woollen and worsted manufactures. The manufactures in wool and in worsted are so closely connected, in reference both to their past history and to the industrial arrangements involved in them, that it will be convenient to treat of them under one head. Wools are divided into two great classes—closings-wools and combing-wools, or short-wools and long-wools; and the fabrics woven from them are termed woollen or worsted, according as the one or the other is employed. A high perfection is now obtained in both; the property which enables the fibres to felt or interlace one another, and to form thereby the dense compact material of which men's garments are so largely made in this country, as well as the still thicker felt for hats (hat manufacture); whereas combing-wools, though long in fibre, are deficient in the felting property, and are therefore employed for stuffs, merinos, hose, and a large number of fabrics which do not undergo the felting or fulling process.

History.—It is probable that no other of the textile manufactures is so ancient as that of wool. Sheep were reared from the earliest times, and there can be little doubt that the use of the wool for clothing was soon adopted. A mass of woolen fibres be pressed firmly together in a flat layer, the fibres, by virtue of their felting property, will cohere into a continuous sheet even without the process of weaving; and this property could not fail to attract notice. The passages in the Bible which seem to allude to the use of woolen garments are well known; and we have indirect evidence from various quarters to show the prevalence of a similar custom in the East generally, in early times. The spinning of the fibres was most probably effected by the fingers; while the thistle or teasel, as at present, was used to comb out the fibres: the thistle, too, if it is possible, was well understood by the ancients. Among the Greeks and Romans the woolen manufacture was of a domestic character; but yet it would seem that the clothing of large armies must have required arrangements of a more extensive kind. The natives of India, after the epoch of Macedonian conquests in that country, made shawl-cloths of exquisitely beauty, consisting, as is supposed, of short wool woven without felting; and the Greek carpet-writers have derived some of their materials to the effecting from such a quarter. But however this may be, the Romans of both sexes were woolen garments very generally.

The decay of the arts consequent on the irruption of the barbarians into Rome did not appear to have extended to this manufacture. Woollen clothing was still made in most of the countries where the Romans had established colonies; and there are indications that in the 10th century the manufacture became the occupation of a particular fraternity in the Low Countries. The wool employed was at first the produce of their own country; but they afterwards imported wool from the other countries, and carried on the manufacture to such an extent that the Low Countries became in a great measure the clothing district for Europe. Spain produced cloth for herself, and acquired, about the 15th century, considerable reputation for the beauty of the fabrics produced upon the fine wool which abounded on the fine wool which Spanish sheep have for centuries produced. The Italian and French entered upon this manufacture at a later period.

The Conquest of William the Conqueror an inundation which occurred in the Netherlands drove many of the clothiers into other countries, and some of them came to England. William of Malmsbury says that the king, glad of such an accession, placed these Flemish clothiers first in Carlisle and then in the western counties. From that time the mention of clothiers is frequent in the old chronicles; London, Oxford, Lincoln, Huntingdon, York, Nottingham, and Winchester, being mentioned as towns wherein the manufacture was carried on; while at other towns there were cloth-dealers who paid a licence duty to the king for the privilege of buying and selling dyed cloths. It has been stated [wool and the wool trade] that the king frequently derived considerable revenues from English wool; and this circumstance led to the enactment of many laws, tending to the exclusion of foreign wool and the use of English wool only in our manufactories. The exclusion of Spanish wool from English broad-cloth; the limitation of the width of broad-cloth to two yards; the determination of the width of striped cloth made at Bristol; the appointment of towns where alone cloth could be bought and sold; the appointment of the officers of kinsman whose duty it was to attend the cloth-makers and measure all the cloth sold, to see that there was no deficiency of length, and who received a fee for every piece of cloth to which he assented; the duty imposed to export woollen cloths until they were entirely full; the granting of permission to make certain kinds of cloth three-quarters of a yard in width; the fixing of a leaden seal to pieces of cloth wrought in London and the suburbs—these are some of the regulations which the government either issued directly or through the manufacturers; and they will serve to convey an idea of the general character of others.

Edward III. brought about a great extension of the manufacture by inviting over some skilful weavers from the Netherlands. English wool was said to be worked up more successfully in the Netherlands than in England; and Edward thought that by getting over some of the artificers to this country he could improve the manufacture. This seems to have been done; and the following distribution of the manufacture, consequent on this immigration, shows how widely this fashion of industry became spread throughout England: Norfolk, Suffolk, Lincoln, Berkshire, Essex, Essex, and Kent, the broadest; Devon, Devon, Cornwall, and Devon, the best; and Somerset, Somerset, and Somerset, the worst. But this is not entirely correct, as a comparison of the worsted manufactures of England and the Netherlands shows. Wollen cloths became very large, inasmuch that when, through foreign wars, the markets of Spain and the Netherlands were closed to the English, great complaints arose among the manufacturers, who could not sell the cloth which they sent to Blackwell Hall, a kind of Cloth Hall whence London dealers and merchants were supplied. About this time the manufacture in the counties of Somerset, Gloucester, Wiltshire, and Worcester was limited to certain towns, and the laws were passed to confine it to those favoured spots. During the reign of Elizabeth, owing partly to many of these restrictions being removed, partly to the influx of English from the Netherlands and Flanders driven from the Netherlands by the persecutions of the Duke of Alva, a considerable advance was made in the English manufacture. In the following reign the English dyers succeeded in obtaining a law prohibiting the export of cloth to the White or yellow lands, under the expectation that they would be gainers thereby; but, like many other monopolies, it defeated its own aim; the Dutch and Germans refused to purchase English cloth in those lands, and thus England lost so enormously that dyers as well as manufacturers lost by the impolicy of prohibition.

