REPORT

ON

WOOL AND SILK MACHINERY.

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REPORTS ON WOOL AND SILK MACHINERY.

MACHINERY USED IN WOOL MANUFACTURE.

Probably the first materials woven into continuous cloth—wool—necessitated for its treatment some mechanical device to transform the short fibers into a fabric. The same process devised in the first ages of civilization has remained to the present day, viz, producing a long continuous thread from the short fiber, and then weaving these threads into a compact network. The wool industry has perhaps grown quite steadily without sudden or great improvements during any short period, the machinery having gradually improved both as to workmanship and efficiency. The greatest impulse given to this industry, which it shares with many others, was the application of steam power, enabling the spinning and weaving to be done automatically. It is only lately, however, that the entire process is performed by power machinery, many of the older mills still running hand-jacks for spinning.

In this country the growth of the manufacture has been gradual and parallel with the improvement of the machines. This steady increase is due to the fact that wool, whatever the condition of finance, business, or other important factors, is a staple absolutely necessary for existence in our present civilized state, and hence but slightly dependent on other considerations. This may appear untrue at first sight, but is of course a mere relative statement in comparison with other industries, such as silk, jewelry, etc., etc. It is of course true that rich tapestries, heavy carpets, and many similar productions may suffer during periods of depression, yet the main business—the manufacture of cloth for clothing and like purposes—always finds an ample market, unless greatly overproduced.

The use of machinery has played a most important part in the progress of the industry. In the first place, it would be impossible to produce the annual amount of goods consumed at present by hand or any other method. Formerly weavers, and those skilled in the process, constituted, like the present iron-workers, a class, upon which the manufacturers were much more dependent than they are at present. In the spinning department alone, even only a few years past, were the jack-spinners to strike, the stoppage of the whole mill would follow.

Secondly, the machines at present in use have enabled the production of a better quality of goods and increased the profits of the manufacturer both by diminishing the cost of production and by causing a greater demand for a better class of goods. In the opinion of many manufacturers it is believed that for the past twenty years the improvement in the machinery, and the consequent advance in the industry, has been at least 25 per cent. At present, with but very few exceptions, the quality of products has equaled, in some cases (for practical use) excelled, foreign manufactures.

Steam power has perhaps, as just stated, had more influence on this industry than in parallel ones. The treatment of the wool and its dyeing, necessitating a large amount of heat, steam, and water, involves inevitably the use of boilers to a great extent. The power thus becomes but a factor in the steam plant, not the sole object, as in cotton manufacture; hence the fact that it is more economical to locate a woolen mill conveniently to points of demand and supply than to place at a water power. Steam is absolutely necessary in the process, and but a comparatively small increase in the steam plant will cover the power. Auxiliary water power, if accessible, may be a source of economy, but in the location of a new mill the other considerations are of greater importance than this question of power.

The greater part of the machinery in our mills is of American manufacture. In some of the older mills foreign machines are still in use, but are invariably replaced when new ones are wanted by domestic appliances. In many mills the reason for retaining old machines is either the conservative spirit of proprietors (this is, however, rare in face of competition), or more often the fact that a profitable business is carried on and the first cost of new machinery a bugbear.

In most cases all American wool machinery is but improved foreign design. For many years no very notable new mechanical contrivance has been introduced which would have a revolutionary effect. The English loom has been greatly improved, but does not differ essentially in principle from the first power-loom. The Jacquard attachment for figured goods has likewise been increased in efficiency, but is the same machine. The spindle now running in our mills with remarkable speed and steadiness is but an improved form of the first spindle brought to his country.

There have been many new inventions, which have improved the various machines and greatly assisted in the general advance of the mechanical efficiency, yet there has not been any new departure or novel idea of transforming effect, such as there has been in many other industries, since 1776. This is, perhaps, due to the fact that the process has become reduced to its simplest form consistent with the quality of the product, and the machinery direct and appropriate. Usually a new invention, of great and widespread value, is the result for an almost imperative demand by circumstances for such an idea. Wool manufacture has grown, the business is profitable, and manufacturers of machinery are bent simply on improving present forms, without introducing new ones. The total improvement over hand labor can barely be estimated as an absolute value, for the present efficiency cannot be obtained. In the principal operations the increase has been about as follows: In olden times a woman could card 1 pound of wool a day by hand. At present one operative, with the necessary machinery, can card 100 to 125 pounds a day. Hence the improvement is about 125. On a spinning-wheel a woman could produce daily 2 skeins. An average mule to-day spins about 500 pounds; hence the improvement is about 560. On a hand loom it took a day to weave 2 to 3 yards. Power looms produce from 35 to 50 yards a day, or an improvement of 17. Hence, disregarding all other factors but these, and placing a modest estimate, it is possible at present, with power machinery, to produce over 700 times more goods to-day than in the olden time with the same number of hands, and disregarding the quantity, design, etc.

It may be here stated that the difference between hand-jacks and looms is about as follows: Hand-jacks, 48 cents a 100 run; mules, 20 cents a 100 run; or less than half.

In general one set of woolen machinery will require 26 horse-power to run. Worsted machinery needs about 25 horse-power per set. A set of woolen machinery consists of a set of cards (two peakers and one finisher) and the necessary amount of machinery to convert the wool from these into yarn or cloth. This amount varies according to the class of goods manufactured, the opinion of superintendents, etc.

Before describing the various machines used in the process, of which only the principal ones can be detailed, owing to the immense number of various appliances, a short description of the process will enable one to comprehend the relative position and duty of the various machines.

PROCESSES.

The various products of wool manufacture are so numerous and of such different natures, that a complete account of the details would fill many pages. Wool, besides being made up into various cloths, yarns, etc., is mixed with other materials, such as cotton and flax, and a process different in some of its details is involved. Wool, besides, is graded, according to the length of the staple, into wool and worsted, the latter being the longest and requiring certain preliminary operations which are not necessary for the short staple.

The usual process for "coatings", etc., is as follows, with but slight variations: The wool is first thoroughly dusted on machines to remove the grosser impurities and prepare for the subsequent washing. Wool, unlike other textile raw materials, is brought to the mill in an extremely dirty condition. It is received in bundles, which contain each one fleece, and as shorn from the sheep, in its natural grease, containing sand, dirt, and often other matter to increase the weight when sold. Fraud is often perpetrated, the inside of the fleece being filled with "pulled wool", or wool pulled from dead animals. It is usual to wash the sheep before shearing to remove part of the impurities, but in some cases, when the animal is valuable for breeding purposes, this is not done, to prevent sickness.

After the preliminary dusting the wool is passed through a washing machine and scoured. This machine, described further on, removes the last vestiges of grease, and leaves the wool pure and white. It is then either dyed, called wool-dyeing, or is first picked, carded, and spun, and then dyed, called yarn-dyeing. In some cases the wool is not scoured, but is run on the cards in its natural condition; this, however, causes the separation of much dirt at the cards. Before the scouring the wool is carefully sorted into various grades, the number depending on the kinds and qualities of the goods manufactured at the mill. This work has to be done by skilled labor, as there is but one way of separating the various grades; that is, by the sense of feeling. The difference in these qualities may be stated as being the difference in the number of fibers per ounce; that is, a difference in the fineness of each fiber. The length of the staple is also a factor in this sorting. Much weight is lost during the scouring, varying greatly according to the amount of grease, etc., in it. The weight of 100 pounds is often reduced to 30 or 40 pounds—even less. After the dyeing the wool is dried roughly in a centrifugal machine, termed an extractor. It is then taken to the drying-room, exposed in a machine to the action of a current of hot air for several hours, and every vestige of moisture removed. It is next conveyed to the picker, a machine which tears the bunches of fibers apart and spreads them out into the shape of a sheet, being the first mechanical separation of the wool. It is next carded, or the fibers brought parallel by a system of cards or combing-machines described further on. There are usually three carding machines to one set; that is, the wool passes through three of the machines, graded so as to gradually reduce the sheet of tangled fibers into continuous skeins of soft wool. This is spooled, and is ready for the subsequent twisting or spinning. This is effected on spinning frames, mules, or jacks. The two former are automatic, the latter needs the assistance of an operative. As referred to previously, the jacks are being rapidly displaced by the self-operating mules.

After spinning, the wool is spooled and run into a beam for weaving. This consists of a series of parallel threads, obtained by a mechanism described further on. The warp is then placed on the loom and the cloth produced. The weaving machinery of to-day, described in the succeeding pages, has been notably improved, yet the improvements are solely in the details and not any radical change in the principles involved. Perhaps the most prominent innovation of late years is the positive-motion loom, in which the shuttle is carried at a certain definable speed instead of being shot through the loom by a picking lever. The cloth is well beaten up, of even width, and thanks to the faultless operations of the Jacquard and chain systems, the figures and artistic vari-colored effects are produced with uniform regularity and without as great trouble in reducing from the design to the loom as formerly. From the loom the material is taken to the fulling-machine, which saturates it with sizing and beats the cloth into a compact mass. The cloth shrinks considerably during this operation and has subsequently to be tentered or stretched. Considerable improvement has been made in this portion of the process by the adoption of rotary fulling-mills, which reduce the latter by a half, incidental to the old fulling stocks. The cloth is next dried and then gigged on special appliances for this purpose. These consist of machines, which raise the nap on the cloth generally by the use of rows of teazles, which comb the projecting fibers. These are then sheared to an even depth on a shearing-machine, resembling in principle a lawn-mower. The cloth is then usually measured and wound on automatically winding appliances, sometimes finally stretched and pressed or rolled between rollers to give softness, and packed for market.

WASHING, CARDING, AND SPINNING MACHINERY.

After the preliminary sorting of the wool and dusting it is washed. Several machines have been devised, and, as it would be impossible to describe them all, one has been taken as type, the principle being about the same in all. This is Sargent's wool-washing machine. (See Fig. 1.) The machine consists essentially of a series of bowls, through which the wool is impelled by rakes, some movable and others stationary, and which contain a solution of scouring liquor. The wool is placed on the feeder (on the left of the figure) and is dropped into the first bowl, back of the first stationary rake, which, similarly to the others, swings a small amount on its suspending pivots. The portion of the wool is drawn through the rake by the first movable rake, which has long, curved teeth, which penetrate between the teeth of the stationary rake, and thus draw out the fiber. The machines are built of different sizes, with different numbers of rakes, this process of drawing through being repeated two, three, or four times. The motion of the movable rakes is peculiar and ingeniously arranged. They are hung on a crank near their center, and the upper end operated by a swivel-stand. The motion of the teeth is therefore that of an ellipse, being nearly a straight line at the lower portion of the motion. The effect of these successive drawings is to thoroughly saturate the wool with the liquor and to loosen all dirt, grease, etc. The last rake draws it from the bowl and places it on the "convex table", an arrangement shown on the right of the figure, and which consists of a cylinder of large radius with projecting teeth; this catches the wool. A swing-carrier, with jointed teeth, arranged so that on the backward motion they slide over the surface of the wool, is connected with the rake. When the motion is reversed the teeth remove the wool from the convex table and places the wool so as to be engaged in a pair of rolls called the squeeze-rolls. This arrangement is claimed by the makers to be of special efficiency, as the wool is carried to the rolls in an even mass of almost uniform thickness, thus insuring a uniform pressure at every point of the rolls. These rolls are arranged with spring-lever and weight, and a pressure of nine tons can be procured on the wool. The wool is almost completely dried by the rolls, the liquor passing to the end of the bowl. Some of the rolls are covered with rubber, and have been found to leave the wool almost entirely free of water. The wool is taken off by a beater or fan or an apron.

When several bowls are used the quality of the liquor is of course best in the last bowl and worst in the first. It is drawn off from the latter and is let in from the former by a steam jet. Steam is likewise admitted during the process to keep the liquid at a proper temperature, and the condensed water of the mill is used to save time in heating the liquid when the machine is first filled and to save steam in the subsequent operations. For maintaining the proper temperature steam is injected in each bowl in small jets by a perforated pipe. The machine is claimed to wash wool as well in the hot months as in the cool; a feature which is not usually possible in the old method of tub and rinse-box. Fig. 2 gives a perspective view of the machine and a better idea of the rake mechanism than the elevation Fig. 1. Figs. 3 and 4 show two varieties of dusters for the preliminary removal of gross impurities from the wool. The machine consists essentially of a cylinder with teeth, which separate the wool loosely. Meanwhile it is subjected to a blast. Fig. 3 is the larger and more complete machine.

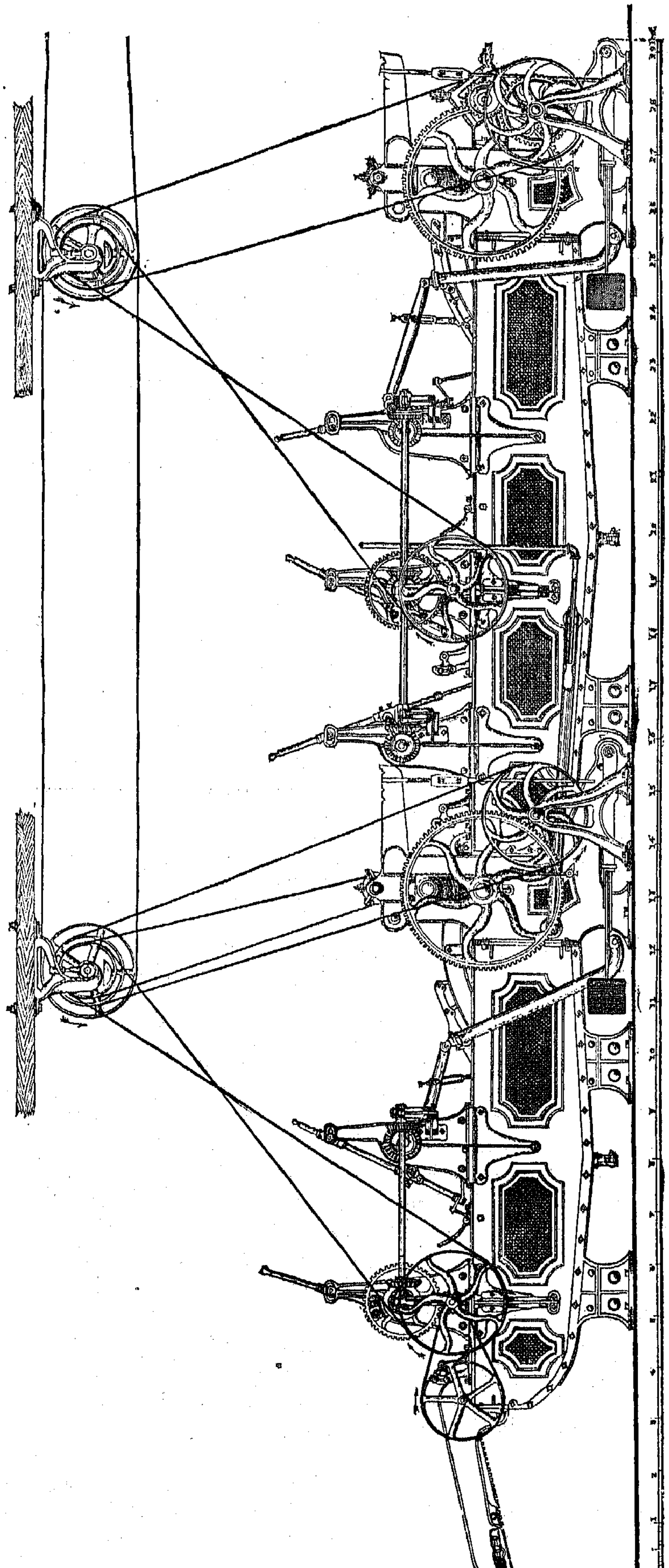

Fig. 1.

From the washer the wool is taken to the drying-machine, of which several forms exist, the principal being that the wool is placed on wire netting, air is drawn by a suction-fan through a coil of steam-pipes and is blown through the wool. The machine shown in Fig. 5 can, by simply reversing the fan, be converted from a hot into a cold-air machine.

