WORSTED, and WORSTED MANUFACTURE. The term worsted is applied to yarn, and manufactured goods made of combed wool. Worsted is properly a branch of the Woollen Manufacture, to which article we refer our readers; but the latter term, strictly speaking, is applied only to yarn, or pieces made entirely or in part of carded wool. The characteristic distinction between combing-wool and short or clothing-wool has been already stated under the article WOOL. (See Wool and Woollen Manufacture.) Worsted goods were made in England as early as the time of Edward II. In the account of exports in the following reign, already given in the article Woollen Manufacture, the number of pieces of worsted goods exported is nearly double that of woollen cloths. According to Camden, the name is derived from Worfield, a town in Norfolk, where worsted stuffs were first made. According to Dr. Parry, in his "Essay on the Merino Breed of Sheep," worsteds were called by the Flemings 'Oiffades;' and as the manufacture was in their hands long before it was introduced into England, it is probable that our appellation is a corruption of their's. Oiffade was long ago a common surname in Flanders, and was perhaps that of some perfum famous for this particular branch of the woollen trade, which afterwards was appropriated to an establishment of similar manufacturers in Norfolk.

Worsted yarn is made of long or combing-wool, in which the fibres are all laid even parallel with each other by the wool-comb. It may be classified into two great divisions, the soft and the hard worsted yarn. The soft yarn is made of the shorter kinds of combing-wool, the forting of which has been already described under the article Wool. The short and long combing-wools are both prepared for spinning by the comb in the same manner, except that for some kinds of fine hard yarn made from the latter, the wool is combed, and afterwards spun nearly without oil. This is the cafe with the yarn for bombazines. The soft yarn for hosiery receives but little twist in the spinning, and two, three, or more threads are afterwards twined together on what is called a doubling-mill, to make a thread of requisite strength and thickness to be woven on the flocking-frame. See Stocking-Frame.
WORSTED MANUFACTURE.

Knitting-yarn is twined much harder than yarn for the frame. For mixed coloured stockings, part of the wool is dyed and mixed with the white in the procefs of combing. The principal feats of the worsted hofery manufacture in England were Nottingham and Leicester; but of late years the worsted hofery has declined at the former places, the trade there being principally confined to silk and cotton articles. Formerly hofery comprised a variety of worsted articles, particularly caps, which were generally worn in England before the introduction of hats.

At Aberdeen, in Scotland, there is a considerable manufacture of hofery, the wool being principally supplied from London. Worsted stockings, and lamb's-wool hofery, to the amount of from fifty to seventy thousand pounds, are sold to have been annually exported from Aberdeen to Holland. Of the number of hands employed in worsted hofery in England, or the annual value of the goods made, we have no correct account. Perhaps some estimate may be formed from the amount of exports of woollen hofery given under the head Woollen Manufacture, in the table of exports, in which it will be seen, that in the year 1816 the worsted hofery exported amounted to one hundred and fifty-one thousand and forty pounds, or about one-third of the hofery made of woollen yarn, or what is generally called lamb's-wool yarn, an article which, since the beginning of the present century, has been greatly increasing in demand. Soft worsted yarn for hofery, during the last twenty years, has been principally spun and doubled by machines in large worsted-mills. Previously to that time, worsted-making by hand-spinning was a distinct trade from hofery. The worsted-maker bought his different sorts of combing-wool from the worsted-flapper, combed and spun it, and sold the yarn to the hofier. Since then, the hofiers have been principally supplied with worsted yarn from large mills established in Leicester, Nottingham, and Warwickshire. Of late, however, many of the hofiers are manufacturing their own yarn on machines or mules turned by the hand, or in small mills turned by horses or water.

The combing-wools of Kent are better suited for hofery worsted yarn than any other in England, particularly for machine-spinning. This excellence is derived partly from the softness as well as from the wool; but particularly from the flake being nearly of one uniform thickness from the bottom to the top. See Wool.

Picardy and Normandy were the principal feats of the worsted hofery in France. Under the article Woollen Manufacture, it will be seen that 1,250,000 pounds weight of wool were consumed annually in the manufacture of hofery in Picardy before the French revolution.

The flocking-frame was invented by William Lee, M.A. of Cambridge, in 1589, and was afterwards introduced into France. This invention took place in England only 28 years after the knitting of hofery yarn on needles had been introduced from Spain. See Stocking-Frame.

Hard worsted yarn for worsted fluffs or pieces is spun much smaller, and twitted much harder, than the fine worsted yarn for hofery. In all the flour kinds of worsted goods, the long or heavy combing-wool is used. (See Wool.) Under the article Woollen Manufacture we have noticed the introduction of the worsted trade into England, and various places where it was first established. Norwich and some of the towns in Norfolk and Suffolk appear to have been the first where any considerable quantity of worsted pieces or fluffs were made. The names which have been mentioned in the preceding pages have received the number of looms that has been employed in preparing and finishing the goods. These names soon became obsolete, being supplanted by other kinds of worsted goods, so that we do not know at present what particular kind of pieces some of them were formerly applied; the essential difference consisting in their being woven plain, twilled, or figured, or made with a warp of single or doubled yarn, and woven flouter or more lightly, or of greater or less width, and whether they were glazed or not in the finishing.

The most important distinction between worsted pieces and woollen cloth consists in the former not being milled or railed, so as to cover the surface with a pile, but the thread is left bare. To take off the loose hairs which rise from the surface, the worsted pieces are treated and washed over a red-hot cylinder in the same manner as many kinds of cotton (see Cotton Manufacture): this process is called fingering. For some particular purposes, a flight degree of milling has recently been attempted to be given to worsted pieces in the fulling-mill. The glazing communicated to these kinds of worsted goods is given by pressing them between sheets of rifle glazed preis-paper and heated iron plates, which are compressed in a strong pressing-frame. For the weaving of figured pieces, see Weaving, and Manufacture of Looms.

Some kinds of very fine worsted goods are made with a warp of mohair or silk, as silk camlets and bombazines. The latter goods, with a silk warp and wefted with hard worsted yarn of the finest kind, are manufactured at Norwich. The term bombazine appears to be derived from bombyscia, a kind of silk dress used by the Romans, and said to come from Assyria. It is generally understood to have been made from the threads of an insect called the bombyx. Bombyscia is sometimes confounded by commentators with byssinum and sericum. Byssinum appears to have been a very fine kind of linen or lace; sericum unquestionably means silken stuff, so called from the Seres, the nation whence it was procured. Probably bombyscia was a coarser kind of silk. In the middle ages, the word bombyscia was applied to cotton. Macpherson's Annals of Commerce. See Bysus.

Bombazines are woven with a twill, and have, as before stated, a warp of silk and a weft of fine worsted yarn. The Dutch refugees, who fled from the persecution of the duke of Alva, introduced the manufacture of this article into Norwich in the year 1675, when the Dutch elders, according to Blomfield, presented bombazines in court at Norwich. (Blomfield's Hist. of Norfolk, vol. ii. p. 255.) Worsted goods were made in Norwich as early as the reign of Edward II. This appears from a patent granted to John Peacock, for the measuring every piece of worsted made in the city of Norwich or country of Norfolk. Norwich has continued from that time one of the principal feats of the worsted and stuff trade. The sale of stuffs made in Norwich only, in the reign of Henry VII., amounted to 100,000l. annually, besides worsted stockings, which were computed at 60,000l.