During the time of the Stuarts a narrow policy almost ruined the manufacture. At one time there was an attempt to get all Spanish wool brought to this country, and to no other countries; at another time the exportation of English wool, of fuller's earth, and other necessary parts of the manufacture, was prohibited. English cloths were prohibited from receiving Flemings amongst them, from a feeling of jealousy; the London merchants procured an act prohibiting all foreigners from buying and selling; and many other measures were passed, either by parliament or the corporations, tending to cripple the free spread of the trade and manufacture. Ireland suffered severely from this mischievous system; for after being compelled to give up the exportation of cloths to England, on account of the complaints of the grangers, she turned attention to the growth of wool; but this offended the English wool-growers; and if Irish cloths were sent to England, this roused the opposition of the English clothiers; so that from about 1640 to the end of the century there was one continuous struggle in Ireland to bear up against the selfish policy of England in respect to wool and its manufactures.

Throughout the greater part of the 18th century the manufacture still flourished, especially in those counties which have the advantage of good spinning or combing wool. When the inventions in spinning-machine gave an extraordinary impetus to the cotton manufacture, that of woolen became thrown comparatively into the shade; but the application of the cotton machinery has stimulated the production of woolen fabrics; while the great improvements in the quality of German and Australian wools, combined with the maintenance of a liberal policy in commerce and intercourse, have given to the woollen and worsted manufactories in England a more healthy tone.

Woolen manufactures.—It has been before explained that the woolen manufacture relates to such fabrics as require the use of short or combing wool. This wool undergoes a very large number of processes in the course of the manufacture. If we take a piece of superfine broad-cloth as a representative of this manufacture generally, the following are the successive processes by which it is produced:—

1. Sorting the wool.
2. Scouring.
3. Washing.
4. Bleaching.
5. Dying (when dyed in the wool).
7. Pickling.
8. Oiling.
10. Scribbling.
11. Pickling.
12. Carding.
13. Cleaning.
15. Spinning.
16. Warping.
17. Reeling.
18. Rolling.
20. Bleaching.
22. Oiling.
23. Matting.
24. Drying (when dyed in the cloth).
27. Testing.
28. Shearing.
29. Chopping.
30. Braising.
31. Pickling.
32. Oiling.
33. Matting.
34. Packing.

More than one-half of these, in the most improved forms of processing, are effected by machinery.
WOOLEN AND WORSTED MANUFACTURES.

are called for in the separation. The sorter has to make his selection in relation to the fineness, the softness, the strength, the colour, the cleanliness, and the weight of the wool; and in rubbing together, passing through narrow quills into the wool into many parleys, which receive the names of primes, choice, super, head, downright, seconds, fine abb, coarse abb,illery, &c. The finest fibre is that of Spanish ewe, the mean diameter of which is of an inch; while the coarsest is that of a Spanish merino, measuring $\frac{1}{2}$ of an inch. All woolly fibres are thicker at one end than the other; but the less the difference in that respect, the more valuable is the wool; and this is one of the favourable points in Merino wool.

When the proper kinds are selected, they are next sorted and washed, to free them from the grease which invariably attaches to them. The wool is laid on an alkaney lay at an uniform temperature of about $100^\circ$ raised with cold water, and passed between the rollers of a powerful press to free it from nearly all moisture.

If the cloth is dyed in the wool, that operation succeeds the sorting; if dyed in the piece, any other process intervenes; and it depends a good deal on the kind of colour as to which is followed. Supposing the dying to be completed, however, the wool undergoes the process of softening or softening, which is somewhat analogous to the brushing or caressing in the cotton-manufacture; the object being to open and disentangle the locks of wool, and clean them from sandy and other loose impurities. One among many forms of softening is to warm the wool in an iron vessel, having an iron cylinder running through its centre; on this axis are fixed three wheels of different diameters, bearing on their circumference four longitudinal bars studded with spikes. The cloth is placed on the cylinders, with a rapid rotation, for two or four hundred revolutions per minute, within an outer cylindrical casing, whose inner surface is armed with similar spikes. The machine is fed, by means of an endless screw, with wool, which enters at the side of the vessel, the larger end by virtue of the centrifugal force produced by the rotation. As it passes onwards between and among the spikes, it becomes opened and disentangled, the fibres being locked separated, and the impurities detached. When the wool has reached the lower end of the cone, it passes into a receptacle where a fan is revolving with great rapidity, by which a current of air is generated sufficient to blow away all the dust mixed with the wool at the same time. It is thus that the machine distributes the wool in a flat equable layer or stratum. Thus the same machine disentangles the fibres, separates the impurities, blows away the dust, and sets the wool in a smooth sheet.

