire gratings on the top, and exhaust fans below to carry off the dust. Some fleeces are so dirty that they are mechanically opened and beaten before sorting. After separating the wool into its different qualities, the classes are piled in bins marked with their names. Wools from all over the world — white, yellow, black and gray — rest side by side

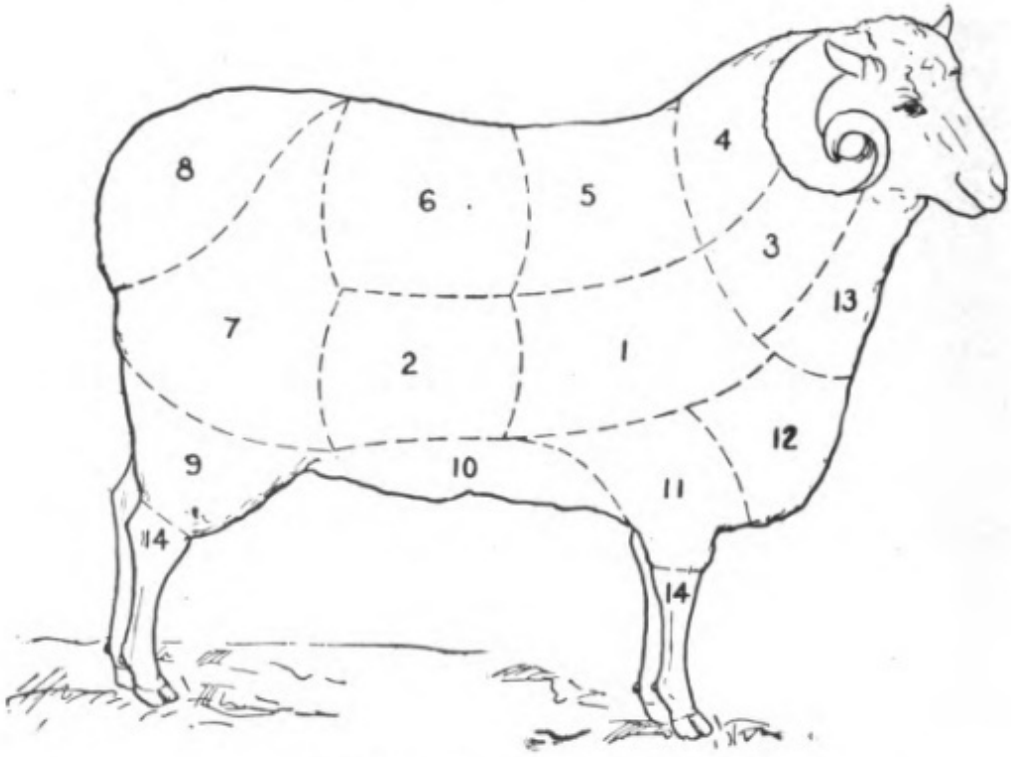

FIG. 83. — POSITION OF SORTS.

From Collins' *Woolen and Worsted Spinning*, by courtesy of the American School of Correspondence.

ready for use. When the wool is needed, it is usually blown through pipes or carried by other automatic means to the part of the mill where it is needed.

The Feed. — (A species of opener.) When wool is very matted and dirty it must be cleaned before scouring. This process is required by short staple wool rather than by long. Wool impurities are difficult to eliminate. Sand and dust can be beaten out, straws and burrs require carbonizing, animal