The burr-picker is the next machine which treats the wool preparatory to the spinning. The machine shown in section in Fig. 6 is of recent invention, and may be described as an example of this class of machinery. The

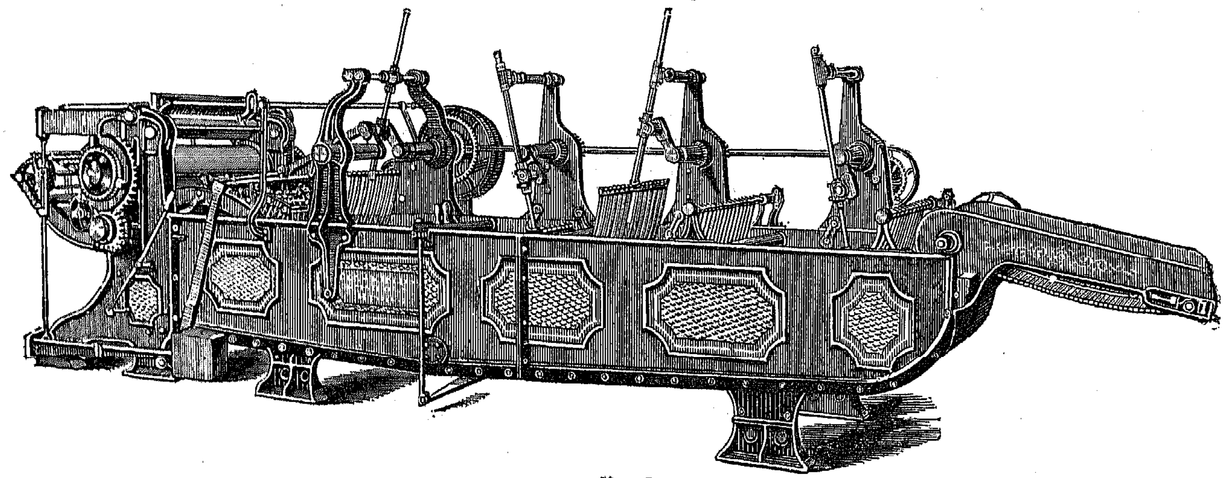

Fig. 2.

advantages claimed are the separation of the wool into four subdivisions, each portion being kept separate. The light impurities are drawn through the fan, and thus separated from the heavier scurf, dust, etc. Burrs, sticks, and straws are separated into a third receptacle and the clean wool into a fourth. The machine is supposed to obviate the opening of the burrs, which are vegetable fibers in knots, and, ultimately, if opened, get in with the wool fiber

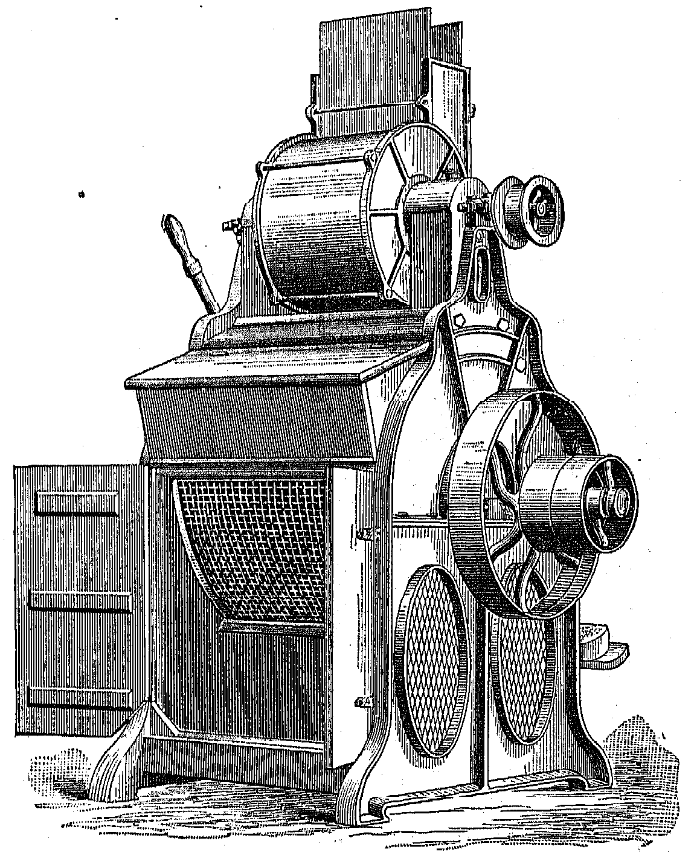

Fig. 3.

to prevent the loss of wool and the mixing of it with already separated burrs. Another claim is, that owing to the immediate separation of the burrs, the gratings under the picking-cylinder can be made fine so as to obviate the dropping of wool through them and consequent loss. The machine is built by Charles G. Sargent & Son.

A is a screen through which the light dust, etc., is drawn through to the fan P, and thrown out at Q. It is removable and can be cleaned, at the same time affording access to the picking-cylinder F. O is the feed-table, which carries the wool to the feed-rolls L M and to the picking-cylinder F. This separates the fibers, which are at the same time subject to the draught of the fan P, which removes the light impurities. H is the burr-cylinder, with its guard I. If too much air is admited under H the light burrs are carried back, but by opening F this may

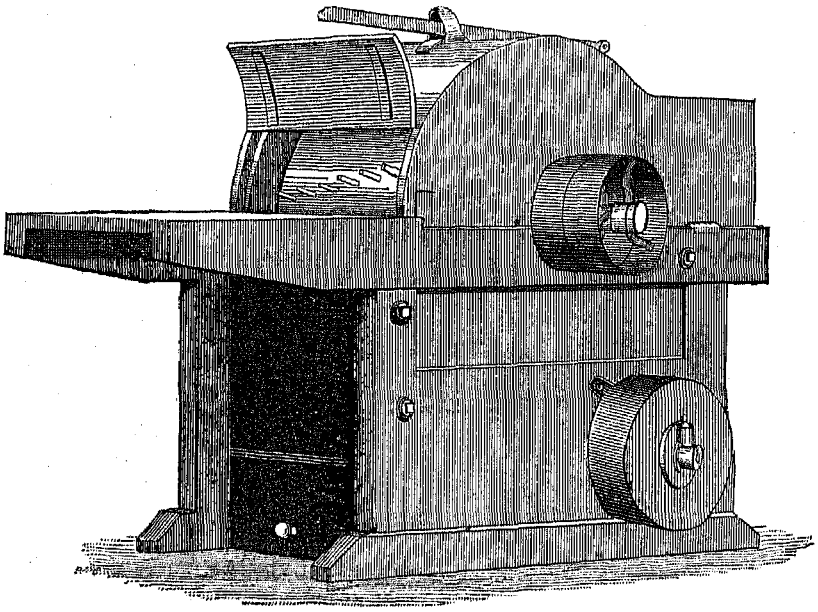

FIG. 4.

be regulated. The rolls L and M exercise a combing action, and liberate the heavy dirt, which drops through the rack G. The wool is thrown back from H by the air currents. J is the brush, which keeps H constantly clear and deposits the cleared wool out at R. There is a difference of velocities in the feed-rolls L and M, which keeps them clear. The picker-cylinder is about 36 inches in diameter and about the same width. It revolves at 500 to 700 times per minute.

During the entire process of treating wool after the burr-picker, it is kept thoroughly oiled with some light oil to prevent felting. The old method, still used in many mills, was to lay the cloth on a brick floor and then

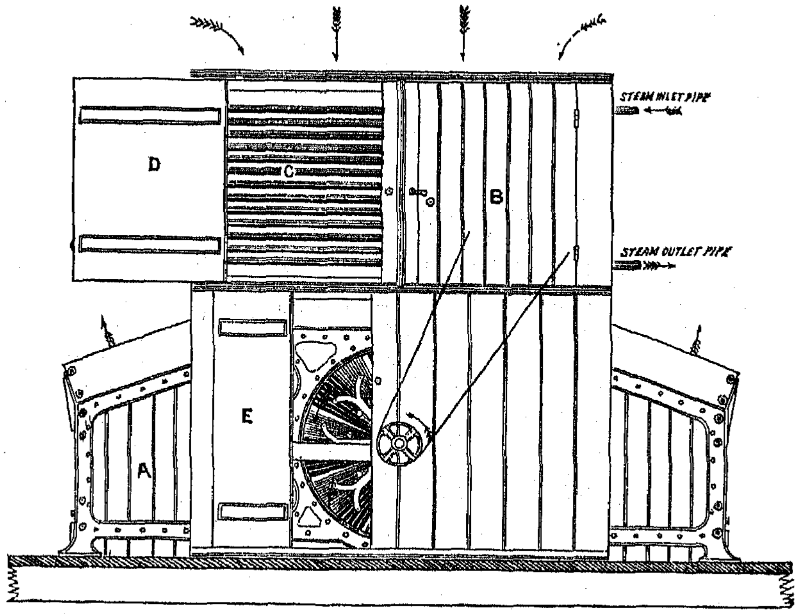

FIG. 5.

thoroughly saturate it with oil. A machine for doing this automatically has lately been devised, and is shown in Fig. 7; it is used before the carding, the next machine in the process, and treats the wool before it enters this machine. It is described as an example of its class. Fig. 7 is an elevation of the machine and Fig. 8 a section view thereof. A is one of the stands upon which the machine rests. B is the oil-tank, which holds about 4 gallons and is about 8 inches above the wool. C is the lever-arm on the dipper, which takes up the oil. D is a connectinglink, one end of which is connected to C, the other to the crank-pin on the eccentric E, giving the vibratory motion to the bucket. E is eccentric and strap connection. It is connected to the brush-shaft I, and gives this a forward

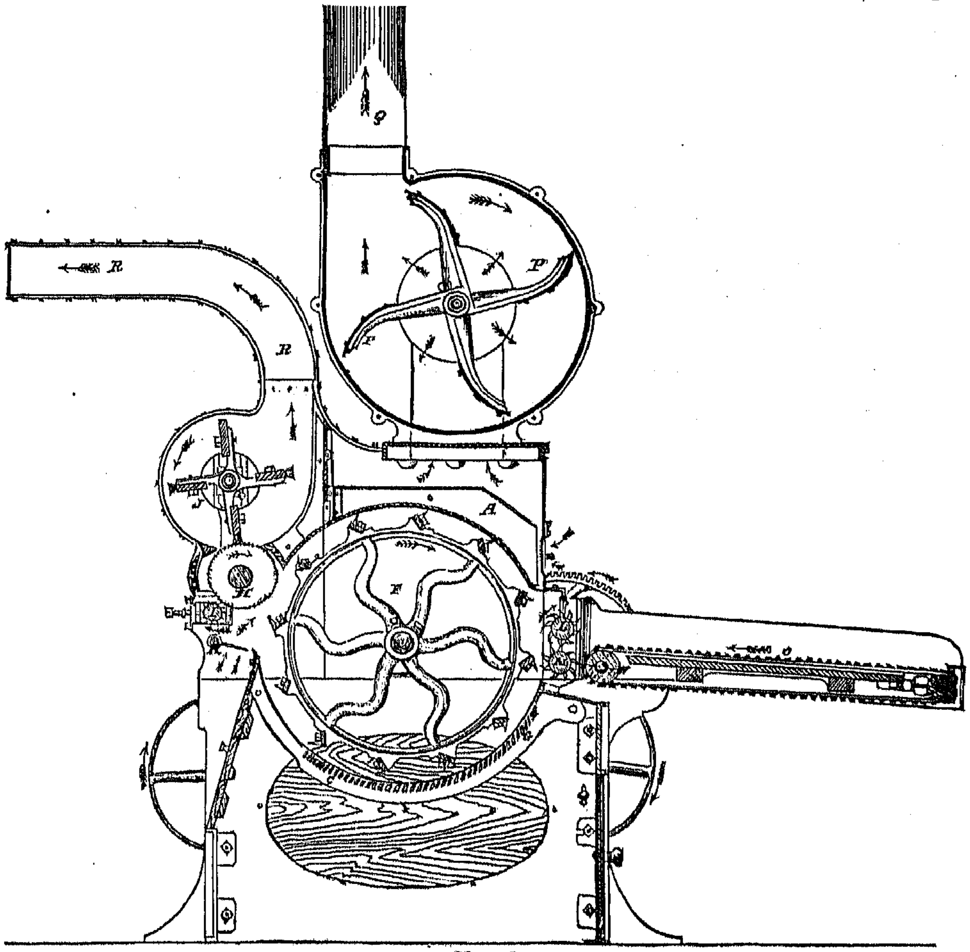

FIG. 6.

and backward motion. K is the dipper or bucket, which brings the oil from the tank to the point of contact of the brush. L is the atomizing brush. The advantages of this machine, claimed by the inventor, are that the oil is

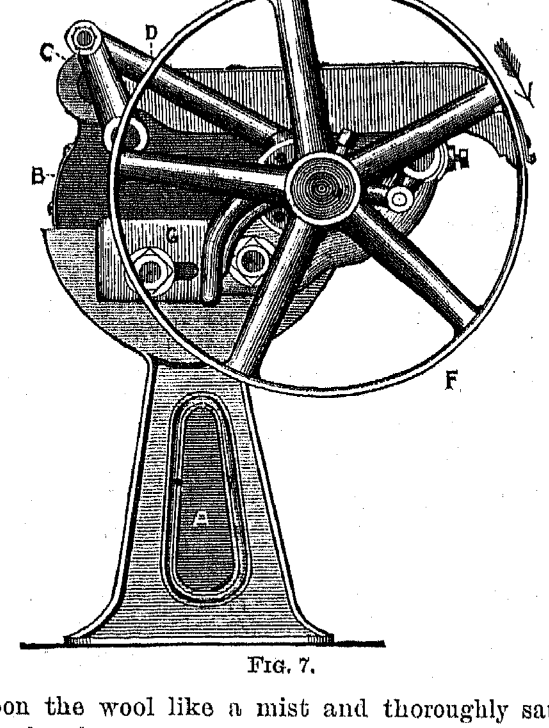

FIG. 7.

completely atomized, and falls upon the wool like a mist and thoroughly saturates the wool. The chance for evaporation is small. The machine has been run successfully with a composition of 1 quart of oil and 4 quarts of water to 100 pounds of wool. The amount of oil can be varied from 1 to 10 quarts per 100 pounds, and is completely under control of the manager.

The backing of many cloths is increased in weight by the addition of shoddy—a material consisting of rags, new and old, torn up in a picker, and reduced to their original fiber. This is then fulled into the cloth and helps the final texture. A machine for wool-mixing is shown in Fig. 9. It consists essentially of a strong frame, with projecting teeth, revolving rapidly, and feeding table and rolls.

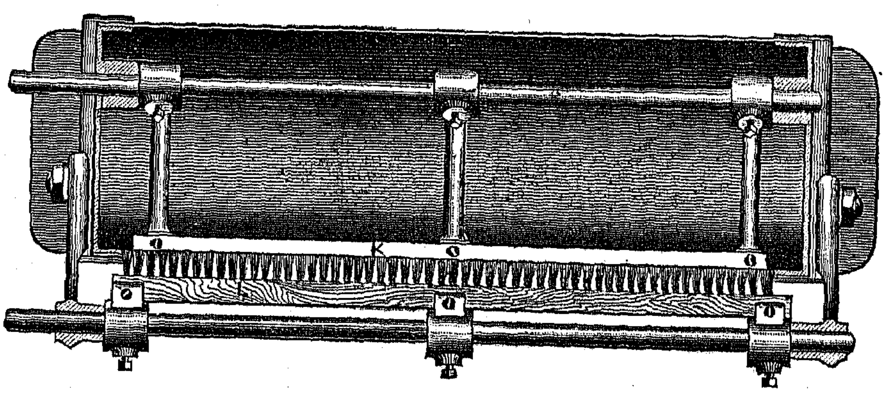

FIG. 8.

Being thoroughly oiled, the wool is next carded. Three carding-machines are usually used to a set, that is, successively. In the carding-machine the wool is combed, the fibers becoming parallel and completely pure, and are by the last operation brought into a tender filament, their first continuous shape. The main organ of a card is the "cylinder", usually about 4 feet in diameter, and covered with card-clothing, which consists of leather strips, in which wire teeth are inserted. Around this cylinder there are several other smaller cylinders, called workers, similarly clothed, which continually remove the wool from the cylinder, separating the fibers and combing them.