Some kinds of wool require willying more than once; but this is not the case with the finer qualities. There are however frequently some impurities which cannot be removed by the process of softening; and such are afterwards picked out by boys or women, called wool-combers, or wool-pickers. A further opening of fibres results from the process of spinning; but before this is effected, the wool undergoes that of oiling; it is being spread out on a floor, sprinkled with olive-oil, and well beaten with sticks. The spinning-machine consists of several cylinders, on whose external surfaces are rows of teeth or wires. These are combined in a strong frame, and so arranged as to just touch each other, and to be set in motion by a hand-wheel, to which the wires on one cylinder are bent in a direction contrary to those in the adjoining one; so that when all the cylinders are revolving, and wool is applied to the first one of the series by an entanglement of the hair, it is caught from the cylinder to cylinder, separated completely from all entanglement, and finally given forth in the shape of a delicate fleece or sheet. It becomes wound on a revolving roller, after having gone through the spinning machine, and when it leaves the spinning-machine it presents the appearance of slender rods, cylinders, or pipes, which are called cardings.

These cardings are then spun into yarn for the use of the woolen-weaver; the process of spinning being generally effected by means of the slubbing-billy or slubbing-machine, and afterwards by the common jenny or mulespinning machine; the slubbing-billy bringing the wool to the state of a soft weak thread, and the spinning-machine giving it the proper firmness and hardness for yarn. The slubbing-billy has a wooden frame, within which is a moveable carriage, running on lower slabs or wheels. The frame contains a number of carding or carding wheels, which receive a rapid motion from a long cylinder, by means of separate cords passing the pulleys of the respective spindles; the latter is a long drum of tin, six inches in diameter, covered with paper, and extends across the whole breadth of the carriage. The spindles are placed in a frame so as to stand nearly upright at about four inches apart; their lower ends being so formed as to act as spindles. The drum lies horizontally before the spindles, with its centre a little lower than the line of the spindle-pulleys. The drum receives motion by a pulley at one end with an endless band fastened on the outside of the drum, and driven by a small hand-spinner with his right hand applied to a winch; and by this movement the spindles are made to revolve rapidly. Each spindle receives a soft card or slubbing, which comes through beneath a wooden roller at one end, and above which is a small drum, by which it is wound on the outside of the main frame, thus forming between the drum and spindles a continuous band or band of yarn, which is then taken up by the card-engine, and places them upon an inclined cloth. These cardings, being drawn beneath the roller, are then caught between two rollers. The movement then is very similar to that of a mule-jenny; a small portion of each carding is allowed to pass between the rails or clasp; and this portion is then drawn out or elongated to the state of a thread by the recession of the carriage wheels, which is driven by an endless chain from the other end of the carriage. Meanwhile the second pair of rollers keeps the band of yarn round the bobbin. The second pair of rollers is driven by a belt which is wound on the bobbin, and which is kept in motion, by which a slight twist is imparted to the thread or slubbing. A full-wire and a rail assist in regulating the winding of the thread uniformly on the spindles. The process then is thus completed, the carding machine, and lays them on the inclined apron; they are then carried up the roller and between the clasp, and the workman by managing the weight of the carriage with one hand, and the wheel which turns the spindles with the other, elongates the carding into slubbing, and winds it on the spindles. The picers are employed and paid by the hour; and some years ago great cruelty was said to be found on the children for working for long hours; but the inspectorships of factories have removed such sources of discredit to the factory system.

In the spinning of the wool, which follows the slubbing, the kind of machines employed and the general character of the processes are so similar to those exhibited in the cotton manufacture, that it will suffice to refer to Cotton Manufacture and Spinning for details, with the following few additional remarks. The soft card or sliver is caused to pass between two pairs of rollers; the space between the two pairs being rather more than equal to the length of the fibres. The two pairs of rollers between which the sliver is compressed do not separate farther than 1 inch, each other in order to stretch it, but that effect is produced by making the second pair of rollers revolve faster than the first. It is necessary to arrange the distance between the two pairs of rollers according to the length of the fibres of the sliver; but the sliver is composed; because if the two pairs of rollers were too far apart, the soft card would be liable to separate between them, and if they were too near, so that the lower ends of the fibres compressed between them at the same time, the sliver could not extend or lengthen by the sliding of the filaments, but the filaments themselves must break with the strain. Hence, in machinery for spinning wool, the length of the fibres in the sliver is taken into account, and the rollers are so mounted that they may be readily adjusted to different distances. In consequence of the greater elasticity of wool, the relative velocities of the two pairs of rollers are so arranged that they produce a greater degree of stretching or extension than is usual with cotton.