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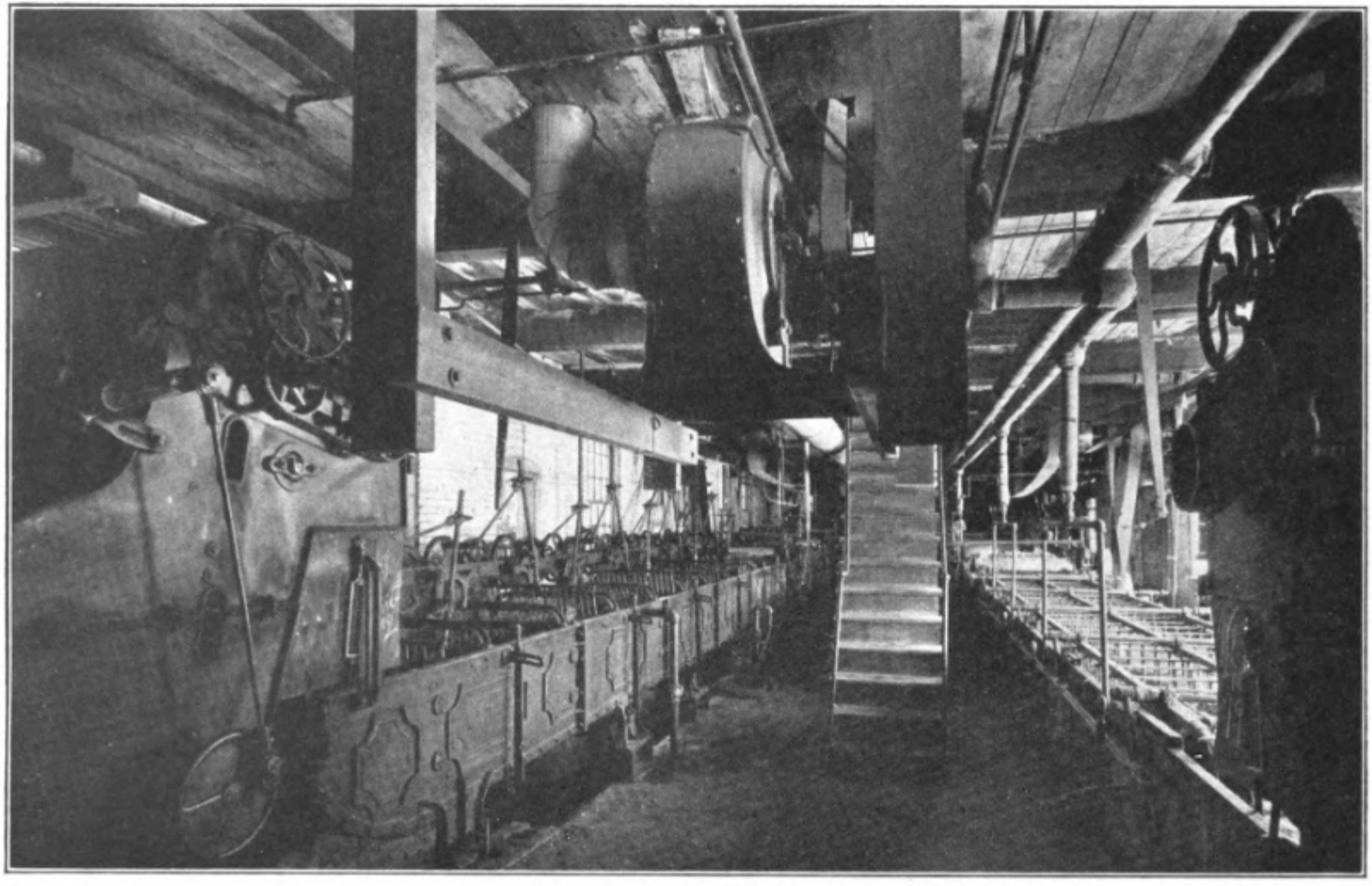

FIG. 84. — WOOL SCOURING.

Courtesy of M. J. Whittall.

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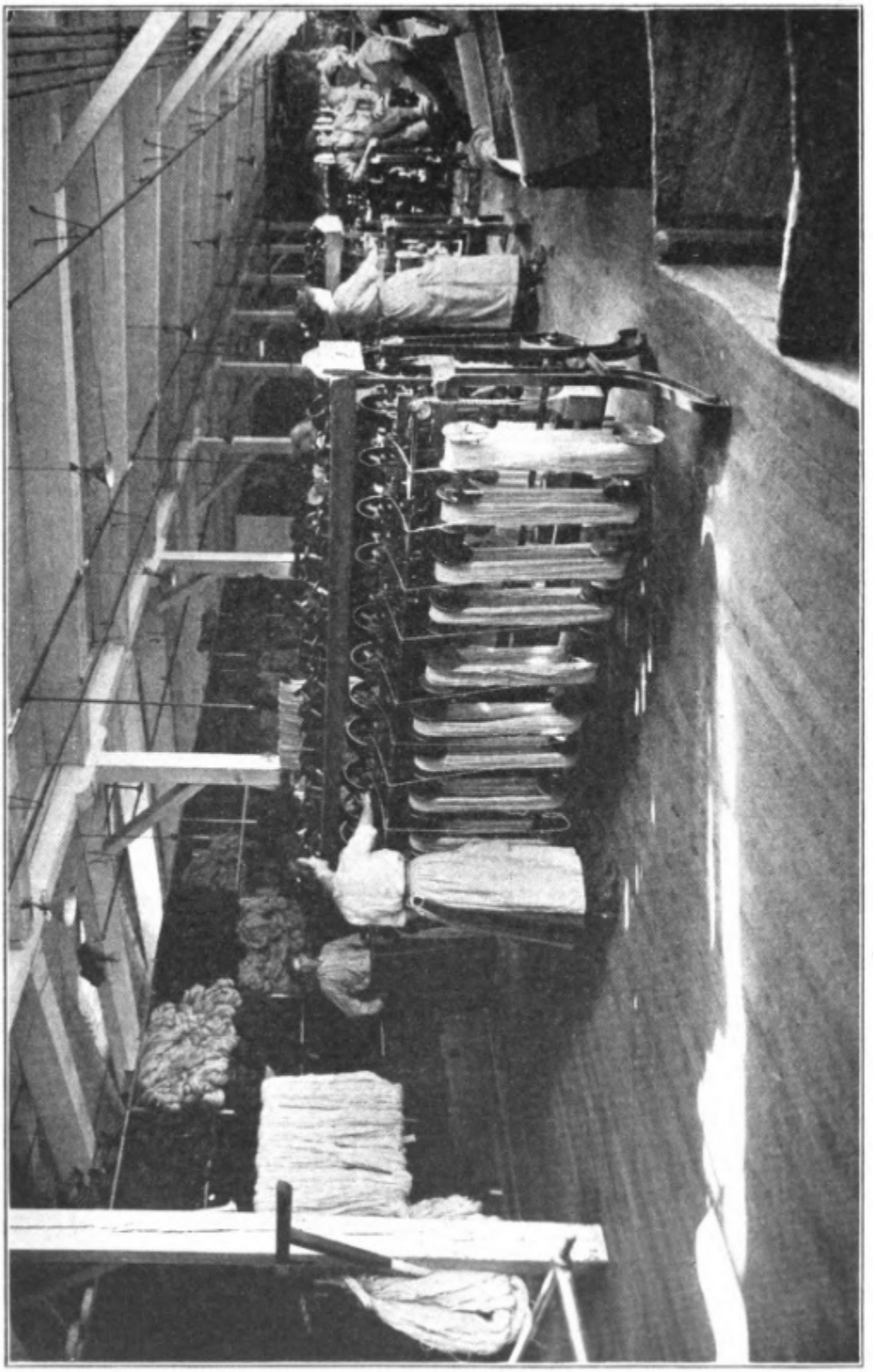