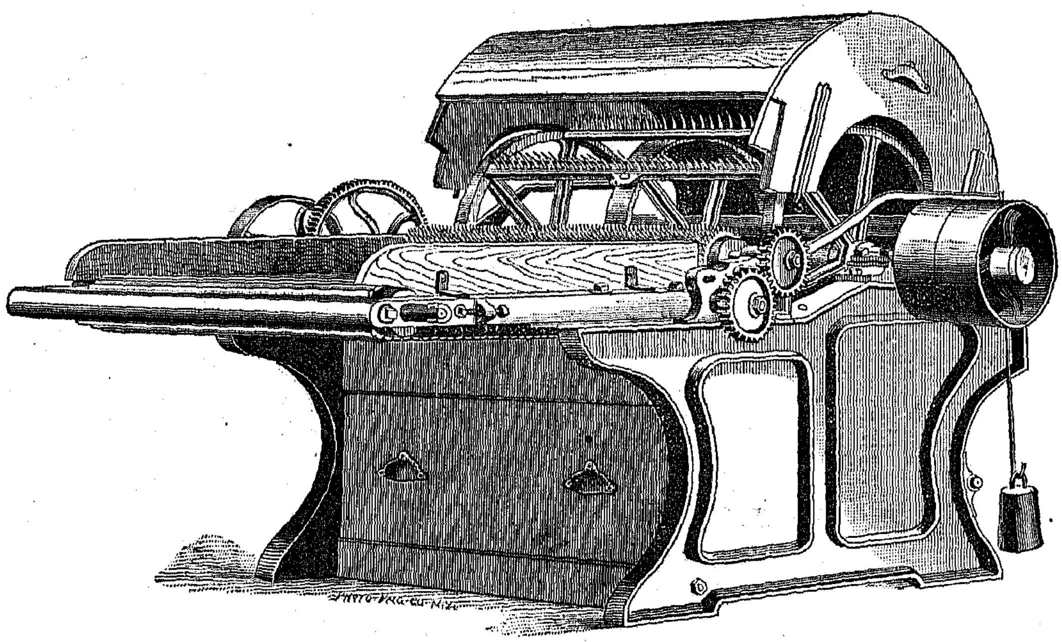

FIG. 9.

From these, as they become saturated with wool, the latter is removed by another roll with longer teeth. This is called the "fancy", and revolves at a considerably higher speed. The carded wool is then removed by a "doffer" and undergoes the same process twice more, each time by finer card-clothing, on what may be considered the remaining portions of the whole machine, and finally removed by a pair of small rollers called condensers. These condensers, one above the other, have strips of card-clothing affixed, which alternate; thus the wool is taken off in long strips. These then pass through more condensing-rollers, which, besides rotating, are given a transverse rectilinear motion, the combination of these two producing a soft and untwisted thread of woolen yarn. Great experience is requisite to operate this class of machinery with efficiency, as much depends on the skill and attention of the operative.

Fig. 10 shows an elevation of the Davis & Furber breaker card, which is taken as a type. On the left is the feed-table, with the cylinder and workers in the center, and the doffer-roll on the right, with its vibrating cone. The sliver is delivered sidewise, as regards the machine, from the roll in front of the doffer. The main cylinder is 48 by 48 inches. The power and other details have been alluded to previously. Fig. 11 gives a view of the finisher

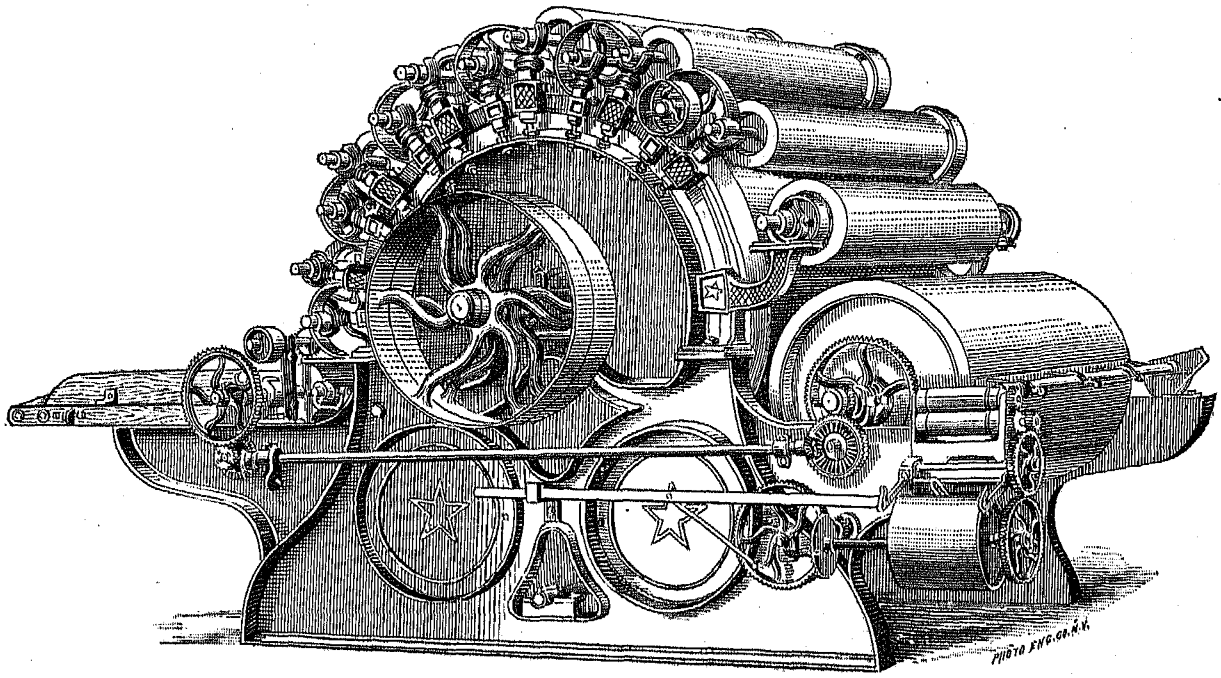

FIG. 10.

card. For feeding from one card to another the Apperly feed is used, a traverse motion being given to the wool, which enables the card to operate on an even mass.

The next principal step in the process is the spinning. In this department the machinery used at present is almost identical with that used for spinning cotton. The various methods for twisting a sliver of mutually adhering

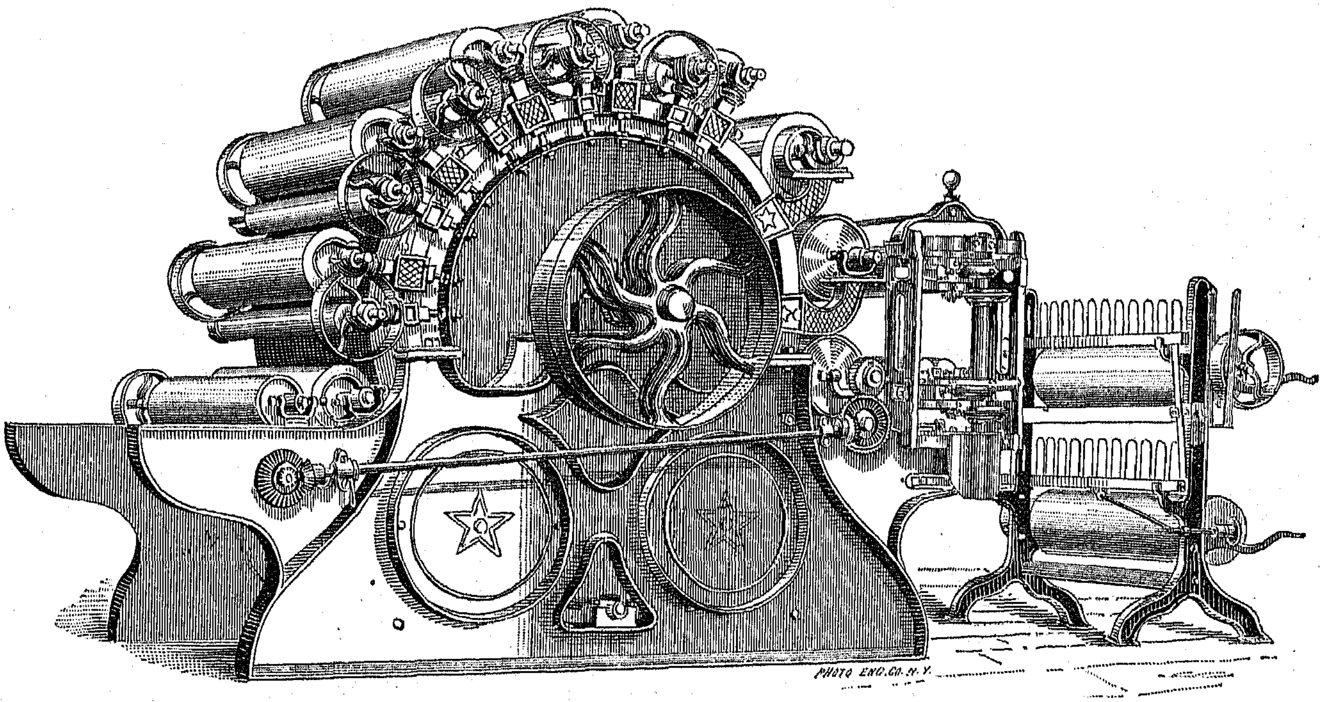

FIG. 11.

untwisted fibers is described in the report on cotton machinery. It may be stated, however, that mules are used to a greater extent perhaps in this industry. Many of the larger mills are running filling on flier and ring frames, though the relative advantages of mule and ring spinning are still debated by interested persons. Figs. 12 and

13 show the Davis & Furber spinning-mules, a type of present practice. The motion is transmitted by ropes, being considered better, as being more elastic. It is adjustable to deliver the amount of roving required. Fig. 13 is a

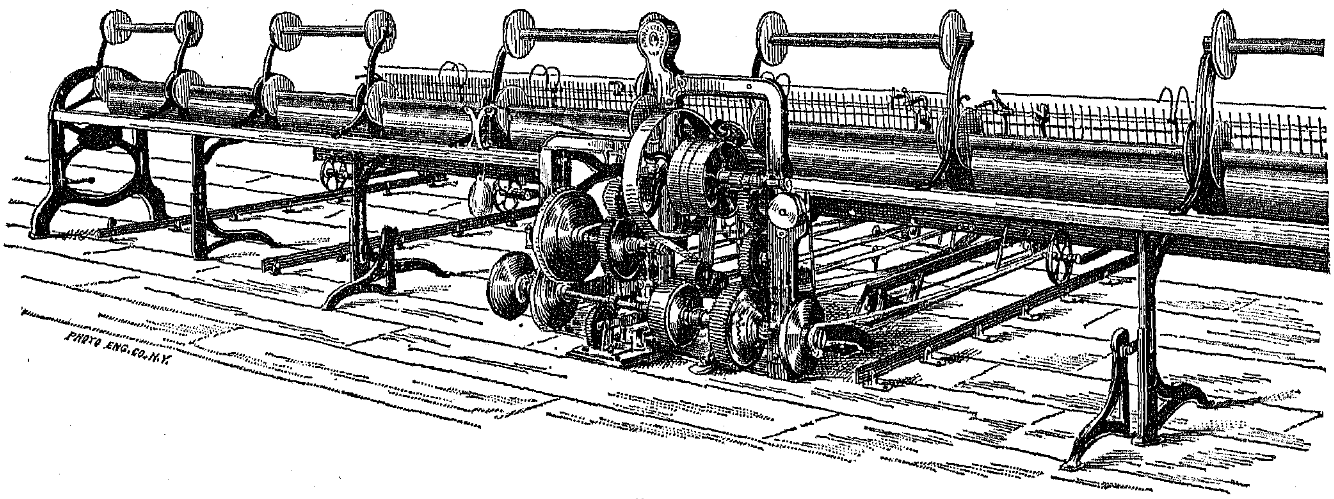

FIG. 12.

front view and Fig. 12 a rear view of the machine. The number of spindles varies according to the necessities of the manufacturer. From the mules, which can be used for second twisting, the yarn is wound in hanks, and if not

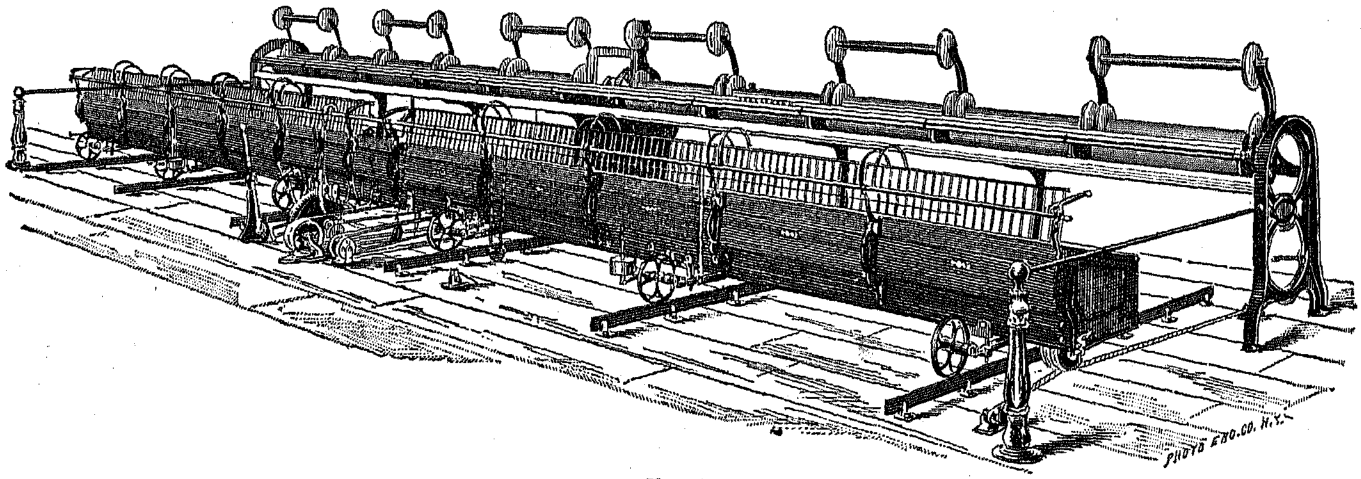

FIG. 13.

dyed in the wool, is dyed in the yarn at this stage, and is then ready for the loom. Filling is wound directly into a cop for the shuttle, and is placed therein ready for weaving. Warp has first to be beamed, and this is done on

Fig. C. Fig. B. Fig. A.

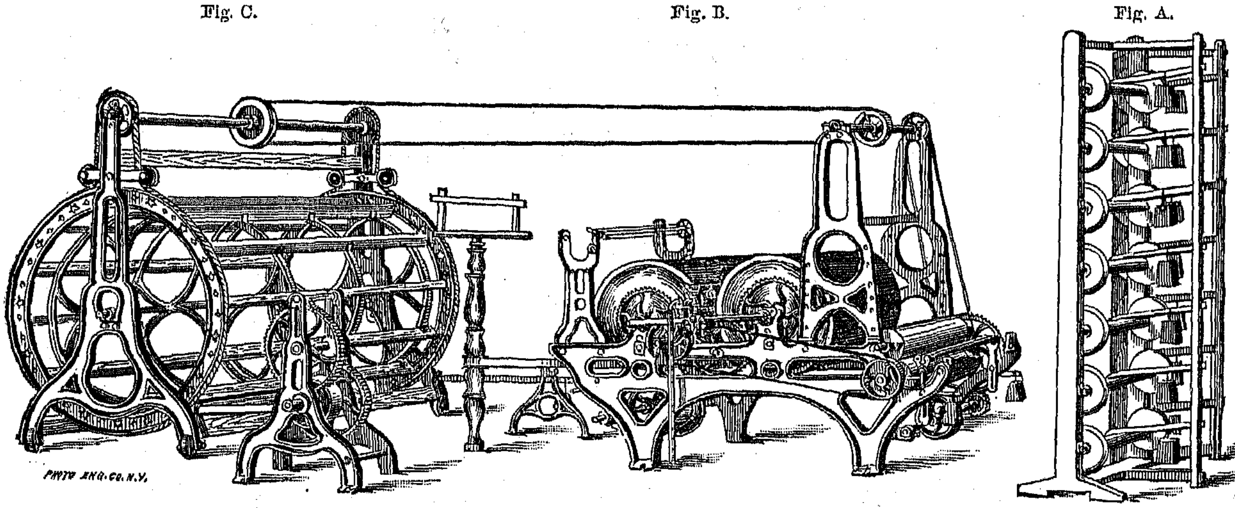

FIG. 14.

the contrivance shown in Fig. 14, which is built by Davis & Furber, serving as an example. The yarn is wound on large bobbins, and is then placed on Fig. A, thence it passes to the dresser, Fig. B, consisting of two copper cylinders having steam-coils inside. From this it is rolled on Fig. C in a beam, that is, a series of parallel threads, as required by the loom for the warp. Fig. C is movable in the direction of its axis, so as to enable the repetition of parti-colored warps from one set of bobbins to the whole width of the loom-beam, whence the warp is now transferred in one continuous sheet.