The process next following that of spinning is weaving, by which the yarn is worked up into a textile fabric. If it be a plain cloth, the loom is very simple. In weaving for ornamental fabrics, the loom is somewhat more complex; but the general arrangements will be sufficiently understood by a reference to the description of the machinery used in the manufacture of worsted. Hitherto woolen cloths have been principally woven by hand-weavers; but the power-loom is now becoming more and more applied to this purpose. Some of the cloths are woven as broad as twelve-quarters, to allow not only for the shrinkage occasioned by the subsequent process of fulling, but for an edging or list, made either of goat’s hair or of coarse yarn, into which the tenter-hooks are thrust in the process of tentering.

The cloth and wool has been dressed with oil before spinning, and with size before weaving; it becomes necessary to cleanse it from these impurities immediately after the weaving. This is the object of a second scouring process, in which the cloth is washed with warm water being let in upon it first, and then clear water. Being then carried to the drying-room, or the tenter-ground, it is stretched out by means of hooks on rails, and extended through the process of tentering into a room and examined by barbers, who pick out all irregular threads, hairs, or dirt. After this it is ready for the important process of fulling, or felting, which imparts to woolen goods that peculiar quality of surface whereby they are distinguished from all others. A large mass of cloth folded into many plies is put into the fulling-mill, where it is exposed to the long-continued action of two heavy wooden mallets or stocks. Superfine cloth receives four fullings of three hours each, a thick solution of soap being spread between each layer of cloth every time. During the violent percussions which the cloth thus receives for twelve hours, the fibres, being at every stroke strongly impelled against each other by means of the little serrations on their surfaces, until they become firmly and inextricably united; each thread, both of the warp and weft, being so compacted with those that are contiguous to it, that the whole seems formed into one substance, not liable, like other woven goods, to unravel when cut with the scissors. This compacting process in the cloth manufacture is effected by beating, and is called fulling; in the hand-weaving, it is effected by pressure and rolling, and is called felting; but the two are clearly analogous in principle. This process thickens the cloth remarkably, but diminishes it by about one half.

In the fulfilled state the cloth presents a woolly and rough appearance, to improve which it goes through the processes of beardng or raising, and shearing or cutting. The object of the first is to cut off the second to cut them off to a uniform level. The raising of the fibres is effected by thistle-heads, teasels,-carding, or wire brushes. Textures are the seed-pods of the dress, being used in mankind since the days of which woolen cloths were formerly used in the cloth manufacture thus: a number of them
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were put into a small frame with handles, so as to form a kind of curry-comb; and this was worked by two men over the surface of the cloth, which was suspended horizontally; the direction of working being first parallel with the warp, and then parallel with the weft. From the trouble required to clean the bars of the teasles when filled with woolen fibres, from the weakening of their points by the water with which the cloth was saturated, and from the high price which the large demand enabled them to command in the market, numerous attempts were made from time to time to substitute metallic points; but from various causes the teasles are still preferred, and are now used in a more efficient way than formerly. The teasles are arranged on a cylinder in a machine called a gig-mill; the cloth is stretched on a two cloth-beams; the cylinder moves in one direction and the cloth in another; and the fibres become thereby worked or combed up. The annexed cut shows the section of such a machine; where the cloth, passing from a roller \( b \), round the roller \( f \), comes in contact with the brushes \( e \) on the wheel \( a \), and afterwards passes round \( y \) and \( t \) to the roller \( h \); the roller \( y \) being so regulated by the pinion \( s \) and the rack \( m \) as to keep the cloth thoroughly stretched; and the revolving brush \( f \) being so adjusted as to clean the teasling-cards \( c \). In some machines the teasling-points are made of wire, to obviate the waste of 9000 natural teasles, which takes place in the dressing of one piece of cloth.

When the ends of the fibres have been thus raised to the surface, they are next shaved or cropped; a process of great beauty and simplicity. Originally this process was performed by means of large hand-shears, the cloth being stretched over a stuffed table, and the workman proceeding to clip the ends of the fibres in a regular and equable manner. This was an operation requiring great dexterity; and the men who worked at it being in the receipt of good wages, were so alarmed at the introduction of shearing-machines, in the early part of the present century, that serious riots occurred in the west of England.

But the machines became by degrees extensively employed. They consisted each of a pair of shears, as in the hand-method; but all the movements were effected by machinery. More recently, a machine has been introduced, the action of which is regulated on a different principle, as will be seen from the annexed cut: \( b b \) are disk-formed cutters, working against a thin bar of steel, \( a e \), of a semicircular form; which cutters in their revolution travel round against the edge of a knife-like blade in such a way as to shave off the filaments standing up on the surface of the cloth beneath. The cloth is represented by the shaded part of the wheel \( c c \), set in motion by machinery, imparts motion to the circular cutters attached to it through the medium of the rack \( d d \).