Norwich is at this day the only part of England where any considerable number of the very finest stuffs and bombazines are made. The manufacture of the coarser kinds of worsteds, except camlets, has been transferred in a great measure into Yorkshire. The period preceding the American revolution, from the year 1743 to 1763, may perhaps be regarded as the most flourishing era of the worsted manufactures of Norwich. According to the account of Arthur Young in 1774, the manufacture of this place had increased four-fold in the preceding 70 years. The number of looms was then estimated at 12,000, and each loom was supposed to employ six persons in preparing and finishing.
WORSTED MANUFACTURE.

the material; and the total annual value of the goods was estimated at above 1,200,000l. Of these goods the estimate then was,

<table>
<thead>
<tr>
<th></th>
<th>£</th>
</tr>
</thead>
<tbody>
<tr>
<td>The export to Rotterdam</td>
<td>480,000</td>
</tr>
<tr>
<td>to London</td>
<td>550,000</td>
</tr>
<tr>
<td>to various places</td>
<td>200,000</td>
</tr>
<tr>
<td><strong>Total value</strong></td>
<td><strong>1,230,000</strong></td>
</tr>
</tbody>
</table>

The number of persons employed being from seventy to eighty thousand.

Since the time to which Arthur Young refers, the manufacturers of Norwich have engaged extensively in the trade of silk flannels and other articles, in which no worsted whatever is used. Still, however, the worsted manufactures of Norwich may be considered as in a flourishing state. The number of looms employed in worsted at the present time (1818) may be estimated at 10,000; half of which weave camlets, calimancoes, and other stuffs; and the other half bombyx, step, and broad. The former are chiefly for home consumption, the latter for the Spanish market. The East India Company take a considerable quantity of the fine camlets manufactured at Norwich.

By far the greatest part of the worsted yarn employed at Norwich is supplied by machine-spinning, from the worsted-mills in Yorkshire, Lancashire, and Durham. But some yarn still continues to be spun in the old manner, by the running-wheel, in Suffolk, Essex, Hertfordshire, and Cambridgehire. In Norfolk alone, the use of the dialuff still remains. This instrument is the most ancient of which we have any notice, either in sacred history, or the fabulous traditions of Grecian mythology handed down to us by Homer and Hesiod. It is at present vulgarly called the rock. In using it, the thread is drawn out from the end of the fliver of combed wool. The motion is communicated to a rough kind of spindle, by twirling it between the right-hand and the thigh, which is suffered to continue revolving when suspended by the thread, which the spinfires gradually lengthens with her fingers.

In wheel-spinning, a small portion of the combed wool or fliver is laid across the finger, from the centre of which, called the twitch, the thread is drawn out. About thirty years since, the counties of Norfolk, Suffolk, Hertfordshire, and Essex, not only supplied all the yarn that was wanting for the manufactures of those districts, but sent large quantities of worsted yarn to Halifax and Manchester. At present the trade is completely turned, and, as we have before stated, the greater part of the yarn used at Norwich is sent there from the northern counties of England. This change has occasioned great diffireis in the villages where the yarn was formerly spun, by depriving the wives and children of the cottagers of their common employment.

Until the middle of the last century, worsted goods were manufactured in considerable quantities in Warwickshire, Oxfordshire, and Northamptonshire; but about that time the extension of the worsted trade in the West Riding of Yorkshire, particularly at Halifax, Bradford, and Wakefield, gradually drew this trade in a great measure away from those counties. The manufacturers in Yorkshire, or rather the merchants who bought the worsted pieces from the manufacturers, were, however, long unacquainted with the best modes of dyeing and drilling them; they were therefore sent to London or Coventry to be finished, but afterwards they were finished in Yorkshire. The demand to Spain, Portugal, Italy, and the Levant, took off the greater part of the worsted goods manufactured at Halifax; those manufactured round Wakefield and Bradford, consisting chiefly of tammies and shalloons, were consumed principally by England and her colonies. The Piece-hall at Halifax was first opened about the year 1780; and the intervening time, from thence to the year 1792, or the breaking out of the French war, may be regarded as the most flourishing era of the worsted trade in Yorkshire. Though the cheapness of calicoes, as an article of female drefs, since the improvements in the cotton manufacture, materially abridged the rate of sale for some kinds of worsted goods in England, this was more than compensated by the increased demand for carpets with worked warps, and other matters of luxury, in which worsted yarn was employed.

The demand in foreign markets, from the year 1782 to 1792, for English worsted goods, greatly exceeded that of any former period; but after the breaking out of the French war, the worsted trade at Halifax began to decline. The greater part of the foreign markets being closed against us, most of the mercantile houses engaged in the export of worsted goods were in consequence ruined or declined; the trade altogether, and many of the small manufacturers, engaging in the cotton trade. The introduction of English calicoes into Turkey and other parts tended also to lessen the regular demand for shalloons and other worsted goods, as articles of female drefs, in those countries. Soon after the breaking out of the French war in 1792, the spinning of worked by machinery was established at Bradford and the vicinity; and continuing to increase, drew round that place the manufacturers of worsted goods on the decline of the Halifax trade. Bradford is now become the principal seat of the worsted manufacture in Yorkshire; and some of the proprietors of the worsted mills, besides supplying the smaller manufacturers with yarn, employ a very great number of looms themselves, and carry on this branch of trade on a scale of extent never before known in the worsted manufacture. Within the last two years, the worsted trade has also greatly revived at Halifax.

The following are the kinds of worsted pieces at present principally made in Yorkshire.

**Bombazets** are woven both plain and twilled, with the warp of fingle thread; they were pressed, and finished without glazing; the width 22 inches, length 29 yards.

**Tammies, or durantes,** with fingle warps twilled, and generally coarser than twilled bombazets; width from 32 to 36 inches, length 29 yards.

**Shalloons** are woven with a twist, and have a warp of fingle thread. We believe the name was derived from Châlons in France. The pieces are from 32 to 36 inches wide, and 29 yards long.

**Cubicas** are very fine shalloons so called.

**Syes, or ansefettes,** are twilled and made with fingle warps; they are of two kinds, one running 27 inches wide and 30 yards in length, the other 42 inches in width and 44 yards in length.

**Morcas** are woven plain and watered or embossed, and are made very stout, being principally used for furniture; their width is 28 inches, length 24 yards.

**Calimancoes** are woven plain and striped; width 17 inches, length 29 yards.

**Camlets** are both plain and twilled; width 18 inches, length 29 yards. They are shorter than bombazets, but not many are made in Yorkshire with double warps.

**Lstitials** have double warps, sometimes of two and sometimes of three threads, and are made with very variety of patterns, either plain, twilled, or flowered, and are distinguished by different names, according to their figures and quality.
WORSTED MANUFACTURE.

quality; as prunelle, amens, (probably from Amiens in France, where they were manufactured,) and drawyows: the width 18 inches, length 30 yards.

Worsted flag, or velvet woven like corduroi and cut, is made principally at Banbury, in Oxfordshire, and at Coventry; but has been manufactured also in Yorkshire. In the worsted manufactories of France, there were greater varieties of pieces than in England. One kind of camlet, made with a fine warp from the wool of the Angora goat and a weft of fine worsted, was remarkably beautiful; but we believe it has not been manufactured in Yorkshire or at Norwich.

For some account of the worsted manufactories of France, see Woollen Manufacture; under which article we have given the history of the worsted manufacture as connected with the woollen, and where may be seen the number and value of the worsted pieces exported from England in the year ending January 1817. See also long combing-wool, under the article Wool.