LOOMS.

When the yarn has been prepared by the foregoing machines it is ready to be placed on the loom and converted into a continuous sheet. The invention of the hand-loom dates back into the dawn of civilization, but for many centuries nothing but plain goods could be woven. It is only at a comparatively recent date that figured goods and goods of one color and with designs woven in their texture have been produced. The latter varieties, though used at times in wool cloths, are more used on cotton and silk goods, and are simply alluded to here. The improved form of hand-loom as devised by the Kays, father and son, in 1760 is still used in silk, carpet, and other industries. The power-loom, now exclusively used in our mills, is but a modification of this form, though the efficiency and rapidity of work have been greatly increased.

Wool-looms are usually classified, according to the motion of the shuttle, into picking-stick looms and positive-motion looms. Some other forms are in use, such as the needle-loom, which has been tried on carpets, and the rack-and-pinion loom, which, however, is confined to narrow goods, generally silk ribbons. The general functions of a loom are to form a firm stand, on which a series of parallel threads are stretched, called the warp, and which form the foundation of the cloth; to separate these threads so as to pass another thread transversely through the series, either over and below each alternate thread or series of threads; to move the threads of the warp so as to inclose the transverse thread or filling (weft); and, finally, to beat up each successive thread of the filling against the preceding one, so as to make a close continuous fabric. These requirements also involve an arrangement for rolling the cloth on a cylinder and unrolling the warp from another, keeping the threads at a certain tension all

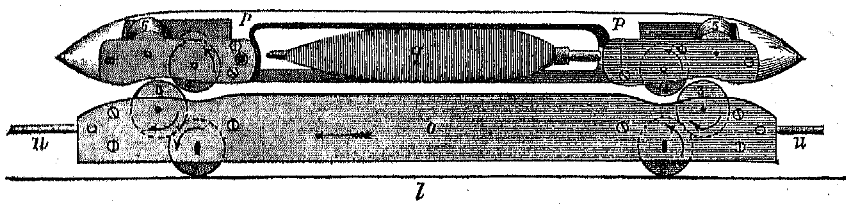

FIG. 15.

the time. This is called the let-off and take-up motions, and they are effected in several ways. Another indispensable contrivance attached to the loom is the temple, which keeps the manufactured cloth stretched to the full width of the warp, as it has a tendency to shrink and thus draw the warp-threads, not yet interlaced by filling, out of parallelism.

The ordinary picking-stick loom for plain goods, represented in the figure, consists of two cylinders or beams, between which the warp is stretched, the number of threads for the texture of the cloth in the width having been determined by experience. Each thread is threaded through a mail, eye, or loop, which is hung by a cord to a lath frame, the whole contrivance being called the harness, of which there are at least two. If the threads are simply to be interlaced with the filling, there are but two harnesses, each alternate thread being on the same harness. If two, three, or more threads are to be raised over or covered under the filling when shot through, and thus a different fabric produced, several harnesses are used, amounting in some cases to 40 in number. When the two harnesses are at the extremes of their motion, the filling is passed through what is termed the shed, being the angle between the divergent threads of the warp. The harnesses are then reversed and the filling beaten against the preceding thread by the reed, which consists of a row of flat wires or small metal slats set in a frame, and through which the warp is threaded. The shuttle, containing the cop of filling, slides through the shed from side to side of the loom in a way. Two boxes are set at each end of this way and receive the shuttle as it is thrown from end to end. The motion is given the shuttle by lever, a sharp rap sending it flying through the warp. Each trip of the shuttle, forming on thread of the filling, is termed a pick. It is evident from the above that though figured and vari-colored goods can be produced by employing warp of different colors and a number of harnesses, yet the number of variations is limited; hence the use of the drop-box, a contrivance which enables the use of several shuttles, each of a different color or kind. The drop-box, invented by the younger Kay, and applied to the hand-loom, simply consisted of a box, having two or more shelves, in which the shuttle was held. The whole contrivance had a vertical motion, which brought the various shuttles on to a level with the way and the picker, or hammer, which impelled them. This contrivance has been adopted on power-looms, the motion of the box being caused by a chain and a number of shuttles used. Thus, with arrangement of the warp, of the harness, and of the motion of the shuttles. To cause the motion of the harness and drop-box to occur at the proper times an arrangement consisting of two endless chains, having small bars between their links, on which are fixed projections, so that the lever corresponding to a certain harness is engaged and the harness moved. A similar arrangement operates the drop-box. The principle of this contrivance is taken from the Jacquard attachment, which is alluded to further on, and which operates each warp-thread separately, instead of the whole harness, the heddles or threads holding the mails or eyes being separate.

An ingenious contrivance has been introduced on some looms, which consists of a circle operating a projecting rod. When the shuttle enters into the box it pushes the circle and prevents the rod from deflecting the belt. Should, however, something prevent its entrance, the rod is not displaced and the loom is stopped.

Positive-motion looms are looms in which the shuttle has a positive motion at every moment of its run. This is done by placing it upon a carriage. See Fig. 15.

The warp passes between the wheels 3 and 4, 3 being rotated by 2, and hence the position of the warp-threads is not deranged, the velocity of 3 and 4 being equal to 2, and hence to the speed of advance of the shuttle. Several appliances for regulating the motion of the shuttle, quick at the middle of its stroke and slower at the ends, and for causing dwell in the lay, obviously necessary in a slow, or long-traveling shuttle, are introduced in this loom.

The advantages of this form of loom are as follows, briefly enumerated: The abolition of the picking-sticks or impelling levers, and their sharp motion; the positive motion of the shuttle; economy of power; the unlimited variety of figures, patterns, etc., that may be woven; the great width of the warp, being 24 feet in one case, and

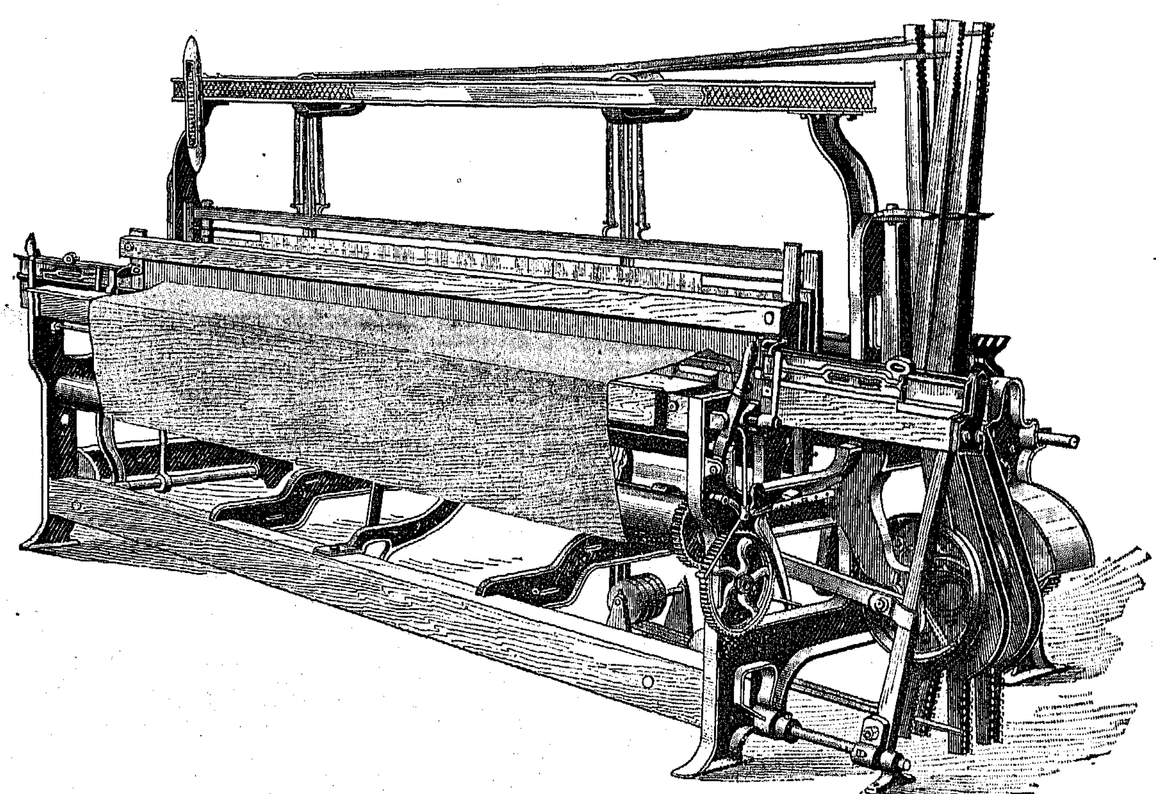

Fig. 16.

the diminution of wear, owing to small motion of the reed, the small opening of the heddles, the abolition of the sudden jerk to the filling in starting, and the almost entire absence of friction between the shuttle and the yarn.

The take-up and let-off motions in the various makes of woolen looms are different, depending on the class of goods manufactured, the extent to which the cloth is beaten up, the number of picks or motions of the shuttle per minute, and the size of the yarn of both filling and warp. The motion of taking up is often done by pawl and ratchet, while the let-off is frictional.

The temple alluded to previously is simply a small roller of wood, with nine teeth, in an iron frame, which hold the cloth steadily stretched. A spring is so attached to the frame as to yield sideways in case of accident. These are the general features, and the following illustrations and descriptions will give an idea of present forms.

A few words should be said, however, of the needle-loom, which has been quite successfully applied to silk-weaving, and experimented with on carpets. The idea is to get rid of the shuttle entirely, and substitute a needle with a split eye, which will catch the filling and draw it through the warp. It is more fully described in the report on silk machinery, in which industry its application is greatest. The Jacquard attachment is likewise detailed therein, as it is of greater use for figured silk goods than in woolen goods, where harness-looms are more generally used. The combination of Jacquard and positive-motion shuttles has been successfully made on corset-looms.

Pile weaving consists of weaving wires into the fabric and then removing them, thus causing a tube of warp to be raised. This is either cut, as in velvet and some kinds of carpets, or is preserved in its rounded shape, as in

Brussels carpets. The mechanism employed is very ingenious, each wire being automatically pulled out from the cloth and placed in front of the series in the shed.

Figs. 16, 17, and 18 represent various cam and fancy looms, and may serve as examples of present practice.

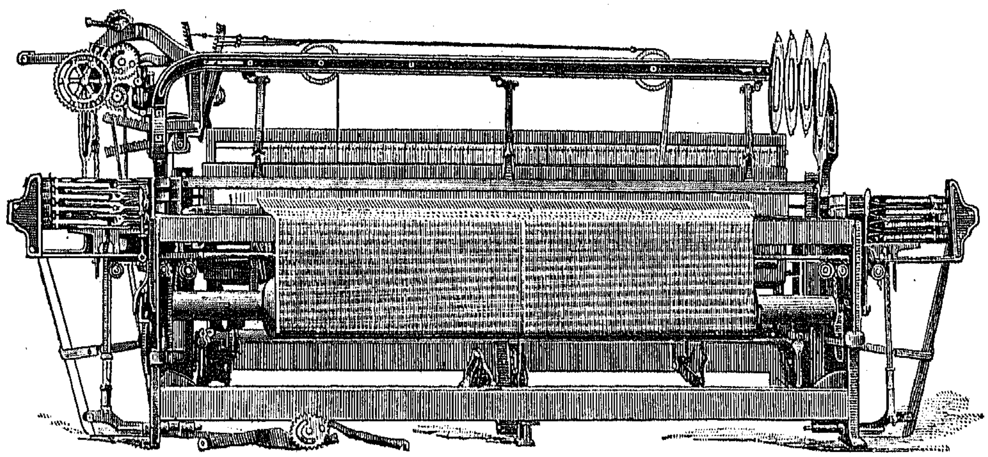

FIG. 17.

Fig. 16 is a cam-loom, built by Davis & Furber. The harness, levers, and cam motion are shown in the figure, and the various parts may be seen and understood from the previous descriptions.

Fig. 17 represents Knowles's fancy loom. The machine is an open shed-loom, its principal advantage being an

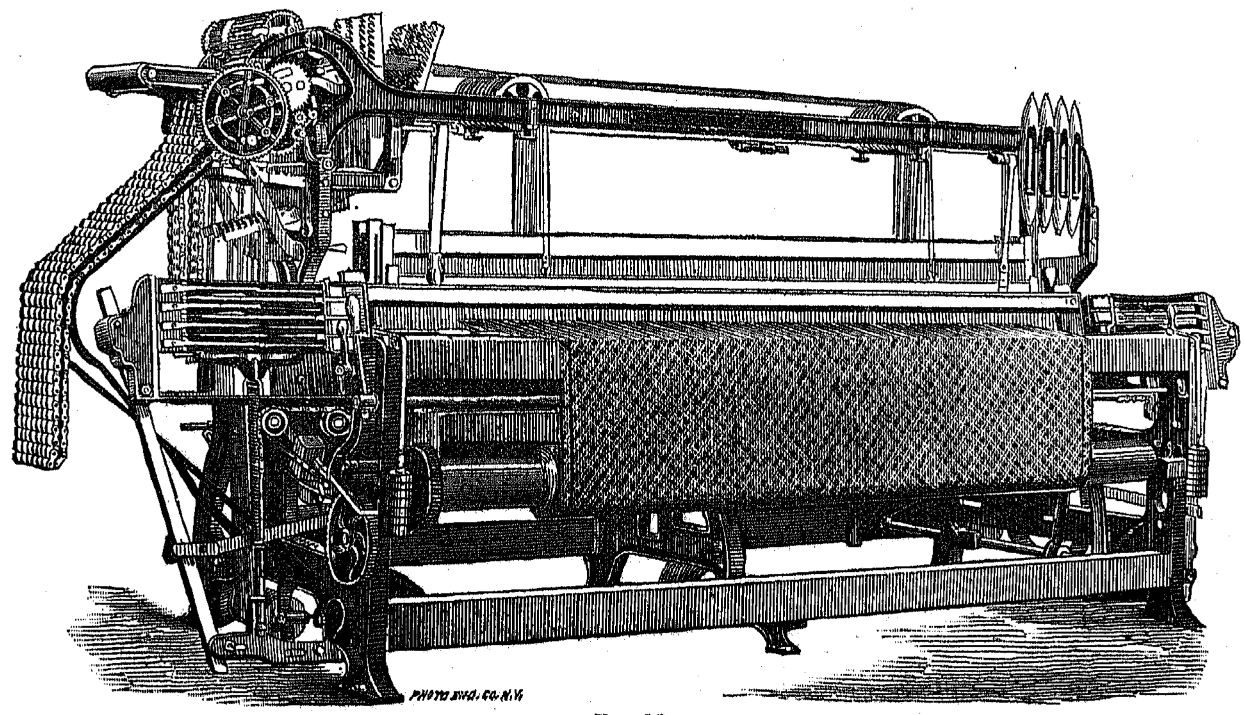

FIG. 18.

arrangement by means of which the chain can be moved by hand, so as to remove filling woven in by mistake, by a retrograde motion of the design-producing machinery.

Fig. 18 is a forty harness-loom, having capacity for seven shuttles. It is one of the largest and most efficient looms of its peculiar style. It is also built by Knowles & Bro. Its construction will be understood from previous descriptions.

FULLING-MACHINES.

After the cloth has been woven it is necessary to remove the oil with which it was saturated before carding, to press together the fibers, introduce a certain amount of shoddy or backing, and sometimes sizing. Formerly this was done by fulling stocks, a cumbersome, noisy, and comparatively inefficient machine. These are now being superseded by the rotary mills, in which the cloth is treated by pressure, insuring a better fulling, with less power and attendance.

As previously stated, the reduction in labor, as estimated by manufacturers, is about one-half.