FIG. 86. — WINDING OR SPOOLING YARN.
Courtesy of M. J. Whittall.

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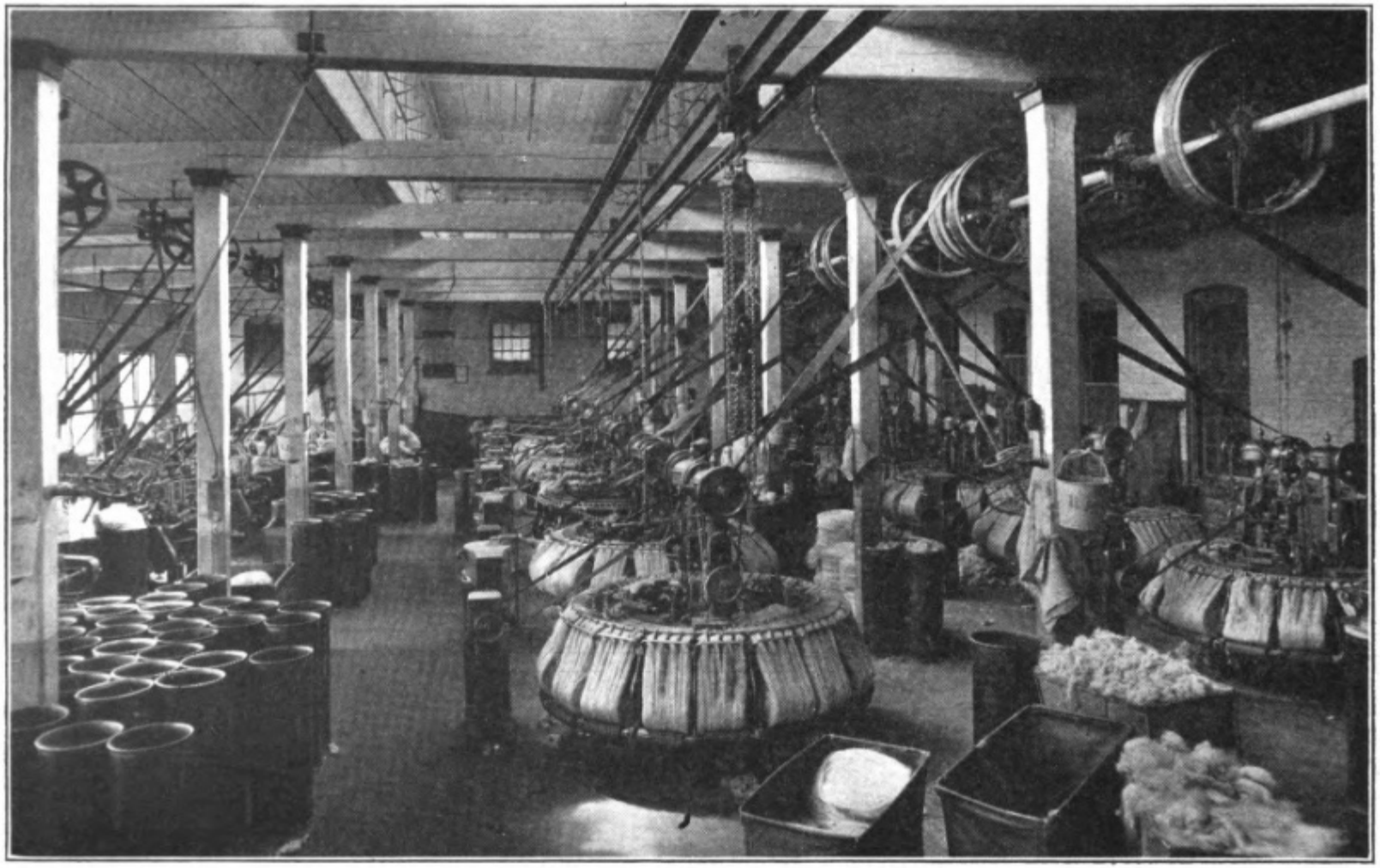

FIG. 87. — WOOL COMBING. THE NOBLE COMB.

Courtesy of M. J. Whittall.