Worsted Spinning. In the article Wool we have given an account of the different kinds of long wool which are proper for spinning into worsted, also the manner of forting and scouring them. The worsteds must be prepared for spinning by the worsted combings, with a comb or heckle that is provided with a great number of long fleece pins which are sharp-pointed. These points being few in number compared with the teeth of cards, they can be safely introduced between and drawn through the long fibres of the wool, in order to separate and straighten them, without materially breaking them. Another object of the combing is to separate the shorter fibres which are intermixed with the long ones; for in spinning any kind of thread, it is desirable that the fibres should be as nearly as possible of a length.

Wool-combing. In the ordinary process of wool-combing by hand, the implements used are, 1. Two combs for each workman. 2. A poft, to which either of the combs can be fixed, to support them during the operation. 3. A comb-pot, which is a small flove to heat the teeth of the combs, which is found to facilitate the combing. The combs are shown at fig. 1. Plate I. Woollen Manufactur: Each comb is composed of two rows of pointed fleece teeth, a and b, disposed in two parallel planes. One of the rows contains longer teeth than the other. They are fixed into a wooden block or head c, which is covered with horn, and has a handle d fixed into it, perpendicular to the planes of the rows of teeth. The rows of teeth are about seven inches long, and each row contains about twenty-four teeth. The length of the longest tooth is nearly twelve inches, and the shorter ones about eight inches. The teeth are made of steel, of a round figure, and regularly tapering from the bafe, where they are fixed into the flock, to the point, which is quite sharp. The teeth are about one-twelfth of an inch in diameter at the base; and the interval between the two adjacent teeth at the base is rather less than their diameter, or one-eighth of an inch. The space between the two planes in which the teeth are disposed is about one-third of an inch at the bafe of the teeth. The teeth should be straight and well-tempered, and polished. If they become crooked in working, the workman must straighten them, and set them all in a true line. The combs used for the last combing of the wool have three rows of teeth.

In the wool-comber's shop a poft is fixed, as shown by fig. 2, in order to support the combs occasionally during the working. An iron flom g is fixed fast into the poft, and projects horizontally from it; the extreme end of it turns upwards with a point, which is inserted into a hole through the middle of the handle of the comb. Also at the other end of the flom g, close to the poft, there is a small hook i rivetted, which terminates with a pointed pin, situated in a horizontal direction. This point is inserted into a hole made in the end of the handle of the comb, in the direction of its length. The end of the comb-handle being firly placed on the point of the hook, it is let down upon the other point g, which, by passing through the handle, fixes the comb quite fast to the poft, as shown at fig. 2.

In the operation of combing wool, it is necessary to heat the teeth of the combs, in order to soften and relax the fibres of the wool, and render them more easy to work. The heat also tends to distribute the oil with which the wool is lubricated. The combs are heated in a comb-poft or flove, fig. 3, which is a small furnace built in brick, to inclose a fire-place, of which A is the door, B the ash-pit, and C the flue. Above the fire a circular cast-iron plate a a is placed. This is made flat, except in the central part, where there is a concavity, to obtain a better action of the fire. Immediately over the plate a, another plate, b b, is placed parallel to the former, but with a sufficient space between them to admit of the teeth of the combs; several pieces of iron are placed between the two plates, to keep them at a proper distance asunder, and to divide the space into small cells proper for the combs.

In using this slove, the workman must be careful not to heat it too much, and a damper in the flue is very useful to regulate the draught; if the heat is too great, it spoils the temper of the comb-teeth, and injures the wool also. The most improved slove is heated by flame, which will give a sufficient warmth, but cannot overheat the combs.

In order to comb the wool, it is separated into handfuls, each containing near four ounces of wool, which is about a proper quantity to be combed at once. These handfuls are sprinkled with oil, and the wool is rolled in the hands to distribute it equally. The quantity of oil varies from 1/10 to 1/8th of the quantity of wool by weight. The comb is first heated by introducing the teeth into the slove, in one of the cells between the two iron plates; when it has acquired sufficient heat it is withdrawn, and another comb is put in its place. The heated comb is then fastened to the poft, with its teeth pointing upwards, in order to be filled with wool; the comber takes one-half of the handful of wool in his hand, and catches it upon the teeth of the comb by throwing the wool over the points, so that they penetrate it; then by drawing the wool towards him, and at the same time downwards to the bottom of the teeth, a portion of the wool will remain in the teeth. The lock of wool is again caught upon the teeth, and drawn through them, and every time some wool remains; this is repeated as often as is necessary, until all the wool is gathered upon the teeth. The comb thus filled is placed with its points in the slove, and the wool which is upon it remains outside of the slove, but will become slightly warmed. The other comb, which was heating whilst the first was filling, is now filled in turn, in the same manner as the first, and is then put to heat with the wool upon it, and whilst this is going on, the workman occupies himself in making a handful ready for the next combing.

When both combs are properly warmed, the comber holds one of them with his left-hand over his knee, as he is seated on a low stool, and with the other comb he combs the wool upon the first, by introducing the points of the teeth of the comb on the wool close to the base, in the other, and drawing them through it; this is repeated for 14 or 15 strokes, until the fibres of the wool are separated, desengaged, and laid parallel. In combing, he di-
WORSTED MANUFACTURE.

rects the combs sometimes with the teeth of one parallel to the teeth of the other, and sometimes with the teeth of the two combs at right angles, or in a cross direction; but in all cases he must take care to begin gradually, by introducing the points of the teeth, first into the extremity of the wool which is contained in the teeth of the comb, and then proceeding deeper into the wool at every succeeding stroke, till at last he works the combs as near as he possibly can without actually bringing their teeth in contact; without this precaution, he could not draw the comb through the wool without breaking the fibres, and tearing the wool out of the teeth of the comb; but if he proceeds cautiously, the wool will be disentangled, separated, and straightened.

During the working, he frequently changes the combs, so as to work the wool upon both combs; but as the wool will gradually accumulate upon that comb which is most worked, he manages them so that at the end of about 35 or 40 strokes nearly all the wool will be gathered upon one of the combs, and will hang from its teeth in a fair lock of straight and regular wool. This comb he puts to heat for a moment, then fixes it to the poll, and proceeds to draw off the wool from the comb in a fliver. To do this, he takes hold of the wool which projects from the teeth with the fingers and thumbs of both hands, and draws it away from the teeth of the comb in a direction perpendicular to their length, without folding it off their points; as the wool comes away, he takes fresh hold, always feising the wool at a given distance from the teeth. A portion of the wool which consists of short fibres will not come off, because it does not reach to the place where the comber grasps the wool; it therefore remains in the teeth of the comb, and is drawn off afterwards. This short wool, which is called snail, is unfit for worsted spinning; it is combed in part of the short fibres which are naturally intermixed in the long ones, and also of the fragments of long fibres which are broken in the process of combing. The quantity of the snail depends upon the kind of wool, and also on the care with which the comber has conducted his process; but it will seldom exceed 1/5th or 1/4th of the quantity of the raw wool by weight.

The wool which is drawn off from the comb forms a continued fliver or band, the fibres of which are straight and parallel, but not sufficiently so for spinning; it is therefore combed over again, and frequently it is repeated a third time. The first combing is called hacking, and the flivers produced by it are extended five together upon a table; then holding them down with one hand, they are broken again into handfuls by drawing them with the other. These are combed again in the manner before described, but the heat given to the combs is much less. The ultimate fliver, which is drawn off from the comb the last time, should be very even, and composed of long and parallel fibres. On examining it against the light, every part should appear equally dense, without any entanglements of the fibres, for on these particulars the perfection of the spinning will in a great measure depend.