Fig. 19 shows a modern fulling-machine in section. The cloth enters the machine at R^1, and is conveyed by the machine to the main cylinder, A, then beneath the rolls B^3 B^2 B^1, and finally comes out through the trough C D E. The ends of the cloth are joined; the machine started. The fulling crosswise is effected by the rollers B^3 B^2 B^1, which have a tendency to draw it out, hence to contract the warp together. The fulling lengthwise is produced by the sides of the trough C D E, which can be regulated by varying the weight M. The machine is

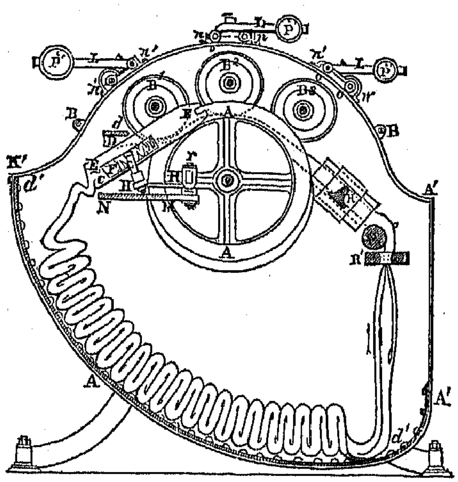

Fig. 19.

entirely under control. A beating motion is sometimes added, by revolving or reciprocating beaters on a fulling-table.

CLOTH-FINISHING MACHINERY.

After the fulling the cloth must be freed both of the water, which mechanically adheres to it, and its hygroscopic moisture. The former is done on centrifugal machines, which removes the greater part. For the latter artificial heat is employed.

From the drier the wool is taken to the tentering-ground and stretched in the rays of the sun. This operation

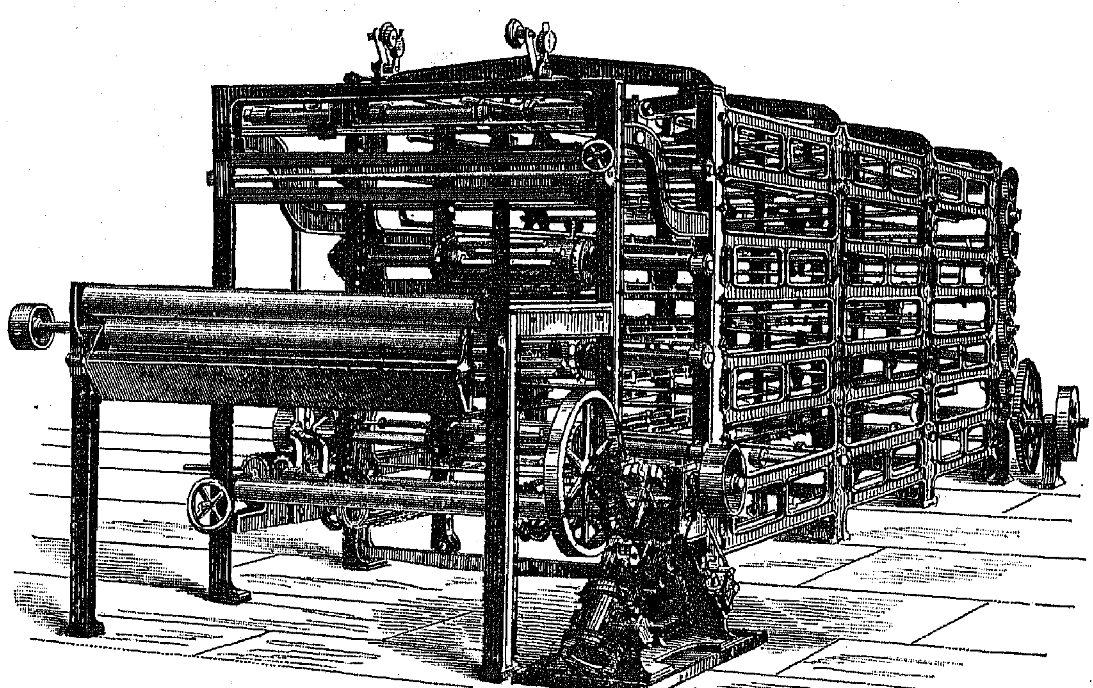

Fig. 20.

is now seldom performed in this manner, except in the smaller mills; those of any size using tentering-machines almost universally. These, combined with drying-cylinders, are shown in the accompanying Fig. 20.

After the latter operations the cloth is gigged, sheared, brushed, measured, and folded, each operation requiring a special machine. Gigs are contrivances by means of which the nap is produced. They usually consist of rollers for winding the cloth, firmly stretched in the intervening space, and operated upon by rows of teasels.

Fig. 21 is Woolson's gig. It is usual to steam the cloth during the operation, hence the kettle arrangement under the main cylinder. This is a species of spider frame, having fourteen flats, to which the teasels are affixed.

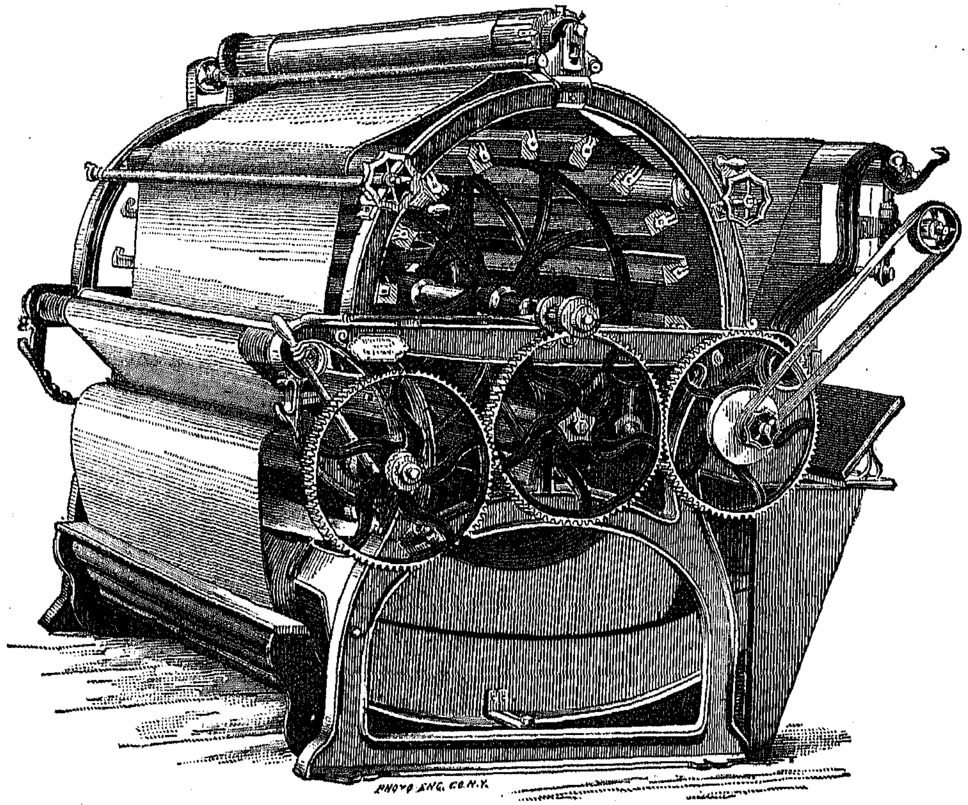

Fig. 21.

Fig. 22 is a wet gig, built by Davis & Furber. In these machines the cylinders are 40 inches wide, making 125 to 150 revolutions per minute. Some of these machines have brushes attached, as in the large gig, by the same firm (Fig. 23). The teasels are on rolls and the brushes on flats. The width depends on the goods.

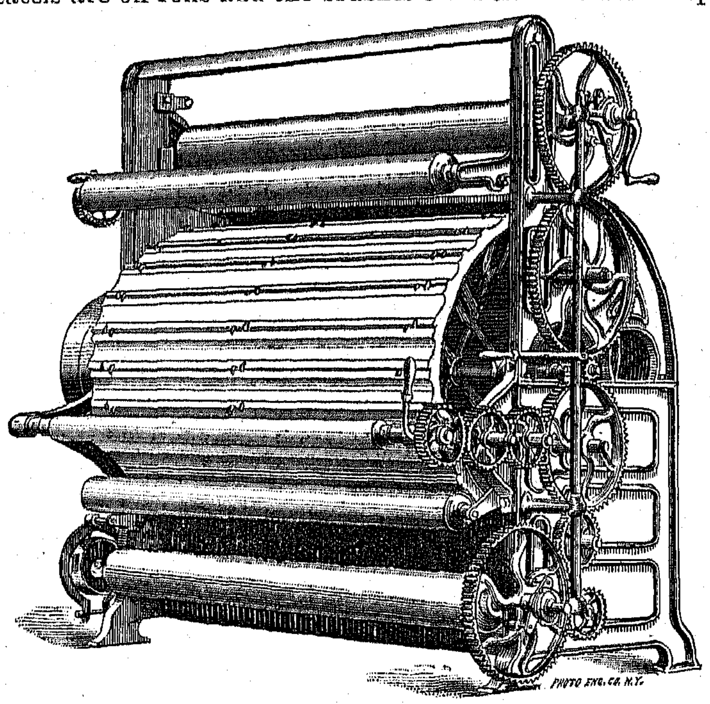

Fig. 22.

Shears for cutting the nap to an even depth are the next machine in the process. Woolson's shear is shown in Fig. 24.

The principle of all machines of this class consists of passing the cloth, tightly stretched between two rollers, over a knife-edge, very close to which revolve spiral blades, like in a lawn-mower. For fine fabrics the cloth is simply depressed under two rollers and the nap cut even by a knife between. This is due to the fact that thin cloths have little elasticity and cannot resist the action of the other machine. The machine has a guiding tray or pan underneath and 26 cutters. Sixteen to 20 yards may be sheared per minute, it is claimed.

After leaving the cutters the cloth is brushed on separate machines to clean the cloth and improve its appearance. Such a machine, built by Parks & Woolson, is shown in Fig. 25. It is essentially the same in principle as the preceding, excepting that a rotary brush is substituted for knives or teazle flats. There are two cylinder-brushes in this machine clothed with bristles. Pressure may be applied lightly to one cylinder and heavily to the other, or the cloth may be pressed on both equally. Sometimes a steaming attachment is affixed to these machines to steam the cloth while thus being operated upon.

Fig. 26 shows a measuring machine, the principle usually being the stretching of the cloth and running it over a roller, which shows, by means of gears, the number of revolutions, and hence the length passed over. All the

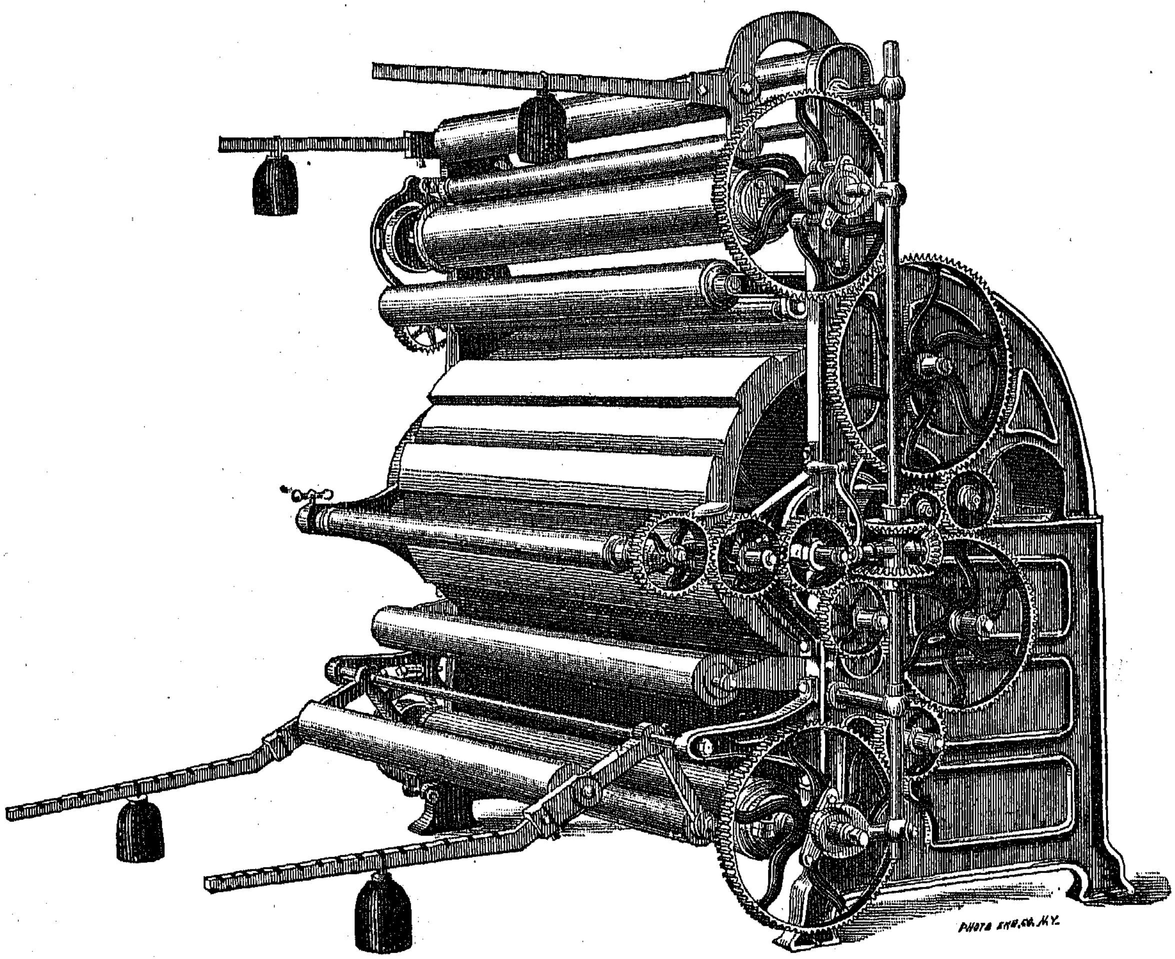

FIG. 23.

latter machines are by the Parks & Woolson Company, and are given as examples of a class. After the final winding or folding the cloth is ready to be packed. In mills where the cloth is packed in pieces these are placed in a folding-machine and then pressed. A final inspection is made, the pieces ticketed, and the product is ready for the market.

WORSTED AND CARPET MACHINERY.

Worsted is long staple-wool, the fibers being considerably longer. The process of manufacture is almost identical with that of ordinary wool, the same machines being employed, with one or two additions. The material is, however, treated differently, and the amount and method of carding, though on the same machines, depends on the product. Skill and experience are required in a high degree. A general outline of the process is as follows, as carried on in one of the largest mills in New England: The wool is first sorted by hand in classes, as in the general process. It is then washed twice in good soap and entirely freed from impurities. The longer fibers are then prepared on preparrers and Lister combs. Medium and short wool are carded, and then combed on Noble combs. The next operation is drawing. This is done on drawing-frames, in gill-boxes, and on roving-frames. The spinning is on cap-frames for short and medium wool, and for long wool on flyer-frames. The weaving, as in the general process, is done on either plain looms, on shedding, or on Jacquard looms, according to the design required. Worsted is often mixed with wool and other materials and woven in with them.

The object of the preparers is to loosen and straighten the fiber, and the combs remove the short staple in the shape of noils and bring the long wool into a sliver. Although no great improvements have been made during the last ten years in the carding, still, by paying attention to the details, the efficiency has been increased about

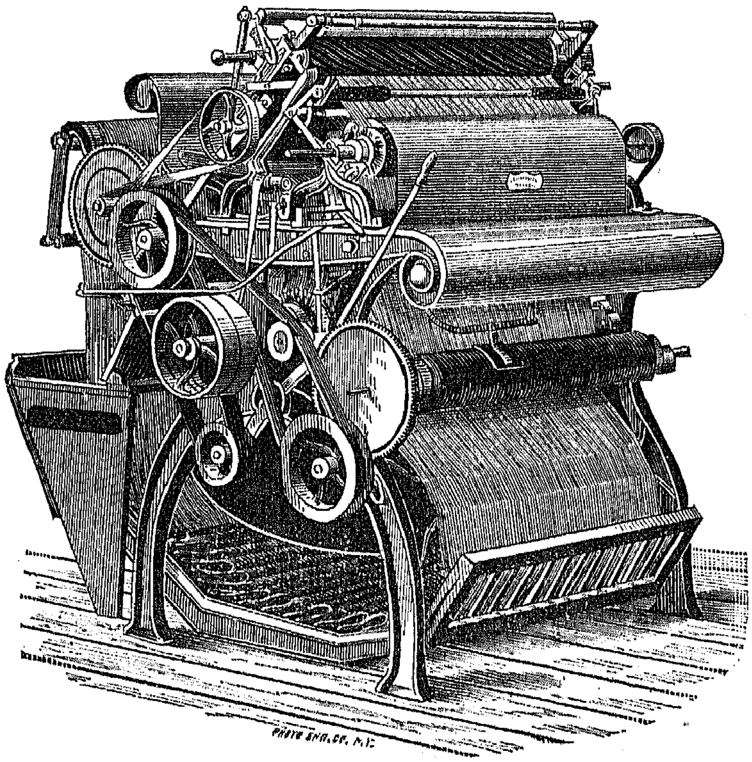

FIG. 24.