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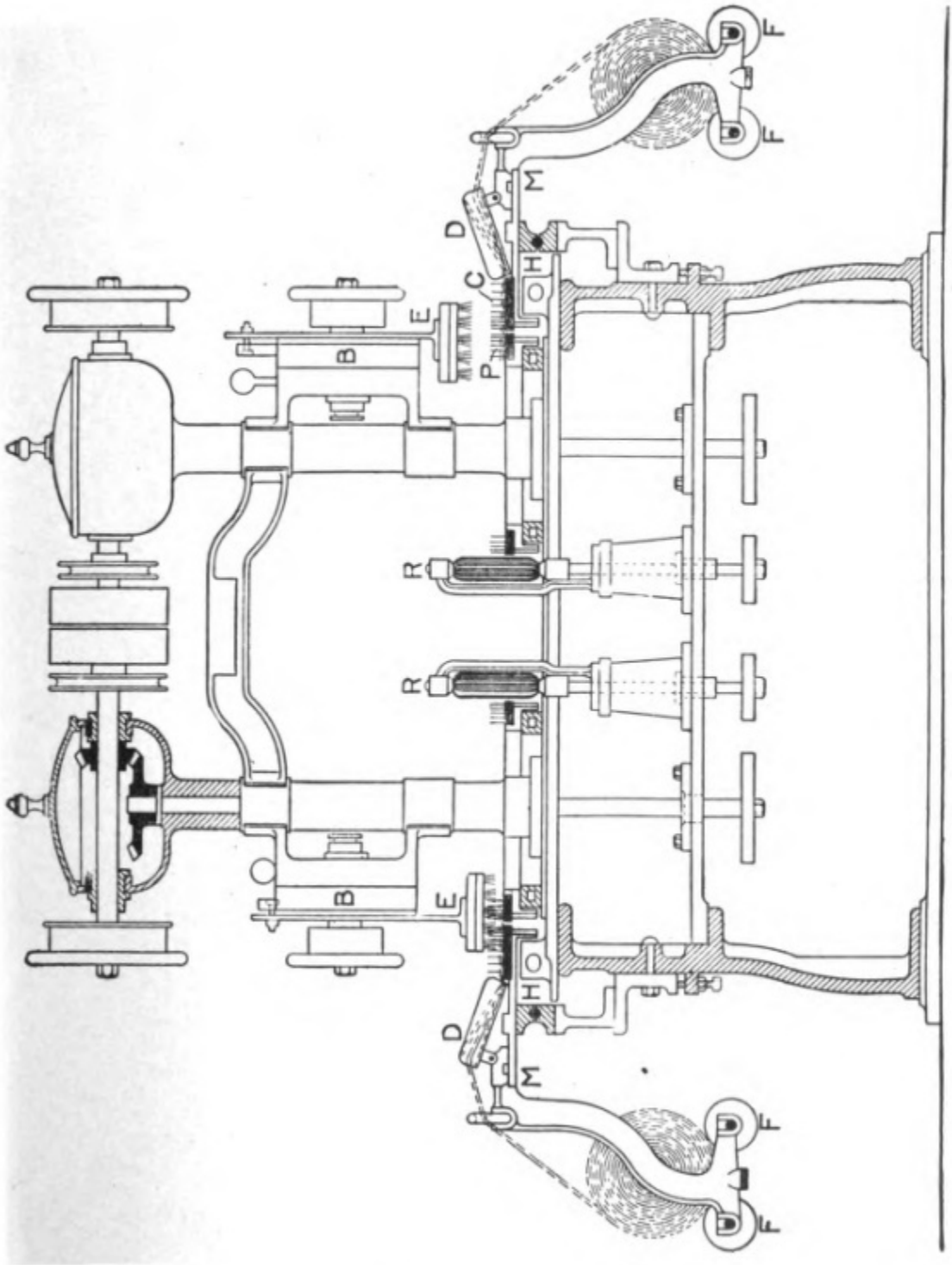

FIG. 88. — DETAIL OF NOBLE COMB.

From Collins' *Woolen and Worsted Spinning*, by courtesy of the American School of Correspondence.