The combed wool produced from sixteen pounds of wool usually weighs eleven or twelve and a half pounds, for about two pounds are lost in washing, and the rest in soaps and water in the combing. When the combing is finished, the flivers are formed into six parcels, each containing ten or eleven flivers, which are rolled up together into a ball, and ticketed with their weight and quality, the wool-comber's mark, and wool-flapper's mark. In this state, combed wool is called tops or Jerley, and is sold to the spinners in the country, who spin it into yarn by the simple hand spinning-wheel; but the manufacturers who spin by their own machinery have wool-combers at their mills, and they usually employ combing-machines in addition.

Combing-Machine.—The first combing-machine was invented by the Rev. Edmund Cartwright. His first two patents were in 1790, and he had another in 1792; but the machine was not rendered perfect, or brought into extensive use, till a later period: and in 1802 he obtained an act of parliament to renew or extend the term of his patent. The specification which he enrolled in consequence contains drawings and descriptions of machines nearly of the same kind as those which are now in use at many of the great worsted-mills, and which we shall describe. Mr. Cartwright proposed to form the raw wool into combed flivers, by joining the pieces of wool together, and slightly twirling them, and in this state they could be presented to the combing-machine; but as this plan was not found to succeed, it was found necessary to comb the wool first by hand, in order to reduce it to flivers. This is still the common practice, and takes away great part of the advantage of the machine; but we have seen a preparing-machine for this purpose, which operated very well upon the raw wool. The inventor's name we have not learned; but the rudiments of it are to be found in Mr. Cartwright's specification of 1790.

Preparing-Machine.—The raw wool is spread upon a horizontal feeding-cloth, which is extended over two rollers, and circulates upon them: by its motion, the wool is carried forwards, and presented to a pair of fluted rollers, which draw it in. This feeding-cloth is situated at the top of the machine, at the height of about five feet from the floor, so as to allow room for the rest of the machinery beneath it. A principal part of the machinery is carried by a horizontal wheel of five feet diameter, which is mounted upon a vertical axis, and is turned rapidly round by the mill. This wheel carries four porcupines, which are small cylindrical rollers, armed with spikes or teeth rather hooked. The rollers are situated horizontally in the plane of the wheel, with their length nearly in the direction of radii. They are about seven inches in diameter, and fourteen inches long, and are fixed upon horizontal spindles, which are fixed from the circumference of the great wheel nearly to its centre, one extremity of each spindle being fastened by the rim of the wheel, and the other in a support fixed to the perpendicular axis. The porcupines are fixed on the ends of the spindles, near the circumference of the wheel; and on the opposite end of each spindle is a small cog-wheel, to work in a worm or endless screw, which is fixed concentric with the axis, being cut on the outside of a hollow tube, through which the vertical axis passes.

By this means, the four porcupines which the wheel contains have a two-fold motion; viz. they are all carried round in a circle by the motion of the wheel, and at the same time each one has a slow rotary motion on its own axis, in consequence of the cog-wheels, which work in the threads of the fixed worm.

The feeding-cloth is so situated, that the four porcupines in the great wheel will pass in succession exactly beneath the fluted rollers, which take the wool from the feeding-cloth; and the teeth of the four porcupines being sharp-pointed, and rather bent forwards at the points, they penetrate and catch the wool as it comes through these fluted rollers, and hang down from them. A portion of wool is thus carried away by each porcupine every time it passes beneath the fluted rollers; but by the slow revolving motion of the porcupines on their own axes, each one presents a different row of teeth every time, and thus by degrees they become clothed with the wool which they take up.
This wool they deliver to a larger porcupine, which is placed beneath the revolving-wheel, or on the opposite side to the feeding-cloth. This porcupine is a cylinder nineteen inches diameter, and fourteen inches long: its axis is placed horizontally, and directed nearly to the centre of the vertical axis; so that the small porcupines will be parallel to the large one when they pass over it. The great porcupine is furnished with rows of teeth exactly similar to those of the small ones, which teeth are not very numerous, but large and sharp-pointed, and rather hooked, with the points forwards. When the small porcupines pass over the large one, there is so little clearance space between their teeth, that the wool which is contained in the teeth of the small ones will be taken off by the large, and remain in its teeth. The reason of this is, that the teeth of the large porcupine present themselves to the teeth of the small ones with the points forwards, and the small porcupines at the same time move with the points of their teeth backwards. It was formerly flated, that the porcupines move with the points forwards when they take the wool from the feeding-rollers, but this wool is applied on the upper side of the porcupines, and the great porcupine is at the lower side; hence the direction of the teeth is reversed in the two cases, and occasions the wool to be given to the great porcupine, a small quantity at a time, from each of the small porcupines, as they pass over it. The great porcupine being turned slowly round upon its axis clothes itself with the wool in a continued fleece, and this is drawn off from its teeth by a pair of fluted rollers, between which it passes in a continued fliver or band; this band is also conducted through a short tube, which revolves round its axis, and rolls up the fliver, to make it adhere better together in a round and compact form.

The action of this machine is not to comb the wool, but to divide the mass of raw wool, which is spread on the feeding-cloth, into a great number of small and equal portions by the successive strokes of the small porcupines; these portions are again mixed together in one film of wool upon the great porcupine, from which the wool is drawn off in a continued fliver, and as much twist is given to it so as to be requisite to make the fliver sufficiently compact to submit it to the combing-machine.

Cartwright’s Combing-Machine, or Combing-Table; called also amongst the workmen Big Ben.—In Plate II. fig. 1. Worsted Spinning, is a horizontal plan of the machine, which exhibits nearly all its parts; we have also given a perspective view in fig. 2, of the operative parts, as they would appear if detached from the framework which sustains them. A A is a circular ring of wood, which is fixed down on the framing; B B is a similar ring, which is fitted into the fixed ring, with liberty to turn round within it. The interior of this ring is furnished with a row of comb-teeth, with the points directed to the centre, and there are two other rows of shorter teeth beneath, so as to make three circular rows of teeth. This forms a large circular comb, called the combing-table, about five feet diameter; it is moved slowly round in the direction of the arrow by means of a pinion, which works into a ring of cog wheels fixed in segments within the circular comb beneath the row of teeth, as is shown in the section, fig. 3.

The wool is filled upon the teeth of the circular comb by means of two machines F and G, called crank-lathers. These supply the wool by lathing or throwing the lock of wool upon the teeth of the comb, and then drawing up the wool to the comb, with a motion very similar to that of the hand of the workman in filling the combs, as we have before described. The crank-lathers repeat their strokes with great rapidity; but as the comb-table is kept in continual motion, the wool which is laid upon the teeth by the first crank-lather F is carried away, and in its course comes beneath the other crank-lather G, by which more wool is filled upon the teeth, and they receive the intended portion. This wool, by the rotation of the comb-table, is then carried beneath a small comb K, which works by a crank movement, but with its teeth always horizontal; they penetrate through the wool, and then rise up fo as to comb it. After this operation, the wool is taken off from the teeth of the comb-table between a double pair of fluted rollers N, situated immediately over the comb-teeth; these draw off the combed wool in a continued fliver, which is conducted through another pair of plain rollers R, and falls into a tin can placed there to receive it.