25 per cent., and the quantity of the product about an equal amount. In 1870 the product of one comb was about 400 to 450 pounds a day. At the present time (1880) this product is about 700 to 750 pounds with the same labor,

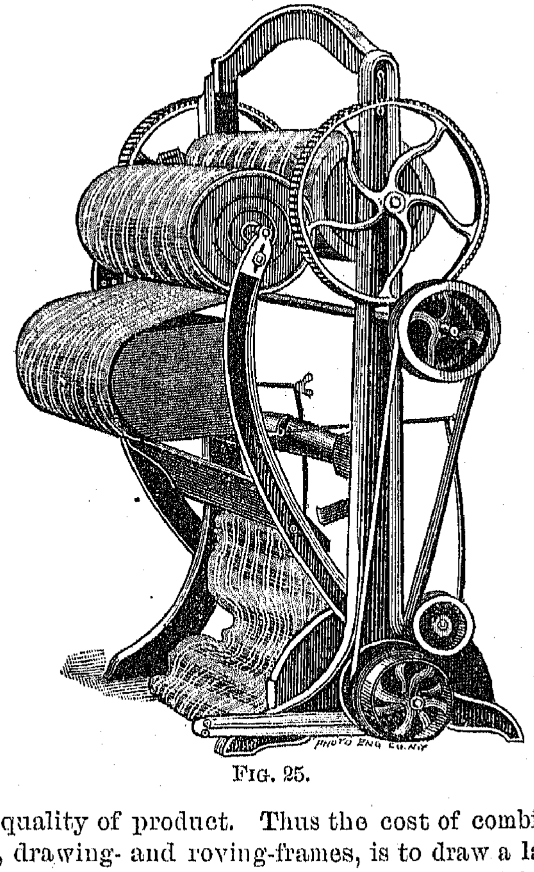

FIG. 25.

yielding at the same time a better quality of product. Thus the cost of combing has been reduced about 25 per cent. The object of the gill-boxes, drawing- and roving-frames, is to draw a large number of slivers into a small uniform roving, ready for spinning. The improvements have been gradual, being noticed only in the increased efficiency, which is also about 25 per cent. The worsted thus prepared is generally used for filling on the looms previously alluded to. The Jacquard attachment was introduced about ten years ago, and at present a double-action attachment is being added, which will increase the speed about 20 per cent.

The machines, excepting the cards and looms, are nearly all English, this class of manufacture being comparatively new; and our machine-builders are only commencing to pay attention to the necessary machinery.

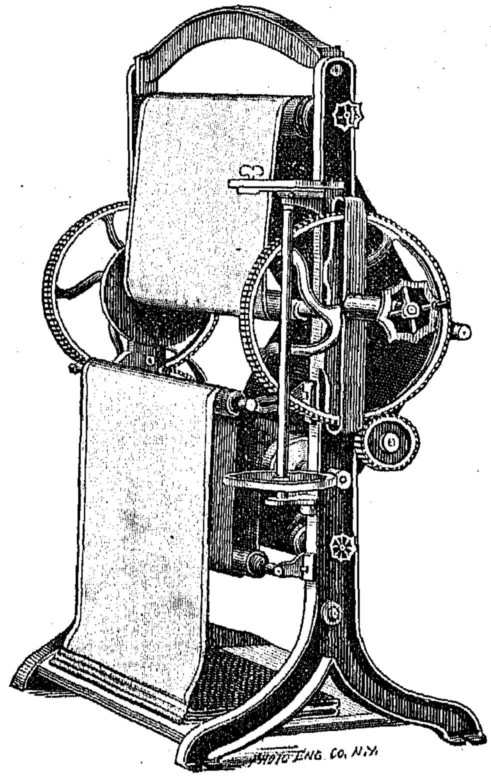

FIG. 26.

Fifteen years ago, at the mills alluded to, only three kinds of goods were made; at present over one hundred and forty styles and patterns are produced; and although the finer qualities of goods are not yet made in this country, still in the qualities that are made our manufactures compare favorably with importations. The manufacture of worsted goods requires a higher class of skilled labor, which is gradually growing up in this country and is replacing foreign labor to a considerable extent.

CARPETS.

The production of woolen carpets is a comparatively simple process, many of the mills purchasing the necessary yarn already spun. The warp and weft are often different materials, and a variety of fibers are used, such as cotton, jute, flax, wool, worsted, etc. A general idea of the features of this machinery may be derived from the following figures, furnished by a prominent machine-shop: Cards, 4 horse-power to a set; capacity, about 400 pounds a day, against 250 ten years ago. Looms: For ingrain, take one-half horse-power, each producing about 30 yards a day; mostly introduced during the last ten years; formerly one hand could produce 14 yards a day. For Brussels, three-quarters of a horse-power produces 40 yards a day, or one-third more, at one-half the expense of ten years ago. These looms are operated by girls, while the foreign looms are operated by men. For Wilton, three-quarters of a horse-power produces 40 yards a day. These have improved about as much as the Brussels loom. For tapestry, one-quarter of a horse-power produces 60 yards a day. The simplicity and speed of these looms has been increased considerably. Shears requiring one-quarter of a horse-power treat 1,000 yards a day.

Brussel looms have an auxiliary arrangement, as stated in the previous pages, which pushes pins in the shed, thus raising the warp into a loop. Several of these pins form a series, and the one nearest the operative being pulled out automatically is placed at the other end of the series in the shed. These pins pass through the entire width of the warp. For wiltons the pins have small knife-edges on the end, the warp-loop being thus cut open when the pin is withdrawn. These brussel looms have often a creel attached, in which are placed the bobbins holding the warp-yarn. This obviates the necessity of warping previously, but takes up much space. Carpet mats are made by hand. First a sheet is woven in streaks, according to a design, and is then cut up in strips. The warp is quite open, the threads being far apart, and serves merely to hold the filling together. The roping thus produced is then used as a filling and again woven on a loom, a new beam of warp being used to hold these strips together longitudinally. By the care taken in weaving the strips at first the design appears in the finished rug. This is a new process, and as yet (1880) entirely done on hand-looms.

Tapestry carpets are yarn printed, which saves considerably in the cost, yielding the same durability.

MACHINERY USED IN SILK MANUFACTURE.

The silk industry of the United States does not exhibit, like many of the other productive industries in this country, an unbroken record of success. Though attempted early in the history of the British colonies—encouraged by the home government—it soon, however, failed when this support was removed. Again, when the craze for the silk-worm breeding, or rather the growing of the *Murus multicaulis*, spread over the country, and proved an ignominious failure, ridicule and mistrust were engendered and the progress of the industry checked. It is only lately, since encouragement has been afforded domestic manufactures by the tariff on imported luxuries, that the business has grown to considerable proportions, and is now one of the many industries the products of which Americans can rightly be proud of. The history of this industry convinces one of the fact that though machinery, improved and often invaluable, has done much toward producing the high quality and excellent appearance of the goods, yet the success of the industry, as a business, has devolved as much on question of general prosperity, supply and demand, government protection, and the dictates of fashion.

In many of the industries of this country, notably the utilization of the grain belt of the northwest, in the success of the American watch, steam-engine, rifle, etc., mechanical invention and improvement were the sole factors. In silk manufacture this is not quite as true; though of late years, especially in the near past, the machinery used in this industry is of great efficiency and mechanical ingenuity, yet the factors enumerated above have played an important part.

The general prosperity of the country is a great promoter of the silk manufacture. When every industry is depressed, and economy is the order of the day, all luxuries are discarded and as little silk worn and used as possible. When, however, the financial condition of the country again improves there is money to spend on comfort and luxury, besides the actual everyday needs. Silk, perhaps more than any other fabric, is dependent on such fluctuations of prosperity, as we can well dispense with it in our clothes and in our homes when wool and cotton are indispensable.

Another important consideration connected with the success of the industry is the question of government protection. Without the latter it would be impossible for domestic manufacturers, even with the most improved automatic machinery, to successfully compete with the hand labor of Europe, so patient, so skilled, and yet so little remunerated.

Success in some branches of trade, especially in its early days, was due in some cases to the fact that ocean freights were slow and uncertain, and domestic factories supplied a demand for a passing fashion before importers could bring the goods from Europe, or supply a lack of imports.

The dictates of fashion have not a little to do with the profit of the manufacturer. In trimmings and similar goods this factor prevents in some cases the use of other than general machines, as it would be a matter of considerable expense and ultimate loss for the manufacturer to build a machine specially applicable to a passing fancy. On looms for ribbons, piece goods, etc., this is not as serious a matter, owing to the applicability of these machines to various patterns, but in trimmings, a large and prosperous branch of the general business, hand labor has to be often used where machinery could be economically employed were the same design to remain for a protracted period.

Mechanical progress has had, however, a good share in assisting the industry in its advance to business success and the production of excellent materials.

Briefly enumerated, the chief mechanical features of a silk-mill are the appliances for twisting and doubling the reeled silk, treating the thread thus formed, and the weaving of the final product. The dyeing is invariably done in the yarn, with the exception of the cheaper class of handkerchiefs and similar goods, which are printed like calicoes.

Silk waste, or imperfect cocoons, the "short staple" of this industry, is also largely treated, and an extremely durable and excellent quality of goods manufactured therefrom.

As there are several thousand various mechanical appliances employed in this industry, it will be impossible to describe them all within the scope of a report of this nature. Mention will be confined, therefore, to a detail of the principal machines—those having a very prominent effect on the general efficiency of the mill. The figures and facts have been obtained from manufacturers and machinists, often widely differing, and not from personal experience or experiment. Before describing the processes and machinery it may be well to give a few historical points.

The only machinery used in the colonial days were, besides the reels in the filatures, common spinning-wheels, such as were used for cotton, flax, etc. About 1800 Horace Hanks introduced his double-wheel head. In 1829 Edmund Golding, a young Englishman, made designs of improved throwing machinery. About this time some improvement had also been made in looms and weaving machinery; and the industry having attained importance, a full description of the processes and machines may be found in the Rush letter, Ex. Docs. 158 and 226, Twentieth Congress, first session. In 1828 Toeshaven Bros. introduced a single machine for reeling, doubling, and twisting at once. This, however, has never been a success.

The next prominent inventor was Nathan Rixford, who in 1838 greatly improved that part of the process relating to throwing. In 1852 a great impetus was given the thread industry by the demand for machine twist, or silk thread appropriate for sewing-machines; and the improvement of the machinery has been rapid and large up to the present day. About 1855 the manufacture of silk goods from spun silk was begun at South Manchester, Connecticut, and necessitating an entirely different process, introduced a series of ingenious and efficient machines. However, up to this day much of this class of machinery is imported.

In 1868 the manufacture of silk nets was begun. A year later lace-machines were introduced, and in 1871 this branch of the industry was successfully begun in Brooklyn, the machinery for which is, however, almost entirely imported and of high cost.

PROCESSES.

Owing to the fact that silk is received in this country in two shapes, viz, "raw silk" or hanks of reeled cocoons, and "waste" or pierced, double, imperfect, etc., cocoons, there are two processes for the preparation of goods. We will first take up the reeled silk and its treatment as being the more widely spread branch of the industry.

The hanks of raw silk imported from Japan, China, and Europe vary in quality, owing to the greater or less care with which the thread was produced at the filature. Expert hands sort this silk and determine the portion to be made into tram or organzine (filling and warp). It is then soaked or washed, usually to remove any remaining gum and soften the fiber. The silk is then placed on winders and wound off on bobbins. Much simplicity is given the process by the fact that the raw material is a continuous thread, and hence the manifold and intricate appliances for reducing a mass of short threads into a thin sliver, as in cotton and wool, are dispensed with. The untwisted or dumb singles, as the filament is called, is doubled and twisted on spindles similarly to cotton yarn, this portion of the machinery being of especial excellence and efficiency. The twisted thread is then wound on reels into hanks and sized and dyed. The so-called throwing is twisting two singles already twisted separately, and usually in the opposite direction, to the final twist. For tram and organzine the threads are wound and again doubled after dyeing, and either warped into a beam or wound on a quill-winder for filling. Before and after these processes the thread is cleaned or cleared; that is, run over a machine which stops at every knot or imperfection, enabling the attendant to remove it. Another special process is the dramming or weighing of the yarn prior to dyeing.

The second, or silk-waste process, is one of considerable and growing importance. Though it has been operated at but a few points, yet the large mills and excellent product of Cheney Bros., at South Manchester, have proved the possibility of financial success in this line. Waste silk is not, as may be imagined, refuse or shoddy from silk-mills, but consists of imperfect, perforated, or otherwise injured cocoons, which cannot be reeled into a long, continuous thread. These, with the short staple produced at the filatures and in the subsequent treatment at the mills, form the raw material for this branch of the industry. A general outline of the process is as follows:

The waste is first washed, to remove the gum and leave the fibers clear and separate. It is then treated on the filling-machine, which is similar to a cotton-card, consisting of a cylinder upon which are set rows of pins which draw the fiber out from between two rollers. When the pins are full the silk is cut and placed between two pieces of board which open like a book. These are placed, several at a time, in the combing-machine, which combs first one side, then the other, and, removing all foreign matter, leaves the silk white and glossy, with all the fibers parallel. The boards are then opened, the flat piece of silk, with the fibers running crosswise, are rolled up and placed on the spreader. This beats the silk out to a flat band, which is then passed through gills on a blade and is rolled upon a cylinder. In this machine it receives its first continuous form. It is next taken to the sett, which is a similar gill contrivance, and reduces the sheet to about an inch in width. The process is then similar to that of other fibers. It passes through drawing-, doubling-, and spinning-frames until it becomes a fine thread. It is wound on bobbins and passed over a winder, upon which are small gas-jets which burn off any knots or lumps and give gloss to it. It is then reeled into hanks and dyed.

The application of this thread is manifold, part being sold for sewing and part being woven on looms into fabrics. Though at first the appearance of such spun-silk goods did not equal that of reeled silk, yet the present demand for cheap goods, such as handkerchiefs, etc., has enabled the establishment of a large business in this branch. The improved English machinery and care in the manufacture now enable the production of spun-silk goods of excellent appearance, almost impossible to discern from reeled silk, at much less cost and equal durability.

In all questions of silk cost it is the raw material that is expensive and which causes the high price of all silken fabrics; hence the advantage of spun silk, which, lacking little in beauty of reeled silk, is equally, and often owing to the absence of "weighting" more, durable.

The weaving of silk goods is done alost invariably on power-looms similar in every respect to those used for cotton, wool, etc. Only heavy black gros grain and other wide goods are still made on hand looms in Paterson, the principal silk manufacturing center of this country.

The Jacquard attachment for figured goods comes greatly into play in this industry. The possibility of weaving of figured handkerchiefs, labels, book-marks, and broader goods as yet depends on this ingenious contrivance, at least on power-looms. It is described in its present form in the succeeding pages. The warping for the looms is done in many mills on a huge wooden cylinder, called the mill, from the bobbins. The resulting beams are combined together. Several establishments are running on rich goods of the damassé and other similar kinds, which are costly, but of excellent quality, and find a ready sale.

Velvets have been attempted, but do not amount to much in quantity of production as yet.

Trimmings form another important branch of the industry, and many appliances have been introduced to assist the skilled hand labor, which, however, is indispensable.

In general, silk machinery is somewhat simpler than that of the other textile manufactures, owing to the nature of the raw material. For the same reason more skilled labor and of a high class is needed, as the personal inspection and removal of imperfections is of paramount importance in the modern American silk-mill. Silk, owing to its smoothness and gloss, shows knots and imperfections to a greater extent than any other fabric; hence the utmost care must be taken with the thread before and during weaving, and hence the necessity of keen-eyed and skilled operatives. Another consideration is the fact that in this country, the machinery being all operated by power and automatic, the stoppage of a loom or other portion, resulting from an imperfection in the thread, is a matter of vexatious delay and financial loss, much more so than in Europe, where the machinery is operated by hand (looms), and hence can be stopped and started without great loss of time or money.