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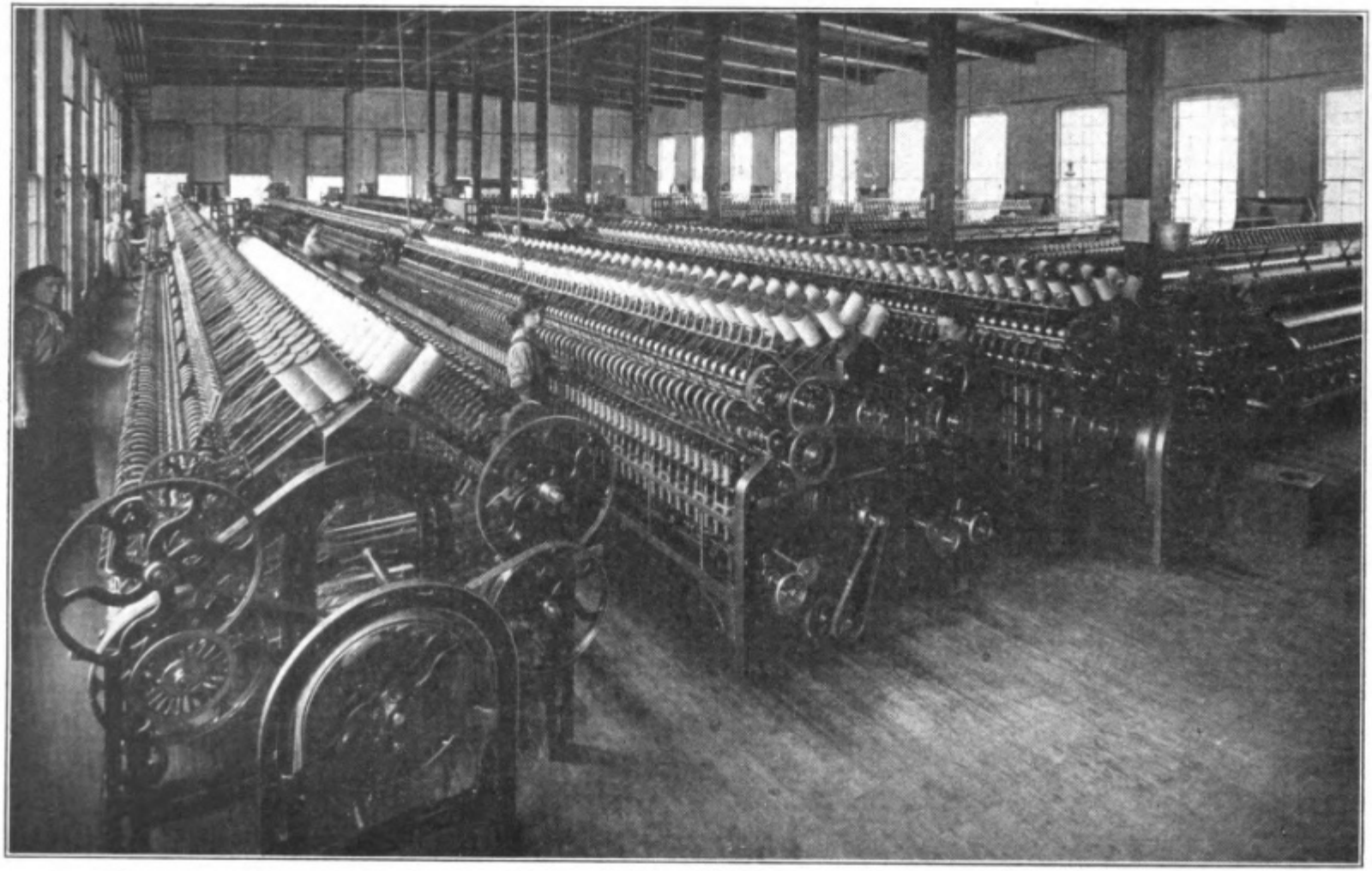

FIG. 90. — SPINNING THE WOOL

Courtesy of M. J. Whittall.

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Worsted suiting is merely napped enough to make the weave look clean and bright. Brushes are often used instead of teazles. Flannels are napped so that the weave is softened, but such felted goods as broadcloths and meltons have the pile so raised that the weave is completely obliterated. They have to pass many times through the gig to accomplish this. Defects are often concealed by softly raising a surface and finishing it to look well. The Raising Gig (Fig. 91) is a large, open cylinder on which a series of slabs or shallow boxes, the width of the cylinder, may be fastened. The best means of raising the nap is the teazle (Fig. 92), which is a vegetable growth something like a stiff thistle. Fine wire raisers are sometimes used, but have this disadvantage, that they break the cloth when in contact with a knot, whereas the vegetable teazles break first.

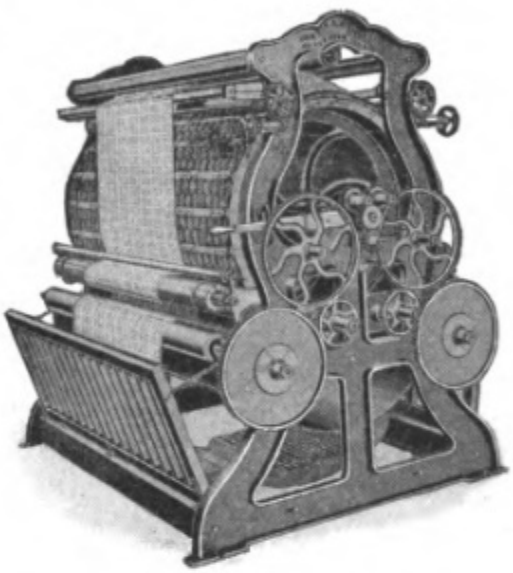

FIG. 91. — DOUBLE-ACTING GIG.

Courtesy of Curtis & Marble.

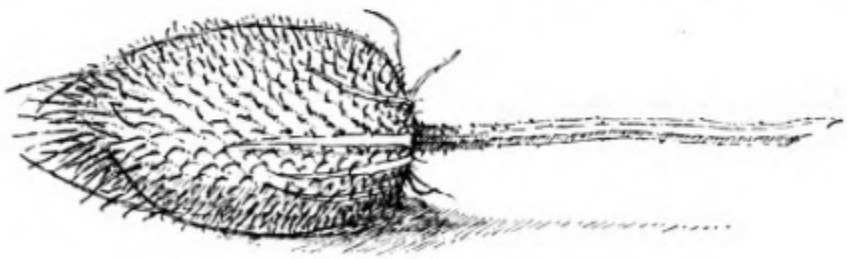

FIG. 92. — TEAZLE.