This machine was not found capable of combing the raw wool, chiefly because the comb-teeth are not heated, and also because the actions of lathing on the wool, and afterwards combing it, begin at once upon wool, at first with their full force, and break the fibres if they are entangled together; hence it is found best to comb the wool by hand once over, or for fine goods twice. The wool is thus divided into fibres, which are jointed together, by laying them ona a table, with the ends lapped over each other, and rolling them together, they will join into one long fliver. Three of these flivers are put into tin cans ii, which are placed upon a circular table I, and carried upwards to the crank-lather F or G, which are both of simular construction. The table I is mounted on an axis, so as to be capable of turning slowly round horizontally, in order to twist the three flivers together into one; but in the machines which we have seen in use, this movement is commonly neglected, for if the flivers are prepared by hand- combing, as we have before described, they will hang together without twisting.

The flivers, which are carried up from the cans to the crank-lather (see fig. 3.), first pass over a roller at e; the axle of this roller is also the fixed centre of motion of a trough H, which forms one part of the crank-lather. The fliver of wool is conducted along the trough H, and then turns over a second roller at f 1; the centre-pin of this roller is the joint, which unites the end of the trough H with a moveable frame d d, which has a tube g fixed in front for the fliver of wool to pass through. A little below the middle of this frame d d are holes through its sides, to receive the pin of a crank k, of which the central axis is supported in bearings screwed to the frame of the machine, and it is turned round by the power of the mill. By means of a pair of bevelled wheels D and E, fig. 1. the cranks of the two crank-lathers are connected together, and have a common motion, but in a direction at right angles to each other. At the lower end of each of the moving frames d d, a pair of fluted rollers i i are fixed, which draw the fliver between them. The rollers are put in motion by means of a cog-wheel k, fixed on the extremity of the axis of the lower roller; this is turned by a small pinion, fixed at the end of an axis, which passes through the frame d d, and which at the opposite end has a wheel h, that receives motion from a pinion fixed fast to the pin of the crank. The upper of the two fluted rollers is pricked down against the lower one by springs, which bear on its pivots with sufficient force to hold the wool firmly between them, and draw the fliver forwards when they turn round.

The motions of the crank-lathers are not easy to be understood from a verbal description. It must be recollected, that the upper end of the frame d d which carries the rollers, being jointed to the end of the trough H, it must always move in the arch of a circle, as shown by the dotted lines, fig. 3; the centre of this arch is e: also that the middle part of the frame d, where the crank-pin passes through it,
WORSTED MANUFACTURE.

is must describe a circle when the crank revolves; in consequence, the rollers, which are at the lower end of the frame, will move in a curve, as shown by the dotted lines. It is an oval or distorted ellipse, with the greatest diameter horizontal.

At the same time the fluted rollers circulate in this orbit, they are in continual motion on their own axis, by the communication of wheel-work before described, and they draw the wool of fliver down the tube; the end of the fliver, which projects from below the rollers, hangs down from them in a lock, and by the motion of the crank-lifter this is thrown against the points of the teeth in the comb-table. At the period when the wool is thus thrown on the teeth, the rollers are moving nearly in an horizontal direction, so as to draw the wool in the direction of the length of the teeth, and they penetrate the wool; but as the rollers proceed in their elliptic orbit, they begin to rise and draw the wool upwards away from the teeth in an inclined direction, as is evident by tracing the dotted course marked out for the rollers. By thus drawing up the wool between the teeth, a portion of the wool will be left in them; the rollers then rise up rapidly in their oval course, and the wool is raised quite above the teeth; the rollers then move forwards to make another stroke, and during such advance, the rollers, being in continual motion, draw forwards the fliver of wool, and the end hangs down ready to be lashed on the teeth of the comb next time.

The motions of the small comb K must be next described. The whole machine receives its motion by means of a wheel or pulley e, fig. 1, upon the axis of the crank for the lather G; D and E are the bevelled wheels by which the other crank is turned; at the extreme end of the axis C is a pinion, which turns a bevelled wheel L, and on the axis of this is a wheel turning two others M M of equal size; on the extremities of the axes of the wheels M M are two cranks II of equal radii, which are both jointed to an iron bar m m, and both turning round together in the same direction, they cause the bar to move in a direction parallel to itself, and every part of the bar describes a circle equal to the radius of the cranks. The small comb K is fixed to this bar, and partakes of its motion, whereby the points of its teeth are carried horizontally into the wool contained in the teeth of the great comb, then rise upwards and draw through the fibres, in order to comb them.

In order to remove the little comb when it becomes filled with wool, it is attached to the bar m by means of a comb-holder or socket L, which has a groove at each end to receive the little comb, and it can be mounted or withdrawn at pleasure. This socket L is moveable upon a horizontal pin fixed at the end of the bar m; so that it can be turned with either end upwards; and as the little comb can be fixed at either end of the socket, a spare comb is placed in the upper groove of the socket, whilst the lower groove holds the comb which is in use; but when this becomes filled with wool, which it has gathered from the comb-table, the socket L is inverted by turning it half round upon its centre-pin, and by this means the free comb is brought down into use, and the other can be taken away to clear off the wool from it. There is a small bolt fixed to the pin on which the socket L turns, which can be shot into a notch when the socket is in a perpendicular position, and will then hold the socket fast from turning, and keep the comb in a proper position for its work. In this way, the little comb can be taken out of the machine and replaced by a fresh one as often as is necessary, without stopping the machine, for the small comb does not move very quick. The same boy who attends to change the combs, when necessary, also lets up the wool in the great comb-teeth with a small scraper, so that the small comb will penetrate through it with more certainty and effect. The plane of the rows of teeth in the small comb is not horizontal, or parallel to the teeth of the combing-table, but inclined thereto, so that those teeth of the small comb which first come into action upon the wool do not penetrate deeply into it; but as the comb-table turns round, the wool advances beneath the small comb, and is operated upon those teeth which go deeper, and the last teeth of the comb go as deep as they can, not to touch the teeth of the comb-table.

The wool is now combed, and only remains to be drawn off in a continued fliver; this is done by the drawing-off rollers N, which are fluted iron rollers, placed horizontally over the comb-teeth, and nearly in the direction of a radius of the comb-table: they are supported in an iron frame, and are turned round by a pair of bevelled wheels from a vertical axis P. This axis extends the whole height of the machine, and is put in motion by means of a pair of bevelled wheels, and an oblique axis Q, which is turned by a bevelled wheel and pinion on the extreme end of the axis of the first crank-lifter.

The great comb receives its motion from the perpendicular axis P, which turns a large wheel T by a pinion on the lower end of it: on the upper end of the axis of this wheel is the pinion which works in the ring of teeth within and outside the comb-table; in this way, a very slow motion is given to the comb-table. There are two pair of drawing-off rollers N, situated close together, and parallel to each other; the first pair are put in motion as we have described, and the back pair are turned by means of equal cog-wheels, so that they move with the same velocity.

The wool upon the comb-table is gathered in the hand, to form a fliver, and the end is introduced between the rollers, which continually draw off the wool as the comb-table turns round. After passing through both pairs of rollers, the fliver is conducted through a forked iron, then through a round wooden tube, and is at last delivered by two plain wooden rollers R into a tin can placed beneath to receive it. These rollers are also turned by bevelled wheels on the perpendicular axis P. The drawing-off rollers only take away the long wool, the fibres of which are long enough to reach to the rollers. The two rollers composing the front pair of drawing-off rollers are not placed immediately over each other, but the upper roller overhangs the lower one, so that the plane in which the axes of the upper and lower rollers are both situated is inclined at about an angle of 45 degrees to the plane of the comb-table: by this means, the wool is drawn off from the comb, at an angle of 45 degrees, to pass between the rollers.