This feature of automatic treatment, and the consequent necessity of perfect thread in the weaving, is eminently a question brought out by the improved machinery used at present. In other words, the improved machinery has improved the yarn; the improved yarn has enabled power-weaving; and power-weaving, being at present almost absolutely the only way to produce the goods economically, has reciprocally caused a demand for the best thread, and hence has caused an improvement in the throwing, winding, doubling, and preparing machinery.

MACHINES.

As compared with cotton or wool machines silk machinery is of great simplicity, as reeled silk does not require the combination of short fibers into one long yarn, and later in the process obviating the drawing process necessary in the other two processes. Hence, after the preliminary operations previously alluded to the first machine in the

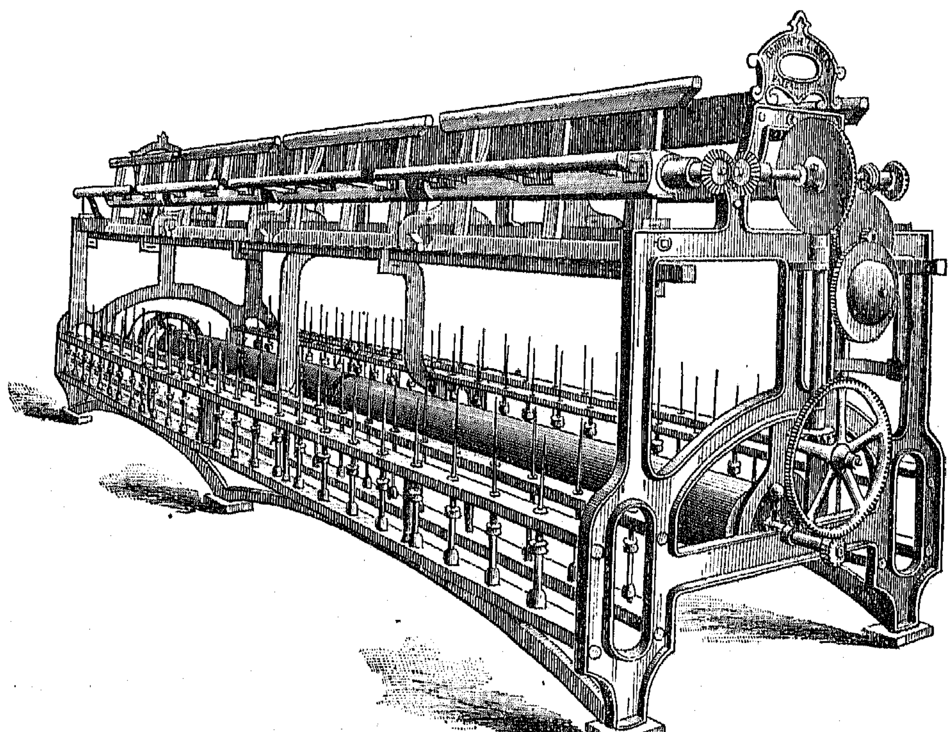

FIG. 1.

process is the winder. These machines are run at considerable speed; power required, about 600 spindles to a horse-power, the attendance being 5 girls to 24 spindles. The winding both of raw and soft silk have improved to a considerable extent. The reel-mill built by the Danforth machine-works, a machine for winding on skein, is shown in Fig. 1.

This machine takes about 1 horse-power to 300 spindles, and requires but little attendance. Doublers take 1 horse-power to 300 to 600 spindles, and about 6 girls to 100 spindles.

The most important machine previous to the loom is perhaps the spinning-frame. In this portion of the process much improvement has been effected, the spindles revolving at a higher velocity, more smoothly, and the whole size of the machine reduced considerably.

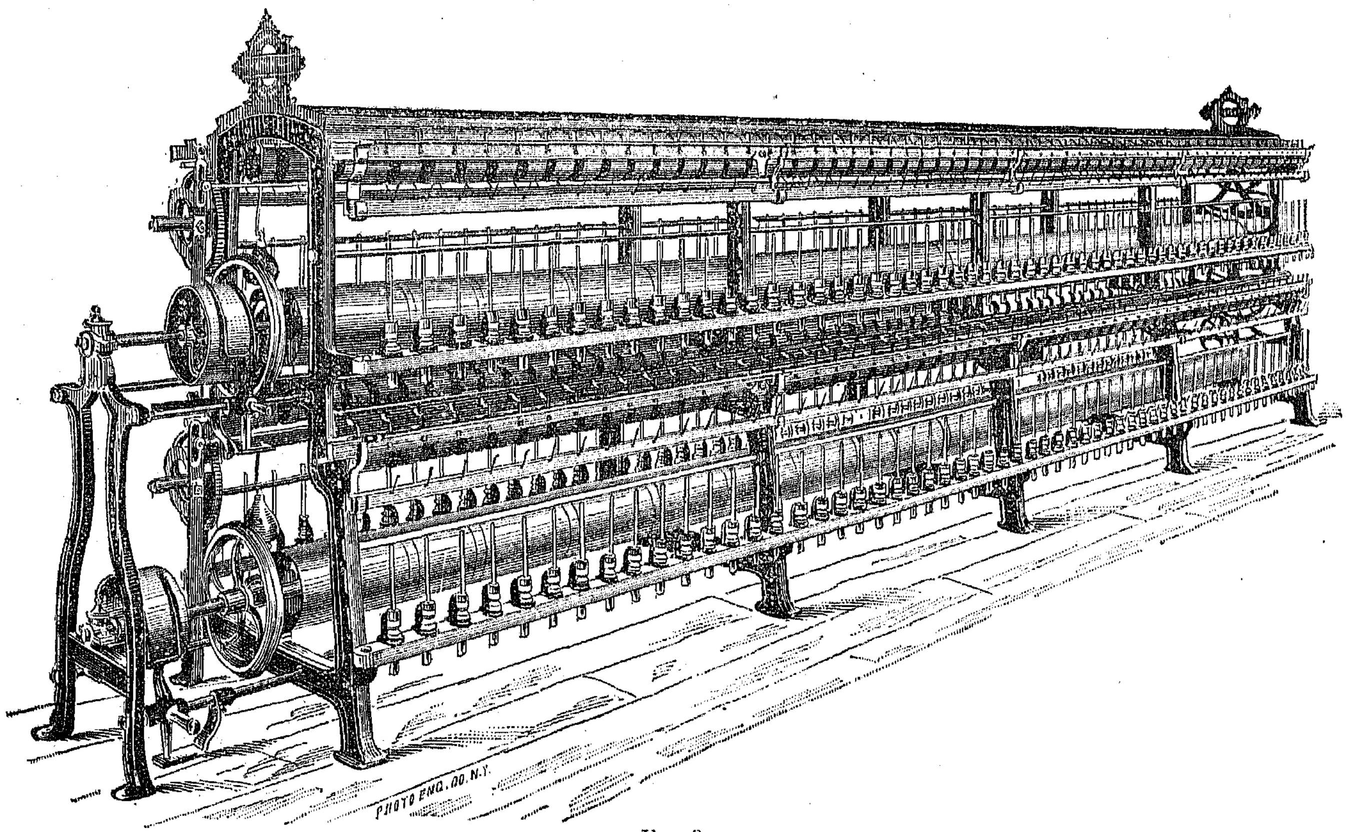

FIG. 2.

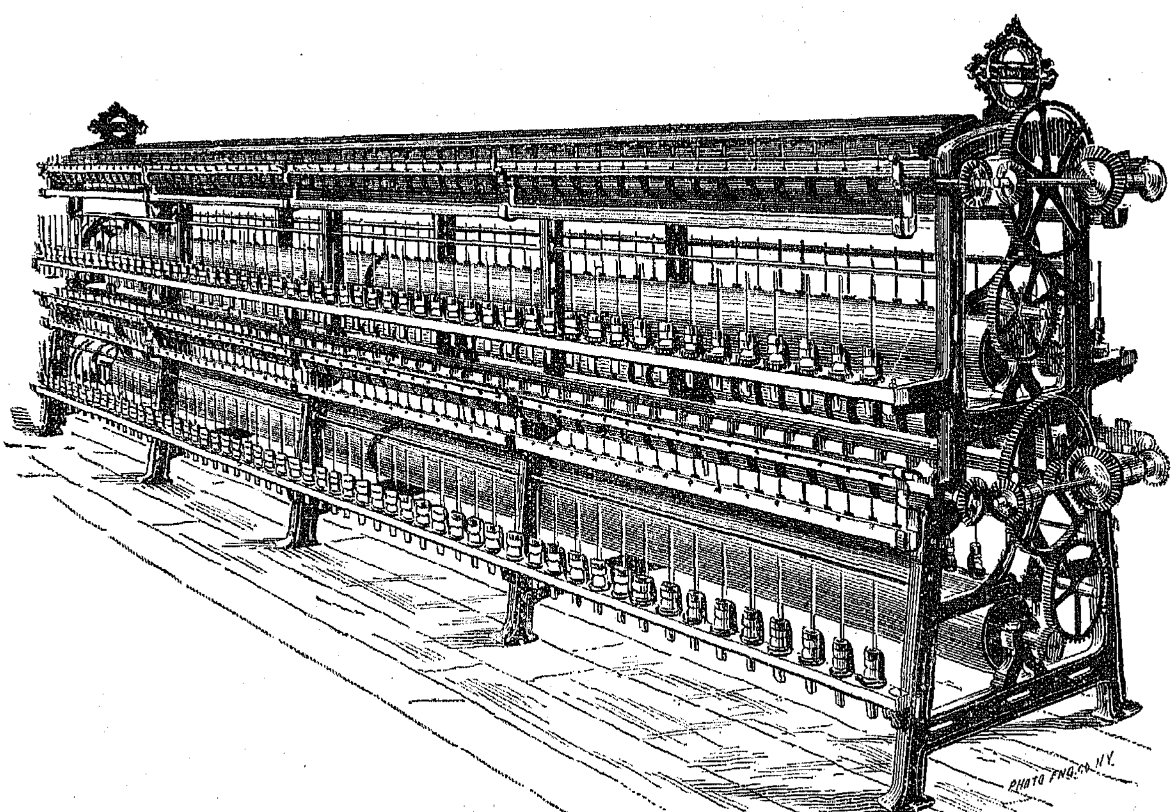

FIG. 3.

Figs. 2 and 3 represent the Danforth machine company's two-story spinning-frame, which is 32 inches between spindles, these being about 4 inches apart. It is estimated for spinning that 1½ horse-power will run about 450 spindles, though of course the power varies, like in other similar machines, with the yarn to be twisted.

Fig. 4 represents the spindle used in the above frame. Fig. A is an elevation, and Fig. B section. B is the spindle; D the sleeve, which insures its rigidity; P the step; G the rail. It will be seen that there is but one rail,

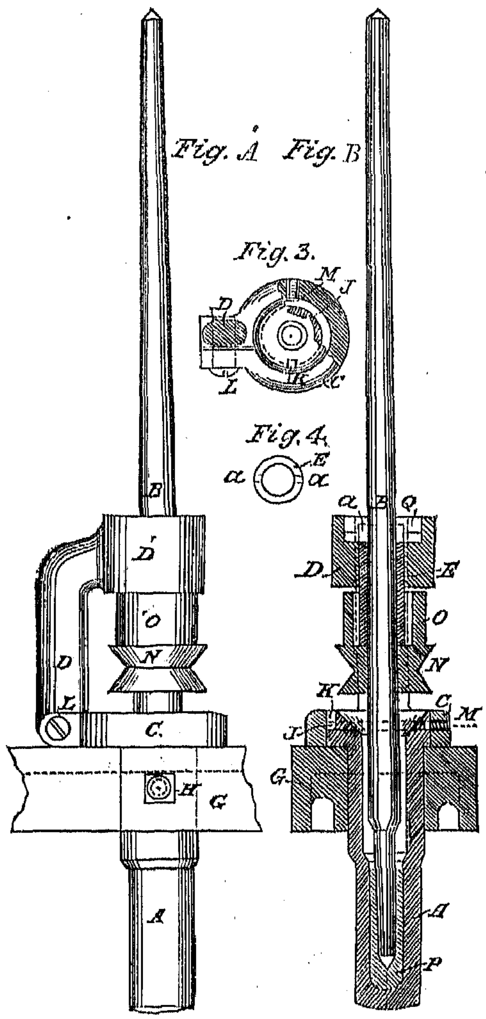

FIG. 4.

the bracket and sleeve D taking the part of the upper rail. This has enabled the reduction of the mill by 12 inches in width; an economy of ground space. N is the pulley. The spindle is a self-oiler, and no oil can escape by centrifugal force, as may be seen from the figure.

The gearing of the frame insures immunity from belt slippage, and though the width is thereby somewhat increased, the gearing shown in Figs. A and B is simple, and by far more direct than in the very narrow spinning-frames, which have been built but 10 inches wide.

At present silk machinery is run at very high speeds, and spindles and other rapidly revolving parts have attained high proficiency. At a speed of 10,000 revolutions per minute the modern spindle moves as smoothly and with no slopping or heating as one ten years ago running at a quarter of this speed. The improvement in this branch, parallel with that in cotton-spindles, has been very rapid the past few years.

Fig. 5 represents a quill-winder, or machine for winding the weft or the small bobbin of the shuttle. Formerly these were quills, whence the name, but owing to the high cost other materials are at present used. This machine takes the place of the more cumbersome winders used for cotton and wool, where the filling is wound on heavy bobbins. The machine takes but an insignificant amount of power and but little attendance, excepting replacing the filled quills.

Silk, especially in this country, is manufactured in greater part into figured goods; hence the necessity of looms capable of producing every variety of design. Probably there are more Jacquard attachments in proportion to the number of looms in silk than in any other textile industry, as this contrivance permits of a greater variety of designs than the common fancy loom.

The Jacquard attachment to a loom, now applied to looms with several shuttles and lately to positive-motion looms with a species of let-off motion to the shuttle for weaving goods not in a plane, is described here for the above reason, though it is applied to woolen and other textile manufacture to a considerable extent. The object of the contrivance is to automatically select certain threads of the warp and raise them above the shuttle as it passes through the shed thus formed, to raise the same threads at the end of each series of variations, and to keep this process up *ad infinitum*. The machine now so extensively used was the invention of the Lyonais whose name it bears, and who, unlike other useful inventors, was well remunerated by his government.

The principle of the machine is as follows: The warp threads pass through the usual heddle arrangement;

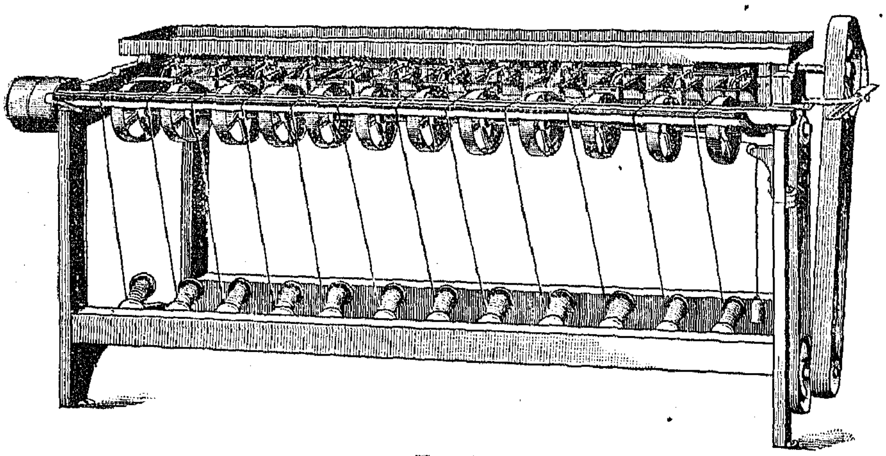

Fig. 5.

the tops of these are, however, separate, each warp thread being thus independent of the others. To the tops of these heddles, which are really lifting-bars, short bars are hooked on. These are called needles. Around them are wound coiled springs, which continually press upon them. Opposite the heads of the needles is a prismatic box, containing holes on its sides exactly opposite the needles, so that these slip in, impelled by the springs. If, however, one of the holes be closed, that needle will not be raised. To raise certain threads and leave the others unmoved a series a card-board rectangles, hinged together at the edges, is run over the prismatic box. Through these are punched holes corresponding to the needles to be raised. Where a hole is punched it coincides with the hole in the box the needle enters, and the thread is lifted. Similarly, if the hole in the box is covered by the card-board, the needle is held and prevented from raising the thread.