The narrow troughs or boxes are filled with the teazles laid lengthwise, so that they present a continuous napping surface. The cloth is stretched tight in the machine, a humidifier often sprays it as it passes slowly along, and the napping cylinder

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moves rapidly in the opposite direction, rubbing up the surface of the material with the teazles. The process is repeated several times, at first with old, soft teazles and gradually with stiff, new ones, until the surface is thoroughly covered with the raised fibers. The nap becomes finer as the gigging is repeated. There are two methods of napping, the wet and the dry. In the former, the cloth is kept moist, and the resulting pile is more

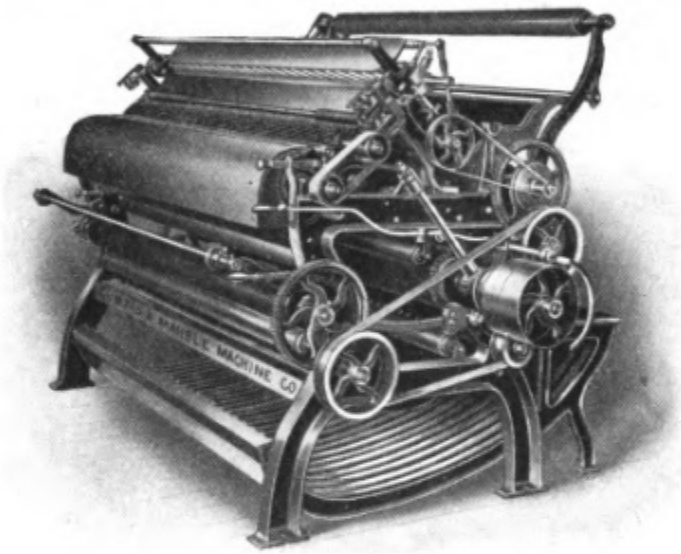

FIG. 93. — SINGLE CUTTER SHEAR.

Courtesy of Curtis & Marble.

shiny than in the dry raising. Dress face goods, such as broadcloths, are napped wet. The dry raising is used for worsted suitings and fancy woven goods. The small clippings from the shear are used for flocks or other purposes.

Shearing, Cutting or Cropping, and Brushing. — Cutting the nap and brushing it clean follow gigging or napping. One machine frequently combines all three processes of raising, cropping, and cleaning. The aim of the shear (Fig. 93) is to trim the raised nap to the desired height, it may be merely to even it off, or it may be to cut the nap close. The shear has to be adjusted to the need and requires care, for if the nap is too long the surface roughens with wear; or if too close, the material is weakened.

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FIG. 94. — A MODERN WEAVE ROOM, SHOWING AN ACRE OF LOOMS.

Courtesy of the Chicopee Manufacturing Company.

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FIG. 95. — COTTON FIELD, SHOWING PICKER AT WORK.
Courtesy of U. S. Department of Agriculture.

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FIG. 96. — THE COTTON PLANT.

From Brooks' *Cotton*, by courtesy of the American School of Correspondence.

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a slotted plate. The seed cotton is received at *A* and carried against the picker roll *C* and the saws *E*. The seeds drop below and the brush *J* carries the lint cotton to a flue to be carried to the condenser. A single gin may be used, or a number may