It is easy to see that, whether the machine travels along over the cloth, or the cloth travels along beneath the machine, every part of the fibrous surface is acted upon in precisely the same way by the double rotation of the wheel and the disk-cutters. There are other shearing machines in use, of equal ingenuity.

When the cloth has been raised and sheared (which operations are repeated two or three times for superfine cloth), it is 'brushed' by a machine consisting of a system of brushes affixed to cylinders; the cloth being exposed at the same time to the action of the brushes and of steam. A few subsequent operations are carried on, having for their object the imparting of smoothness, gloss, &c., to the cloth, preparatory to its being placed in the hands of the dealers.

We have described most of the operations in the woolen industry in their simpler forms, for more ready comprehension; but it is well to bear in mind that new machines and new processes are being continually brought into this department of industry. A meeting of the woolen manufacturers took place in 1640, to examine a new French machine invented by MM. Tavernier and Vivouillon, "to convert slivers or rovings, as they came from the carding-engine, into threads suitable for weaving, by felting and friction, without any spinning process."

It was declared that "many gold medals had been awarded in France for the invention; that many of the machines were at work; that no oil or water is necessary as a dressing; and that 30 per cent. of wool is saved." So far as we are aware, this favourable description failed to make the intended impression on the manufacturers. Many of the recent novelties in the trade relate to the employment of cotton for warp-threads, and of rag-wool mixed with new wool for weft; a subject briefly noticed under the woolen manufacture.

The machine which has been brought into use is called a "comber," by which, when attached to the carding-engine, the wool is brought off in a continuous silver wound on cylinders, ready to be conveyed to the spinning-machine.

Mr. Archibald, of Tillicoultry, in 1886, introduced a machine for piecing the lengths of carded wool as they leave the carding-engine, and forming them into a continuous length or roving; the rovings drop into reversing channels, and thence to travelling belts, which convey them to a machine where they are connected into a length more uniformly than in the ordinary way. Without noticing the almost numberless new machines and processes, we may just mention a very curious process, patented by Messrs. Tilden and Irving, for imparting a metallic lustre to fine woolen cloth. The cloth, either in the yarn or when woven, is steeped in a solution of sulphate of copper, oxide of copper, iod, or bismuth, and then exposed to steam charged with sulphuretted hydrogen gas, by which a metallic deposition takes place.

Other matters relating to the manufacture of woolen cloth will come under notice presently.

**Worsted or Stuff Manufacture.**—The long wools for worsted fabrics, not being felted or failed, pass through a series of operations similar to those hitherto noticed; since the object in view is rather to lay the fibres in a parallel position than to twist and entangle them one among another. All combing-wools are longer in fibre than the clothing-wools, but they are subject to the division into long and short combing wools; the long, varying from six to twelve inches in length, being used principally for coarse worsted goods; and the short, from four to seven inches, being used for hose and some other purposes.

After the wool has been sorted, washed, and scoured from the adherent grease, and dried in a heated room, it is carried to a machine called a "plucker," consisting of a pair of spiked rollers, by the action of which the wool is cleaned, separated, and the fibres straightened, preparatory to the process of combing. In hand-combing, which, until modern times, was the only mode followed, and which is rather laborious work, the proceedings are somewhat as follows:—The comber is provided with a pair of combs such as are here represented, a comb-post to which to attach the combs, and a comb-pot or store for holding the
tooth. Each comb consists of two or three rows of steel teeth, $b$, one row longer than the other, inserted in a wooden stock or head, $c$, from which protrudes a handle, $d$, at right angles to the direction of the teeth. The workman first heats the teeth of one of the combs in the stove, and fixes it in the post, teeth uppermost. He then takes a handful of wool, consisting of about five ounces, sprays it with oil to increase the pliancy and ductility of the filaments, and works it about between his hands to equalize the oil on every part of the fibres. The comb then takes half the bundle of oiled wool, and dashes it upon the upturned teeth of the comb, till it is all deposited there, and caught between the teeth sufficiently firm to be retained. The comb with its wool is placed, points downwards, in the stove, and the comb next fixes the other heated comb in the comb-post, lays the other half of the bundle of wool on it, and places this likewise in the stove. When both combs with their supply of wool are properly warmed, the comber holds one of them over his knee with his left hand, while seated on a stool, and with the other comb, held in his right hand, he combs the wool upon the first, by introducing the points of the teeth of one comb into the wool contained in the other, and drawing them through it. This is repeated till the fibres are laid parallel. The wool which remains uncombed on the teeth, and which constitutes about one-eighth of the length of the fibres, is unfit for spinning into worsted, and is consequently applied to other purposes. In machine combing, the apparatus sometimes consists of two wheels of large diameter, like the