Figs. 6, 7, and 8, from Appleton's *Cyclopedia of Applied Mechanics*, show the construction of the machine. It has been greatly improved lately. Some have been manufactured of such weight as to require sheet-iron cards. By detail improvements it is probable that the best Jacquard has an increased efficiency and speed of at least 20 per cent.

The following figures show the construction which, owing to the necessary mechanical motions in connection with the loom, is somewhat complicated:

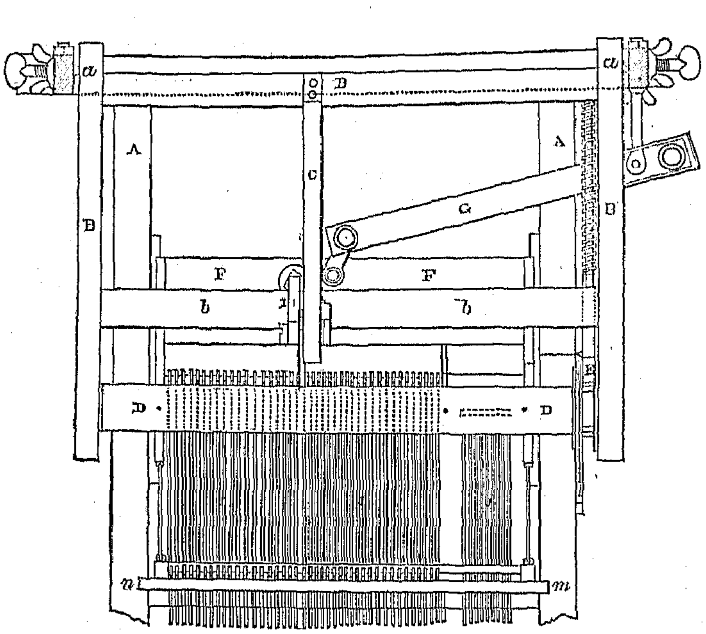

Fig. 6.

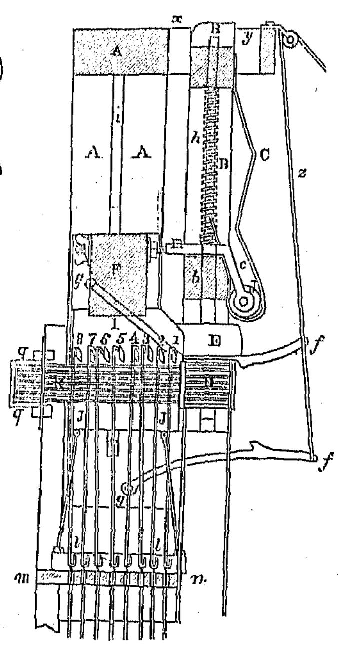

Fig. 7.

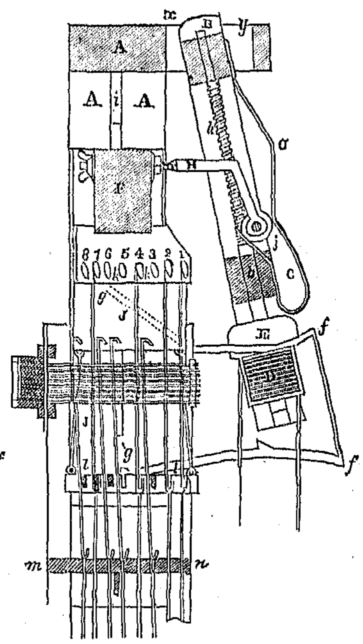

Fig. 8.

These letters are the same in the three figures. A is the frame of the machine; B an auxiliary frame which vibrates about B. Fig. 7 represents the warp lowered, and Fig. 8 when the warp is raised. D is the prismatic box, on which the chain of cards rotates. K K are a system of pins or needles, which are pressed by spiral springs *a a* against the box D and the card upon it. J J are the rising-bars or hooks, which are connected with the heddle-threads (these latter being greatly prolonged) shown at T. 1, 2, 3, 4, 5, 6, 7, 8 are catch-pins, which are fixed in the frame F, this latter having an up and down motion, and thus raising the bars J J when these are caught by their upper hooks on the pins 1, 2, 3, etc. The other motions are visible from the cuts.

The operation of the machine is as follows: When the appropriate card comes on the box the pins K K, that are opposite holes in the card, are pressed in, and draw the hooks J J on the catch-pins 1, 2, 3, etc. The other pins, J J, are kept back, and when the frame F rises, only those hooks are raised that are connected with the needles that have entered holes.

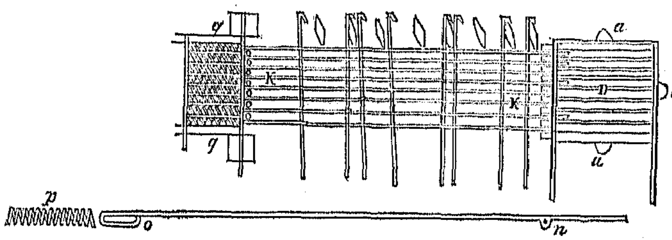

FIG. 9.

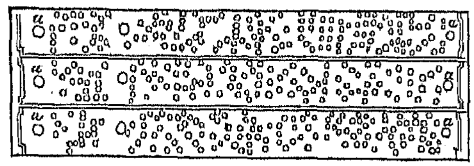

FIG. 10.

Fig. 9 shows the construction of the needles; *n* is the eye with which it connects with the bars J J.

Fig. 10 shows the appearance of the cards. It is evident that the imperfections of the machine are considerable—complicated, delicate machinery, and hence a liability to derangement; considerable difficulty in punching the cards properly. In many cases a very large number of cards are necessary, some designs needing up to 25,000 cards (portraits, book-marks, etc.). Hence the advantage of fancy looms when their use is possible. On very heavy looms sheet-iron cards have been used, but this is unnecessary in silk manufacture. The application of this contrivance to looms is shown in the following examples. At present the frame of the Jacquard is all of iron.

Fig. 11 represents Uhlinger's Jacquard loom. As will be seen from the cut, it is a plain picking-stick loom

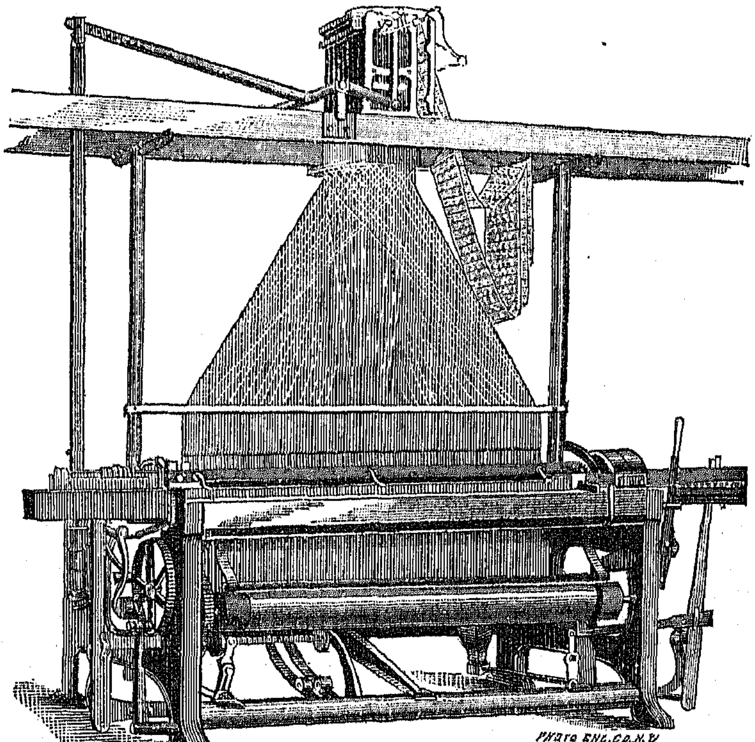

FIG. 11.

with a Jacquard attachment on a frame above. This is the general style of silk-loom for figured goods, and is an example of the greater part of power silk-looms operating on this class of goods.

Fig. 12 represents a loom for ribbons. This is the so-called gang-loom, the shuttles being operated by a rack-and-pinion motion, their stroke being very short, ribbons alone being woven on these machines. There are 2 Jacquards for each machine and 4 shuttles. The ribbon is wound upon the rollers shown, and the take-up motion is a simple gear contrivance.

Fig. 13 is a similar loom, but without Jacquard, being arranged with chain and harness. It is built by Knowles & Brother. It is a rack-and-pinion loom, the shuttles having but a very short travel. The take-up motion is very

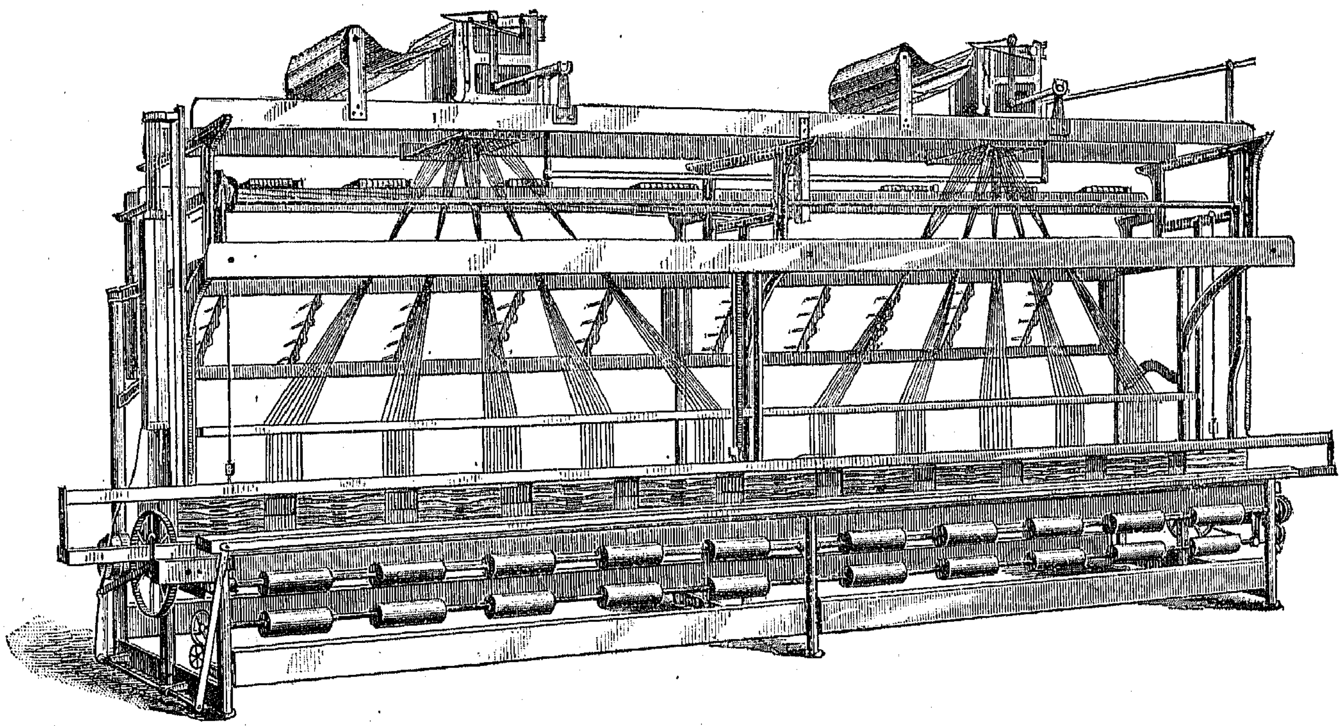

Fig. 12.

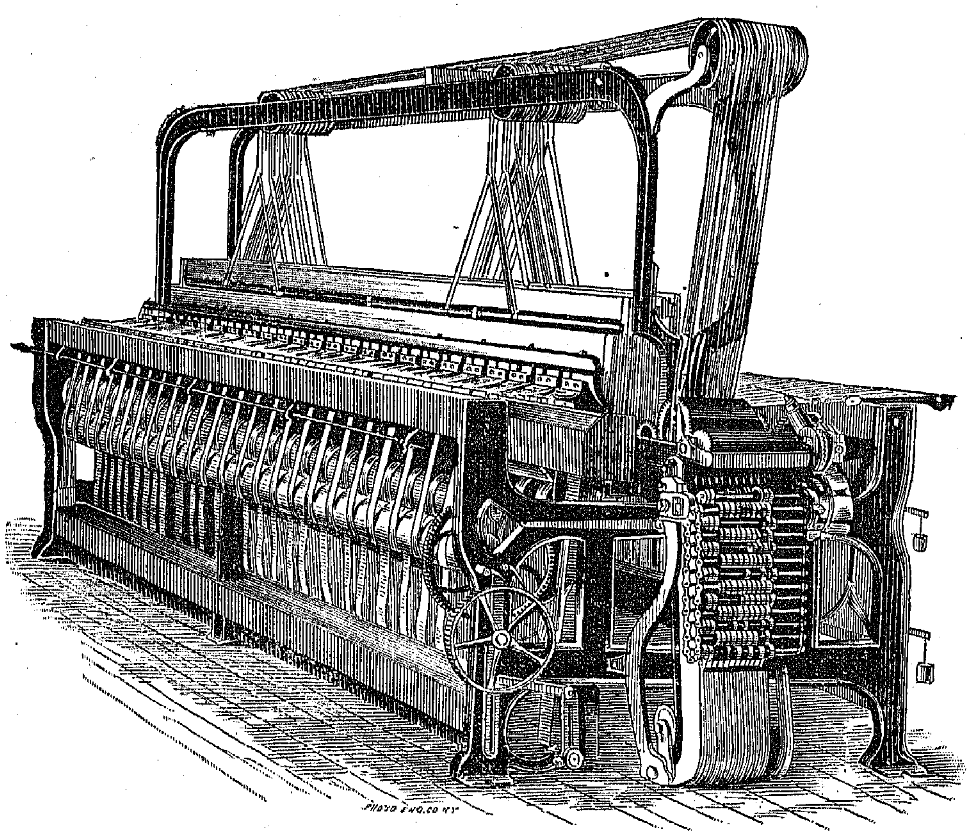

Fig. 13.

simple, similar to the one in the previous loom, and clearly shown in the cut. The advantage of Knowles' other looms is also present in this machine, viz, the possibility of detaching the design, forming machinery, and operating it alone by hand in case of misspicks.

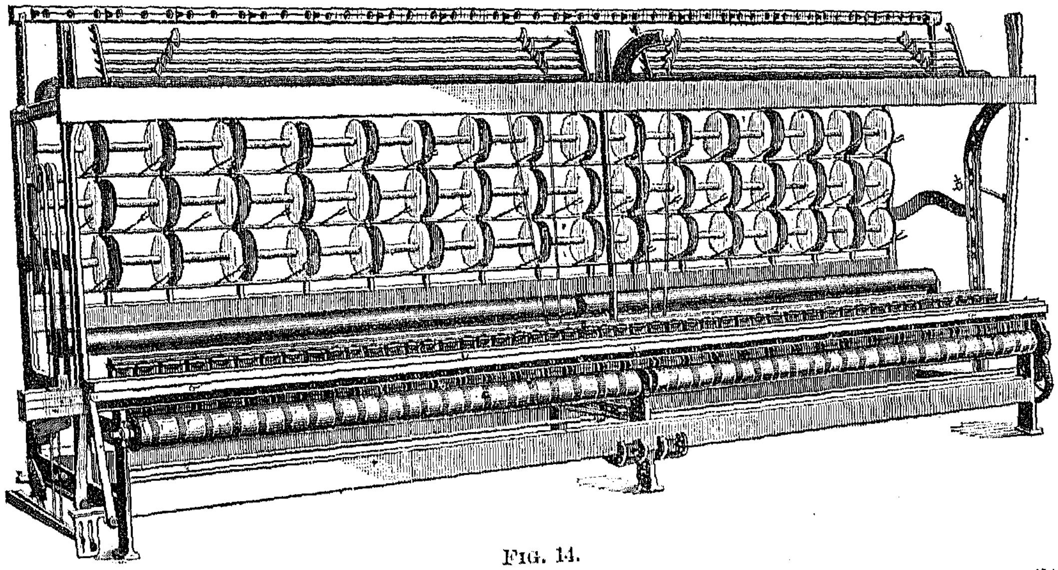

FIG. 14.

Fig. 14 is an extra narrow loom for stay bindings, silk braids, and similar materials. It is built by Uhlinger. The movements are similar to those in the ribbon-loom. It is given as an example of the extreme of the gang-loom.

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