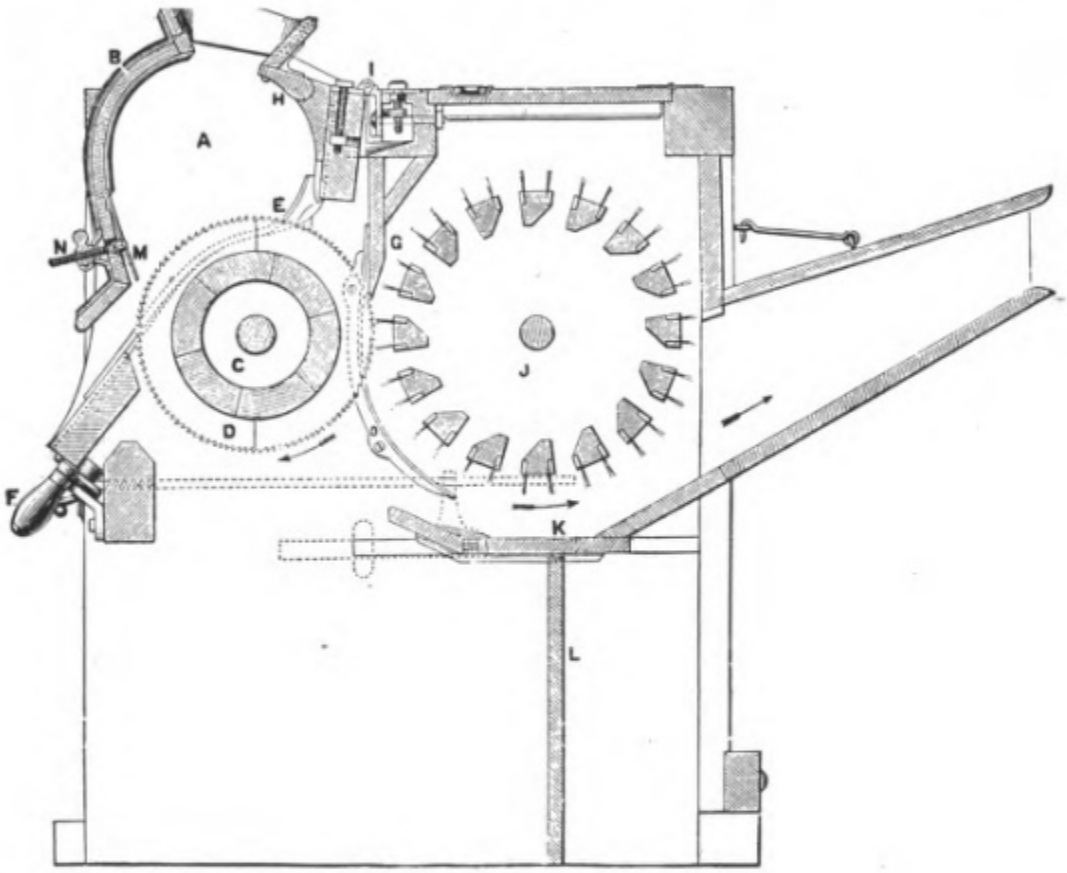

FIG. 97. — THE SAW GIN.

From Brooks' *Cotton*, by courtesy of the American School of Correspondence.

be combined, called a battery. One flue may be used for all the gins, or there may be one for each. The cotton is somewhat cleaned and straightened as it passes through the flue. A 60-saw gin revolving at 60 revolutions per minute will gin about 5000 pounds a day. The saw gin is suited to short-stapled cotton. The fibers of the lint after ginning are crisscross, entangled, and often full of specks and dirt. Several machines must follow in order to lay the cotton in parallel order and clean it.

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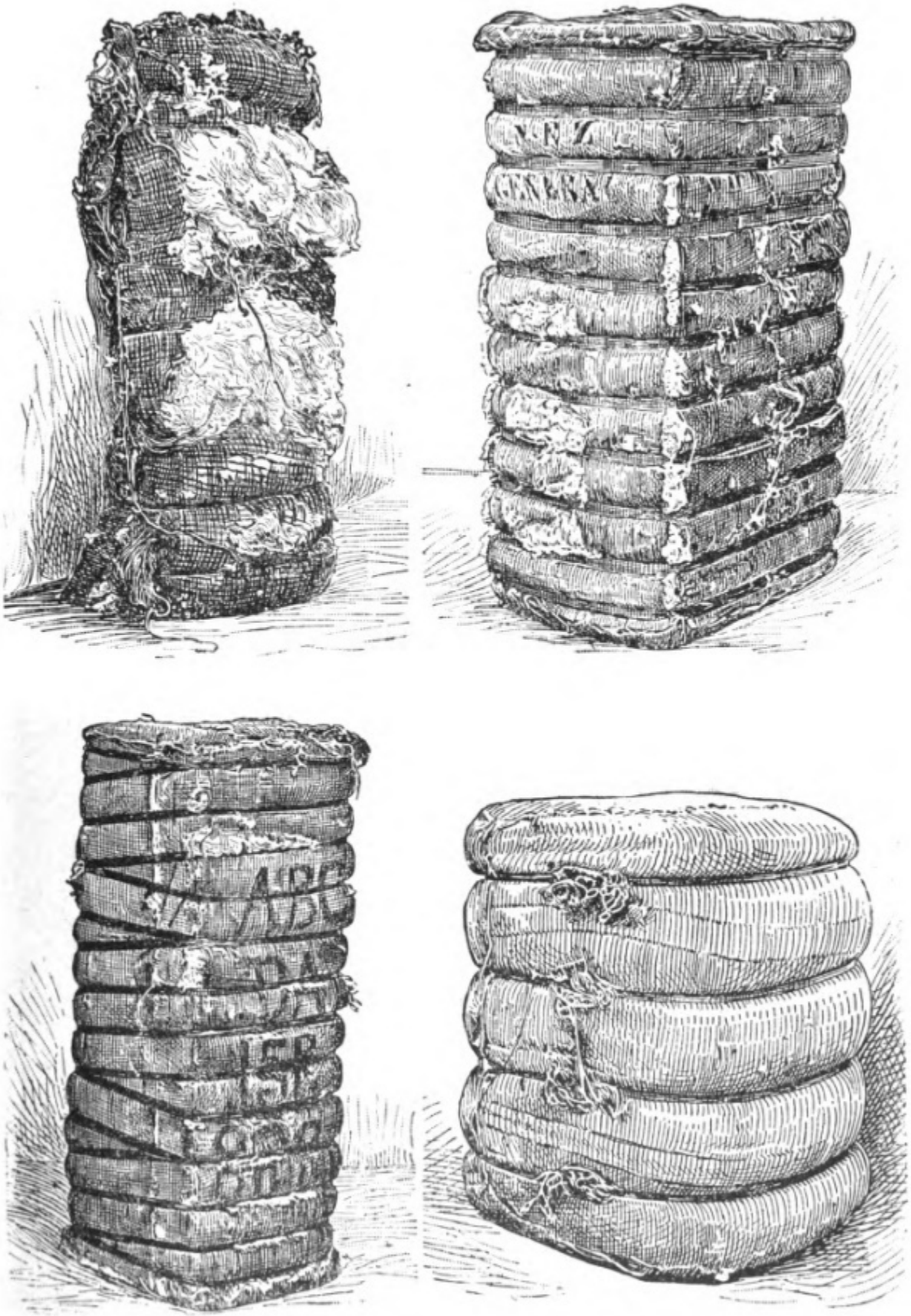

FIG. 98. — COTTON BALES. American bale in upper left-hand corner.
U. S. Dept. of Agriculture, Bul. 33.