The noils, i.e. the short wool and broken fibres, which will not reach the drawing-off rollers, remain in the teeth of the comb-table, and also as much of the long wool as is on the lower side of the comb, and these are called backing: both are taken off by a boy, who is seated for that purpose within the circle of the comb-table; he first draws off the backings from beneath the comb, and then, with one hand above the teeth, and the other below, he draws off the noils.

These two sorts of wool are handed to a boy on the outside of the machine, who puts them into separate boxes. The backings are filled on the small combs before they are put into the machine, and become somewhat combed by the action of the comb: when the small combs are removed from the machine, the wool upon them is further combed by hand, and then drawn off from them in a continued fliver, by means of an additional piece of machinery, which is at the side of the machine.

This
WORSTED MANUFACTURE.

This combing-machine is found to break the fibre of the wool, and it increases the quantity of soil very much, unless the wool is previously combed once or twice by hand; and as it then becomes only a substitute for the second or third combing, it faves little or no expence. The advantage of the machine is found, in the great regularity and equality of the fibre which is produced by it, a circumstance of particular importance for fine spinning. In combing by hand when the fliver is drawn off, the fibre fibres which the comber first takes hold of are longer than the others; then as the fliver continues to be drawn, shorter fibres are found in it, and the flots and fets are left of all. These are called the long and short ends of the fliver; the short end is always marked by twisting or rolling it up, in order that when the flivers are joined together into one for spinning, the long and short ends may be equally intermixed and dispersed throughout the whole length. In drawing off the wool from the combing-machine, the long and short fibres are intermixed and taken up together, so that the fliver is of very equal texture.

There have been several other attempts to make combing-machines which deference notice, though they have not come into use.

Meffs. Wright and Hawkley had a patent in 1791 for a combing-machine; and Mr. Toplis of Cuckney had also a patent of the same date, which contains some good ideas. Mr. Hawkley, in 1794, had a patent for improvements on Cartwright's: the principal one was, to make the combing-table by the combination of a number of small combs, which could readily be applied to the table, or detached at pleasure. If this would allow the combs to be heated, as the inventor proposed, they would work much better.

Mr. Amott had a patent in 1795, and Mr. Pearce in 1798: after this time, Mr. Cartwright's machines had received some improvements from Mr. Hawkley, and came into use; and we find less speculation on the subject.

Gilpin's Combing-Machine.—In 1811, Mr. George Gilpin of Sheffield perfected a very ingenious machine, which combed the raw wool in a most complete manner. We do not hear that this machine is yet come into use, although we have no doubt of its answering the purpose, having frequently examined it while at work: its only fault was a complication of parts, which might be easily removed.

The outline of this machine is taken from that of Mr. Toplis in 1793, but is very much improved and perfected. Fig. 4 of Plate 1. Worfield, is a sketch of the principal parts. The machine works with eight combs at once, which are of rather larger size than the ordinary hand-combs, the rows of teeth being twenty inches long. These combs are fixed upon two reels or frames A, B, which revolve upon their axles by the power of the mill; four combs, D and E, are fixed upon each reel, and in such position that both ends of the comb-teeth, viz., the points and roots, are equally distant from the centre of the reel to which they are fixed; and the reels, with the combs fixed upon them, form two revolving horizontal frames. The combs D and E are so made, that they can be detached from the reels, or replaced and fixed fast in a moment, by the attendants; and they can, therefore, be heated in a stove, in the same manner as the hand-combs. The wool is also filled upon the combs by hand, and the combs and wool are heated in the usual manner before they are put into the machine, in order to comb the wool.

One of these reels A is firmly turned upon its axis, but the other reel B has a curious compound motion given to it by the machinery: thus it revolves on its own axis; but the axis also advances to, and recedes from, the other reel with a motion parallel to itself, which is repeated four times in every revolution. While B advances towards A, it moves with only one-third of the velocity with which it returns from A. The advancing movement is of a limited and congruent extent; but at the same time, there is a third movement which regulates this extent, so that at every succeeding stroke which the machine makes, the two reels will approach nearer together.

Suppose all the combs filled with wool, and mounted in their places upon the reels, the machine is then put in motion, and the two reels A and B turning round in opposite directions, their combs D and E meet each other; and by the compound movement of B, (viz. advancing slowly towards A, and turning round at the same time,) the combs D and E approach in such a manner, that the points of each comb penetrate the wool which is in the other comb, and this is reciprocal of both combs. When the teeth are thus entered into the wool, the moveable reel B retreats quickly from the other, and the teeth, by drawing through the wool, comb and separate its fibres.

The circular motion of both reels is not regular and equal, but is communicated by means of elliptical cog-wheels, which occasion the reels to move round very slowly, at the moment when the comb of the reel B is drawing out or combing the wool; but this motion being finished, the reels begin to turn round more rapidly, and at the same time the reel B approaches towards A with a slow movement, in order to present another pair of combs to each other, which meet; and each one penetrates the wool which is upon the other, and then the reel B draws out to comb it, in the manner before described.

In this way they continue to make successive strokes, until the wool is sufficiently combed: the machine is then stopped, and the combs taken off one by one, to be replaced by others, which are filled with fresh wool, and properly heated.

There is likewise another movement of the reel A, which we have not yet mentioned: the axis of that reel has a slow motion backwards and forwards, endways in the direction of its length, for a short distance. The intention of this is, that the same parts of the combs shall never come opposite to each other at two successive strokes.

It should be observed, that when the machine is first set to work, the combs at their point of meeting do not come within three or four inches of each other, and the points only penetrate amongst the longest fibres of the wool upon the combs; but at every stroke which is made, the combs advance nearer together, and take deeper into the wool, until, after a certain number of strokes are made, the combs approach as near as they can without touching. They continue to work in this manner for some time, and when the intended number of strokes is made, a bell rings as an indication that the machine should be stopped. This is done by drawing a lever, and in consequence the machine will stop itself in the exact position for changing one of the combs on each reel. These are removed, and others ready filled with wool and heat are put on in their places, which being done on both reels at the same time by two persons, is only the work of a moment. The machine is then put in motion again, but by the machinery it will stop itself again at the required position for changing the next pair of combs; it is then put forwards, and so on, until all the eight combs are changed.

The combs which are removed from the machine are put into the stove to heat for a few moments, and then the wool is drawn off from them by a separate machine. The head of the comb is here placed in a peculiar groove, so that its teeth stand horizontal; and a piece of...
of metal, which is fixed to the head of the comb, and projects therefrom like a tooth, enters into the spiral groove of a screw, which stands in a perpendicular position, and is continually turned round by the machinery. By this means, the comb is regularly and slowly let down in the groove, from top to bottom. A pair of fluted rollers is placed horizontally, and parallel to the teeth of the comb, in such a position that the comb, in descending, will pass with its teeth at a proper distance from them, to draw off the wool in a sliver. After passing through these fluted rollers, the sliver is conducted through a perpendicular revolving tube, which gives a roundness to it, the same as it would acquire by being rolled between the hands, and then it is conducted between a pair of plain rollers, which deliver it into a tin can placed before the machine.

A wooden roller is placed above the fluted rollers, with eight pieces of board projecting from it in the direction of radii. When the roller turns round, these boards act to stroke the wool upon the comb, and raise it into a proper situation to be drawn off by the fluted rollers.