the silver of wool becomes elongated to a state of still greater tenuity while passing between them. It is then caught between the rollers $e$, kept in close contact by the weight $p$, and as these rotate still more rapidly than the former, the silver is still more elongated, until its thickness is so small that the fibres can scarcely cohere. But in order to give them the requisite coherent strength, they are slightly twisted by the bobbin and fly $o$, that beautiful contrivance which is so extensively adopted in the textile manufactures. One fork or leg of the inserting fly $o$ is hollow or tubular, and as it cuts this tube a delicate cord of wool passes; then, by the rapid rotation of the fly, the wool or roving becomes wound on the spindle of the bobbin connected with the fly. The straight or rectilinear motion of the roving while approaching the fly, combined with the circular motion at the fly itself, imparts a twist to the roving, sufficient to enable it to undergo the process of spinning.

The spinning of the worsted bears so close a resemblance to that of cotton, as described in Cotton Manufacture, and Spinning, that a reference to those articles will suffice to convey a general notion of the process. When spun, the worsted yarn is wound on a reel, and is then made up into bales of 500 yards each. These bales receive denominations according to the number of them which go to a pound, and the yarn derives its name in like manner; thus, No. 24 yarn has 24 bales to the pound. In some instances the bale is reckoned at 440 yards. The bales are tied up into pounds; the pounds are combined into bundles; and the bundles are made up into bales of 240 lbs. each, ready for the market.

Here terminate the operations of a worsted-mill; for the dyeing of the yarn, and the weaving into the various kinds of textile fabrics, lead us to other departments of industry. [DYING; WEAVING.]

The worsted manufactures, like that of woolen, have been marked by the introduction of many new machines and processes within the last few years. Two or three of these may be briefly noticed. English worsted is becoming less and less fitted for clothes, and more and more for worsteds. Moreover, a length of staple, necessary under the old process of combing, is less needed under the modern. From both these causes any kind of English wool, from three-inch staples upwards, is rendered available for one or other of the numerous kinds of worsted manufactures. Carding-machines in great variety have been adopted; and the chief inventor, Mr. Lister, made an attempt in 1855 to overturn the patent of many of these, but failed in a suit at court of law. Moser, Croft and Steele's machine, introduced at Keighley in 1857, has a number of combs, each forming a circular segment; they are fixed to the outer ends of radiating arms carried by a horizontal disc, which rotates on a vertical axis. The combs, while rotating, pass in front of a feeding apparatus, and have a peculiar combing motion given to them by means of cranks; they advance and retreat, rise and fall, and rotate, all at once. Each comb takes its proper quantity of wool from the feeder, and carries it round to the drawing-off roller. There are circular brushes to clean each comb after its passage, and a hot chamber in which the teeth are warmed.

The great increase in the facility of machine-combing has been one cause of the more rapid advance of the worsted than of the woolen manufacture. Another is, that the fly-spinning, which so late as 1848 only made 2000 revolutions per minute, are now driven at the enormous velocity of 6000 revolutions. Another is, that while woolen cloth, from its great width (often 9 feet before being milled), cannot be woven at more than about 50 picks of the loom per minute, worsted weaving is often conducted at the rate of 360 picks. So great is the facility now offered for the use of cotton in mixed goods, or stuffs and worsteds, that out of 106 pieces of all kinds, taken indiscriminately from those produced in the Bradford district, it is estimated 65 have cotton warps; while the total weight of the whole produce is supposed to be two-thirds wool and onethird cotton. One of the curious peculiarities of recent years is Moser, Saunders and Smith's process for utilizing the greasy resulting from the various scourings and washings to which the wool is subjected. Iron pipes convey the greasy water to a tank, whence a pump draws it up to other tanks, where it is heated by steam to between 100° Fahr. Certain chemical substances are added, by which the creamy mud is converted into a scum and a sediment, with a liquor between them. The liquor is drawn off as useless. The scum

![Image of Combining-Frame]

Combing-Wheel,
and the sediment, nearly alike in composition, are drained in bags of material, or bottled, and made into a sort called "muck," which is used in making starch, soap, and other salable chemicals, while the refuse cycle is sold as manure. The patentees supply all the additional apparatus, besides having the greasy wax at a stated price. Other starchy materials are introduced, and as to contain more oil than wool, is eagerly bought up by farmers as a powerful manure.

**Locality and Varieties of the Trade.**—When it is considered that worsted goods differ so considerably in the lower classes, it is easy to imagine that many varieties may be produced, according to the extent to which this separation is carried out. The various woofs too, in which the warp and weft threads are made to interface, and the dyers of the material, sometimes of the same, or different classes of goods. These four conditions, namely, the length of fibre, the application or not of the felting quality, the production or not of the yarn, after which the warp and weft are made to go round, gives rise to innumerable and fancifully-named kinds of woolen and worsted goods. Blankets, flannels, stuffs, merinos, mouselines-du-laine, bombazines, taffetas, shantings, satellite, sayes, mouselines, calicoes, cottons, linens, and a host of other names, some of which are now nearly or quite out of use, or are giving way to others, to the diverse applications of long-woven in the production of woven fabrics; while less expensive and other names indicate distinctions in the felted wool goods. But besides these diversities, there are others depending on various circumstances; such as the admixture of woolen with worsted, or of either of them with cotton or silk, in the same fabric; the dying of the material, sometimes of the same wool, sometimes of the mixed yarn, and sometimes in a party-coloured mode called "clouding," and the printing of designs on one surface.