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1911–1912 were 121,212 bales of 715 lbs. each of Egyptian cotton, and 28,315 bales of 185 lbs. each of Rough Peruvian cotton. These cottons are purchased for special purposes for which American cottons are not suited, and do not therefore compete to any extent with our cotton. As can be seen, the importations of cotton are a small consideration.

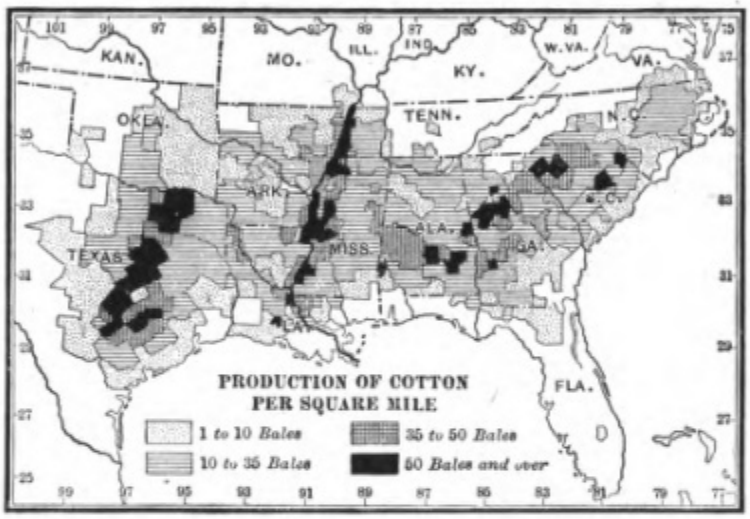

FIG. 99. — COTTON PRODUCING STATES.

From Tarr & McMurry's *New Geographies*, Second Book, 1910, by courtesy of the Macmillan Company.

The American crop in 1912–1913 is estimated at 13,820,000 bales of 500 lbs., exclusive of linters. At an average price of 12½ cts. per pound the value will be $855,920,000. It is estimated unofficially that the linter crop for the same period will amount to 491,300 bales. About two thirds of the crop is exported, but increasing domestic manufacturing interests tend to limit the export. In most of the Southern States cotton is the chief agricultural industry, more than thirty-four million acres being under cultivation in 1911–1912. It is also becoming an important manufacturing industry in many of these states as well.

Cotton in the United States is divided into two great branches, American and Sea Island. The term American cotton covers

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numerous agricultural varieties which are roughly classed as (1) cotton of the Atlantic States, or upland cotton, which is short in staple; (2) gulf cotton, a longer staple grown on the low lands of the states near the Gulf of Mexico; and (3) peeler cotton, a general term for good cotton grown in the states along the Mississippi River. Another classification which

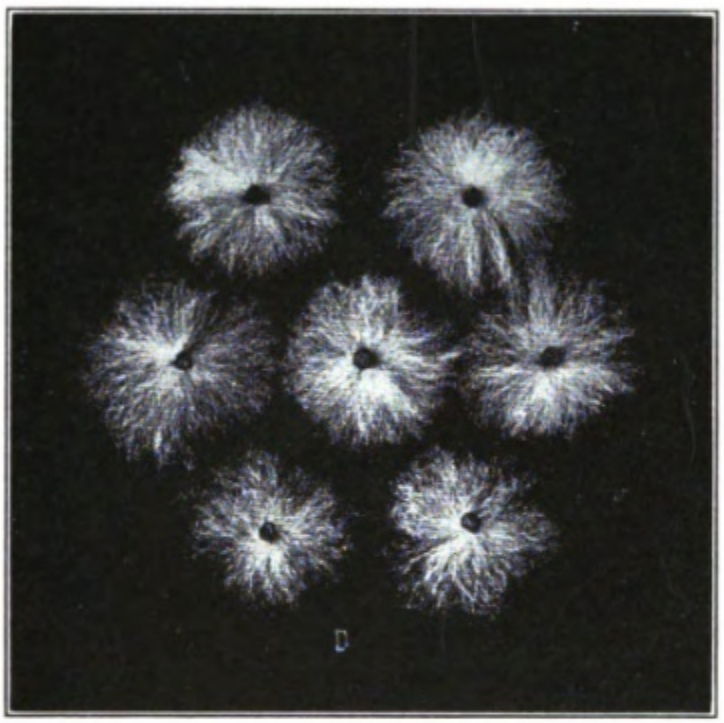

FIG. 100. — COTTON ON THE SEED.

From Brooks' *Cotton*, by courtesy of the American School of Correspondence.

is virtually the same is (1) cotton grown on the uplands of the Southern States with a staple of $\frac{7}{8}$ to one inch; (2) cotton grown on swamp and bottom lands with a staple of $1\frac{1}{8}$ to $1\frac{1}{4}$ inches, and (3) extra or fancy cotton with a staple of $1\frac{3}{8}$ to $1\frac{5}{8}$ inches. The short staple cottons are principally used for filling yarns, the long staple are used for fine yarns, and the extra and fancy cottons for thread, velveteens, and when mixed with Brown Egyptian for hosiery yarns.

Sea Island cotton is the most valuable in the world, being

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