The combs are prepared for drawing off the wool, by heating them as before mentioned, and by fusing the wool from the roots of the teeth half way towards their points. In this state, the combs are carried one by one to the drawing-off machine, and the head of one comb is put into the top of the perpendicular groove: it will be prevented from falling down in the groove by the projecting tooth, which enters the spiral groove of the perpendicular screw. The wool is gathered up and introduced between the fluted rollers; the machine is then set in motion, and by means of the screw the comb is gradually lowered down, and the wool is drawn off from it in a sliver, which is rolled up into a compact form by the revolving tube, through which it passes, and is delivered into the can by the plain rollers.

The attendant holds another comb ready to follow the first, and when the first has descended to a certain point, he flips the next comb into the perpendicular groove, so that it rests upon the former, and the wool upon the two combs joints as it were in one. The stroker, when they pass before it, lays the fibres all one way, and the wool is drawn off by the rollers in a continued sliver, which does not present the slightest appearance of joinings. Another comb is then put in, and the wool joints to the former, and so on. The backings, or wool at the back of the comb, are drawn off by the boy flattened behind the machine; and the combs, as they come through below, are received by boys, who afterwards take away the noil or short wool which remains in the teeth, and then put the combs back into the stove to heat them, ready to be filled again, in order to proceed with another combing. When the wool of all the eight combs is drawn off, the motion of the drawing-off machine is stopped at the moment when the eighth or last comb has descended half way through its course. In this state, the machine waits till another combing is finished, and then the succeeding comb being placed on the top of that one which continues in the machine, the continuity of the sliver will be preserved.

The inventor of this machine states in his specification, that for common work the wool only requires to be operated upon once by the combing-machine; and in that cafe, the machine must be adapted to make twenty-four strokes of each pair of combs before the bell rings. For medium work, such as would require to be combed twice over, in the usual manner of hand-combing, it must be combed twice over by the machine: thus, after having been combed once in the manner before described, the sliver of wool is broken up into handfuls, and filled on the combs again by hand as before, and combed over again in a similar manner; but the combs are left heated for the second time of combing. By changing a wheel, the machine should be adapted to make only fourteen or sixteen strokes before it stops, when it is intended to comb twice over. The wool intended for the finest spinning should be combed three times over, and the machine should be set to make fourteen or sixteen strokes of each pair of combs.

The machine has also two different movements for the drawing out of the movable comb-reel: in one, the motion is over a space of ten inches, and is adapted to comb such wool as is fixed or eight inches length of flaxle, and is called wether wool; but by a slight alteration, the excision of the movable reel can be increased to thirteen inches, and is then adapted to comb both wool, or wool which is from eight to eleven inches length of flaxle.

Mr. Gilpin's machine has the advantages of heating the combs and of filling them by hand, both of which are essential to any machine which is proposed to comb the raw wool. The filling is an operation which requires dexterity, if it is expected that the long fibres shall be preserved without breaking. The person who fills the wool on the teeth takes a greater or less lock of wool in his hand, according to the condition of it, and the degree of entanglement: also in drawing it between the comb-teeth, the force is proportioned to what the wool will bear. Mr. Gilpin's specification states, that in certain circumstances, when the wool will not wash well, but remains taggzy, it is advisable to fill it upon the combs, and slip it off; then fill it again, preparatory for the machine. As the object of this first filling is chiefly to warm the wool, the end may be in part attained by laying the wool upon the top of the floss for a few minutes before it is filled.

**Planking.**—Let us suppose that the wool is combed either by the hand, or by the machine, and we will proceed to explain the means of preparing it into a thread. The combing-machines reduce the wool into a continued sliver, which is ready for the drawing-frame; but the short slivers produced by the hand-combing must be first joined together by what is called planking. These slivers are rolled up by the combers, ten or twelve together, in balls called tops, each of which weighs half a pound; at the spinning-mill these are unrolled, and the slivers are laid on a long plank or trough, with the ends lapping over, in order to splice the long end of one sliver into the short end of another. The distinction of the two ends of the sliver has been before explained; the long end being that which was first drawn off from the comb, and contains the longest fibres of the wool; the short end is that which came last from the comb, and contains the short fibres. The wool-comber lays all the slivers of each ball the same way, and marks the long end of each by twirling up the end of the sliver. It is a curious circumstance, that when a top or ball of slivers is unrolled and stretched out straight, they will not separate from each other without tearing and breaking, if the separation is begun at the short ends, but if they are first parted at the long ends they will readily separate.

**Breaking-Frame.**—Here the slivers are planked or spliced together, the long end of one to the short end of another; they are immediately drawn out and extended by the rollers of the breaking-frame. A sketch of this machine is given in Plate II. fig. 5 it consists of four pairs of rollers, A, B, C, D. The first pair A receives the wool from the inclined trough E, which is the planking-table. The slivers are unrolled, parted, and hung loosely over a pin, in reach of the attendant, who takes a sliver and lays it flat in the trough, and the end is presented to the rollers A, which being in motion
WORSTED MANUFACTURE.

motion will draw the wool in; the flyer is then conducted through the other rollers, as shewn in the figure: when the flyer has passed half through, the end of another flyer is placed upon the middle of the first, and they pass through together; when this second is passed half through, the end of a third is applied upon the middle of it, and in this way the short fibres produced by the combing are joined into one regular and even flyer.

The lower roller C receives its motion from the mill, by means of a pulley upon the end of its axis, and an endless strap. The roller which is immediately over it is borne down by a heavy weight c, suspended from hooks, which pass over the pivots of the upper roller. The four pairs of rollers D moves with the same velocity as C, being turned by means of a small wheel upon the end of the axis of the roller C, which turns a wheel of the same size upon the axis of the roller D, by means of an intermediate wheel d, which makes both rollers turn the same way round. The first and second pairs of rollers, A and B, move only one-third as quick as C and D, in order to draw out the flyer between B and C three times the length it was when put on the walking-table. The flow motion of the rollers A is given by a large wheel a, fixed upon the axis of the roller A, and turned by the intermediate cog-wheels b, c, and d; the latter communicates between the rollers C and D. The pinions on the rollers C and D being only one-third the size of the wheel a, C and D turn three times as fast as A, for b, c, and d, are only intermediate wheels. The rollers B turn at the same rate as A. The upper roller c is loaded with a heavy weight, similar to the rollers A; but the other rollers, B and D, are no farther loaded than the weight of the rollers.

The two pairs of rollers A B and C D are mounted in separate frames, and that frame which contains the third and fourth pairs, C D, slides upon the caldiron frame F, which supports the machine, in order to increase or diminish the distance between the rollers B and C. There is a screw f, by which the frame of the rollers is moved, so as to adjust the machine according to the length of the fibre of the wool. The space between B and C should be rather more than the length of the fibres of the wool. The intermediate wheels b and c are supported upon pieces of iron, which are moved on centres; the centre for the piece which supports the wheel b is concentric with the axis of the roller A; and the supporting piece for the wheel c is fitted on the centre of the wheel d. By moving these pieces, the intermediate wheels b and c can be always kept in contact, although the distance between the rollers is varied at times. By means of this breaking-frame, the perpetual flyer which is made up by planking the flyers together is equalized, and drawn out three times in length, and delivered into the can G.

Drawing-frame.—Three of these cans are removed to the drawing-frame, which is similar to the breaking-frame, except that there is no planking-table E. There are five sets of rollers, all fixed upon one common frame F, the breaking-frame which we, have described being the first. As fast as the flyer comes through one set of rollers, it is received into a can, and then three of these cans are put together, and passed again through another set of rollers. In the whole, the wool must pass through the breaker and four drawing-frames before the roving is begun. The draught being usually four times at each operation of drawing, and three times in the breaking, the whole will be $3 \times 4 \times 4 = 48$; but to suit different sorts of wool, the three last drawing-frames are capable of making a greater draught, even to five times, by changing the pinions; accordingly the draught will be $3 \times 4 \times 5 = 50$ times.