As a style may suffice to illustrate this diversity. Plain broadcloth is a specimen of plain weaving, followed by the fulling process; whereas hereysoure is a twilled fabric, similarly fullled. Serges are twills, having worsted warp and coarse woolen weft. Blankets are made of the coarsest yarn, afterwards woven up into a kind of material for carpeting and worsted milling; and many varieties of coarse cloth are of analogous structure. Bombazines is a twilled mixture of worsted and silk; whereas Poplins is an untwill mixture, showing more weft than warp on the surface. Sarcines and Ourlass are made of wool, sometimes mixed with cotton, and afterwards printed. Stuff is made wholly of worsted; while Merinos is a fine woolen twill, sometimes printed. The material clothings and the worsted woolen and cotton cloths, are made of the same description of the processes. These mills have been erected on a joint-stock principle, by shares of 2d. or 10d. each, principally subscribed by the domestic clotheries. When machines began to be extensively employed in the woolen manufacture, in the early part of the present century, the domestic clotheries became violently excited, under the apprehension that their trade would be taken from them by the newly-invented machines. A parliamentary committee was appointed to inquire into the probable operation of machinery in respect to the well-being of the domestic clotheries; and after examining numerous machines, they made a report to the House of Commons, and recommended the adoption of joint-stock manufactures for the factory and the domestic systems, and came to a conclusion that "the two systems, instead of rivaling, are mutual aids to each other; each supplying the other's defects, and promoting the prosperity of the other." Experiments were made and the correctness of these conclusions. The number of small manufacturers, and the quantity of cloth produced by them, have been increased in the last few years; but, as the number of large factories, and those made in the same, have increased still more rapidly, the former constitute, at present, a less proportion of the trade." One circumstance which has enabled the domestic system to maintain its ground, is, that the great width of woolen cloth has been a difficulty in the way of power-loom weaving; the hand-loom cannot compete with steam in the steam trade, but it can in broad-cloth. The domestic system would nevertheless have succumbed, had not the clothers prudently adopted the joint-stock principle for their mills. Each shareholder takes his own wool to the mill to be cleaned, dyed, carded, and spun; brings it home to weave by himself and family; takes it to the mill to be fullled, washed, and tentered; and sells it at the cloth halls to merchants who employ dressers to finish it.

As respects the sale of the cloth, hall has been established for this purpose at Leeds, Halifax, Bradford, Huddersfield, and other towns, which are attended on the public market-days by thousands of the smaller class of manufacturers. The halls are divided into long walks or galleries, consisting of rows of stands, each of which is marked with the name of the man who owns it; and it occupies the whole of the district, where the cloth is exposed for sale; and when the market opens, the manufacturers take their stands at the stands behind their goods, the mer- chants make their purchases, and constitute the chief business between the rows. The time during which the halls are open is limited usually to about one hour and a half; but in this short interval purchases of a very large amount are made. The cloth-halls at Leeds have been appropriated exclusively to the business of cloth making. They are managed by trustees, and many of the stands are the freehold property of the man who owns them, and who sells in one day, what he sells in whole or short yards, for which they are about five shillings, and sold and undressed. These by or for whom it is bought have what are termed finishing-shops, where the cloth is shorn, dressed, and fitted
for use. This is analogous to a system pursued by the bobbin-net manufacturers at Nottingham, where the net is sold by the maker in the rough state as it leaves the loom, and purchased by other parties, who sing, dress, and finish it ready for the market.

Statistics of the Trade.—In 1792, the writer of a pamphlet on the subject of wool estimated the number of persons engaged in the woollen manufacture at 1,500,000, and their wages at 11,737,000l. per annum. This estimate was obviously an overcharged one. Dr. Campbell, in 1774, thought that there might probably at that time be 1,000,000 persons employed in the manufacture in England; that the value of the wool used was 3,000,000l. per annum; and that this value was increased to 12,000,000l. by the processes of manufacture. In 1806 the woollen manufacturers, in committee before the House of Lords, made the extravagant estimate that there were then 1,500,000 persons directly engaged in the manufacture; that an equal number were collaterally employed in it; that the value of the wool used was more than 6,000,000l. sterling; and that of the manufactured goods nearly 20,000,000l. sterling. In 1815 Mr. Stevenson supposed that there were half a million persons employed, receiving 9,000,000l. per annum wages; and that this sum, added to the value of the raw material, the interest on capital, the manufacturer's profit, &c., gave 18,000,000l., as the annual value of the cloth produced. Mr. M'Culloch ("Statistical Account") forms an estimate on the following data:—That there are about 150,000,000 lbs. of wool worked upon yearly; that this may be worth about 7,500,000l. per annum; that the value of the manufactured goods is three times that of the raw wool, making therefore 22,500,000l. per annum; and that this value is thus made up:—