The size of the flyer is diminished by these repeated drawings, because only three flyes are put together, and they are drawn out four times; so that in the whole, the flyer is reduced to a fourth or a ninth of its original bulk.

The breaking-frame and drawing-frame, which are used when the flyers are prepared by the combing-machines, are differently constructed; they have no planking-table, but receive three of the perpetual flyes of the combing-machine from as many tin cans, and draw them out from ten to twelve times. In this case, all the four rollers contribute to the operation of drawing: thus the second rollers B move $\frac{1}{2}$ times as fast as the rollers A; the third rollers C move $\frac{2}{3}$ times as fast as A; and the fourth rollers E move $\frac{1}{3}$ times as fast as A. In this case, the motion is given to the different rollers by means of bevelled wheels, and a horizontal axis, which extends across the ends of all the four rollers, to communicate motion from one pair of rollers to another.

There are three of these systems of rollers, which are all mounted on the same frame; and the first one, through which the wool passes, is called the breaking-frame, but it does not differ from the others, which are called drawing-frames. The flyers which have passed through one system of rollers are collected four or five together, and put through the drawing-roller. In all, the flyers pass through three drawings, and the whole extent is seldom less than 1000 times, and for some kinds of wool much greater.

After the drawing of the flyes is finished, a pound weight is taken, and is measured by means of a cylinder, in order to ascertain if the drawing has been properly conducted; if the flyer does not prove of the length proposed, according to the size of worsted which is intended to be spun, the pinions of some of the drawing-frames are changed, to make the draught more or less, until it is found by experiment that one pound of the flyer measures the required length.

Roving-frame.—This is provided with runners the same as the drawing-frames: it takes in one or two flyers together, and draws them out four times. By this extension, the flyer becomes so small, that it would break with the slightest effort, and it is therefore necessary to give the flyer new twist; this is done by a spindle and flyer. (See Fig. 6.) A B C D are the two pairs of rollers, between which the flyer is passed; the first rollers A turn round slowly, but the others B revolve four times as quick, to draw the flyer to four times its original length; and as fast as it inflows from the roller, it is twisted by the motion of the spindle C, and wound upon the bobbin a. The spindle C is put in motion by a whip-cord hand, which passes round the pulley c, and also round the wheel D. This wheel is fixed on a vertical axis e, which has a pinion on the upper end, to give motion to the lower roller B, by means of a bevelled wheel upon the end of its axis.

The opposite end of the axis has also a bevelled pinion upon it, to give motion to a bevelled wheel fixed upon an horizontal axis, which carries another bevelled pinion, to give motion to a bevelled wheel fixed upon the end of the axis of the back rollers A. The sizes of these wheels and pinions are fo proportioned, that the back rollers A turn only once to every four turns of the front rollers B, as before mentioned.

The back rollers are capable of being fast at a greater or less distance from the front rollers, according to the length of the fibres of the wool, and in all cases the distance should be rather more than the length of the fibres, but not a great deal.
The spindle is supported on its point, and furnished by a collar at the middle of its length. Upon the top of the spindle, the flyer is screwed; it has two branches, which turn downward, and one of them has an eye at the lower end, through which the roving is conducted, in order to lay it upon the bobbin. This bobbin is fitted loosely upon the upper part of the spindle, and rels with its weight upon a piece of wood projecting from the bobbin-rail. The rail is made to rise and fall continually with a flow of motion, so as to present every part of the bobbin in succession to the eye of the flyer, and thereby wind the roving upon every part of the length of the bobbin. The bobbin is not fixed upon the spindle, but is fitted loosely thereupon; and by reling upon the piece of wood which is fixed to the bobbin-rail, there is so much friction and resistance to the motion of the bobbin, that it gathers up the roving by winding it round itself as fast as the rollers give it out. The twist given to the roving is just enough to make it hang together, and one turn in each inch is usually enough. Some roving-frames are made with four pairs of rollers, and draw ten or twelve times; and in this way, it is not necessary for the flyer to pass so frequently through the drawing-frame.

Spinning Frame.—This is so much like the roving-frame, that a short description will be sufficient. The spindles are more delicate, and there are three pairs of rollers instead of two; the bobbins which are taken off from the spindles of the roving-frame, when they are quite full, are stuck upon wires at L (fig. 7.), and the roving which proceeds from them is conducted between the rollers. The back pair A turns round slowly; the middle pair turns about twice for once of the back rollers; and the front pair B makes from twelve to seventeen turns for one turn of the back rollers B, according to the pinions which are employed, and these can be changed according to the degree of extension which is required.

The spindles must revolve very quickly in the spinning-frame, in order to give the requisite degree of twist to the worsted. The hardest twisted worsted is called tammay-warp, and when the size of this worsted is such as to be twenty or twenty-four hanks to the pound weight, the twist is about ten turns in each inch of length. The least twist is given to the worsted for fine hairy, which is from eighteen to twenty-four hanks to the pound. The twist is from five to six turns per inch. The degree of twist is regulated by the size of the whirls or pulleys upon the spindle, and by the wheel-work which communicates the motion to the front rollers from the band-wheel, which turns the spindles.

It is needless to enter more minutely into the description of the spinning machinery for worsted, because the construction is very similar to the water-frame for spinning cotton, invented by Sir Richard Arkwright, and which is fully described in our article Manufacture of Cotton. The differences between the two are chiefly in the distance between the rollers, which in the worsted-frame is capable of being increased or diminished at pleasure, according to the length of the fibres of the wool, and the draught or extension of the roving is far greater than in the cotton.

Reeling.—The bobbins of the spinning-frame are placed in a row upon wires before a long horizontal reel, and the threads from 20 bobbins are wound off together. The reel is exactly a yard in circumference, and when it has wound off 80 turns, it rings a bell; the motion of the reel is then stopped, and a thread is pulled round the 80 turns or folds which each thread has made; the reeling is then continued till another 80 yards is wound off, which is also separated by interweaving the same thread; each of these separate parcels is called a lay, and when seven such lays are reeled off it is called a hank, which contains 560 yards. When this quantity is reeled off, the ends of the binding thread are tied together, to bind each hank fast, and one of the rails of the reel is struck to loosen the hanks, and they are drawn off at the end of the reel. These hanks are next hung upon a hook, and twisted up hard by a stick, then doubled, and the two parts twisted together, to make a firm bundle. In this state, the hanks are weighed by a small index-machine, which denotes what number of the hanks will weigh a pound, and they are sorted accordingly into different parcels. It is by this means that the number of the worsted is ascertained as the denomination for its fine-ness; thus No. 24. means that 24 hanks, each containing 560 yards, will weigh a pound, and so on.

This denomination is different from that used for cotton, because the hank of cotton contains 840 yards instead of 560; but in some places, the worsted hank is made of the same length as the cotton.

To pack up the worsted for market, the proper number of hanks are collected to make a pound, according to the number which has been ascertained; these are weighted as a proof of the correctness of the sorting, then tied up in bundles of one pound each, and four of these bundles are again tied together. Then 60 such bundles are packed up in a sheet, making a bale of 240 pounds, ready for market.

From this account of the processes of worsted spinning, it will be seen that they are very similar to those of cotton-spinning, after the first preparation of the wool by combing instead of carding.