<table>
<thead>
<tr>
<th>Raw material</th>
<th>£7,500,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil, soap, dyes, &amp;c.</td>
<td>£1,000,000</td>
</tr>
<tr>
<td>Interest, profits, &amp;c.</td>
<td>£4,000,000</td>
</tr>
<tr>
<td>Wages</td>
<td>£5,500,000</td>
</tr>
<tr>
<td>Total</td>
<td>£22,500,000</td>
</tr>
</tbody>
</table>

And dividing this amount of wages at the rate of 300 a year to each operative, on an average, he arrives at the number 84,400, which he thinks approximates a probable approximation to the number of persons employed in the woollen manufacture in this country. Mr. Chapman (one of the Assistant Hand-Loom Commissioners) made an estimate which agrees pretty nearly with that of Mr. M'Culloch: although at the first glance the two estimates seem discordant. He thinks that, in 1831, the number of families directly dependent on the manufacture were:—

- In the West Riding of Yorkshire: 10,000
- In the West of England: 11,000
- In Norfolk and Huntingdon: 1,500
- In the heavy district: 2,000
- In all other places: 15,000

165,000

Then, taking the average number of persons in a family at 5, he arrives at an aggregate of 874,550 persons directly supported thereby. He further supposes that this number must have increased, by 1841, to 228,000 families, or 1,218,364 individuals. Mr. M'Culloch's estimate is of the number of persons employed, while Mr. Chapman's is of the number of persons supported; and this may explain the apparent discrepancy between the two estimates. As to the value of the manufacture, Mr. Chapman proceeds thus:—929,208 families, earning on an average, 17s. 6d. per week each family, which amounts to 10,296,550l.; and the relation between this and the other items of the cost he thus states:—

| Value of wool employed | £10,000,000 |
| Oil, dye-stuffs, soap, &c. | £1,000,000 |
| Wages | £2,000,000 |
| Total | £13,000,000 |

In the last edition of his "Commercial Dictionary," Mr. M'Culloch makes an estimate, which he supposes to approximate pretty nearly to the true figures for the year 1858. He takes the consumption of English wool at 110 million lbs. at 1s. 3d. per lb., and that of foreign at 60 million lbs. at 2s. Then he makes up four large items thus:—

| Wool | £212,875,000 |
| Wages | £12,723,000 |
| Soap, oil, dyes, &c. | £1,000,000 |
| Profit, interest, wear and tear | £2,000,000 |
| Total | £256,600,000 |

Besides 2,000,000l. worth of woollen and worsted manufactures. So far as regards woolen and worsted mills, and the garments engaged in them, see Factories. Some writers have guessed the total value at 200,000,000l., but this is only a guess. At a recent period, in a woollen factory at Leeds, 570 persons were found to be earning 18s. 11d. per week on an average; namely, men's average 22s. 6d.; women and girls', 6s. 8d. Mr. Baines, in an article in the "Statistical Journal" for 1858, estimated that the woollen manufacturers (without the worsted) use up 150 million lbs. of British and foreign wool, 45 million lbs. of shoddy and mungo, and cotton to the value of 200,000l.; that the value of these fibres is about 15,000,000l.; and that the wages, oil, soap, dyes, profit, interest, rent, and wear and tear, raise the total value to 20,250,000l. He estimates that 150,000 persons were employed in the woollen manufactures in 1858; Mr. M'Culloch estimates 275,000 persons employed in the woollens and worsteds manufactures in the same year. From 1725 to 1820 all the cloths made and sold in the West Riding were measured and stamped by officers appointed for that purpose, and from the returns made, it appears that there were full, in the West Riding, the following number of pieces of broad and narrow cloth, in the years named:—

<table>
<thead>
<tr>
<th>Year</th>
<th>Broad.</th>
<th>Narrow.</th>
<th>Year</th>
<th>Broad.</th>
<th>Narrow.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1725</td>
<td>26,071</td>
<td>8,755</td>
<td>1766</td>
<td>72,757</td>
<td>78,822</td>
</tr>
<tr>
<td>1726</td>
<td>26,071</td>
<td>8,755</td>
<td>1767</td>
<td>72,757</td>
<td>78,822</td>
</tr>
<tr>
<td>1746</td>
<td>56,675</td>
<td>63,775</td>
<td>1768</td>
<td>230,289</td>
<td>175,351</td>
</tr>
<tr>
<td>1766</td>
<td>72,757</td>
<td>78,822</td>
<td>1816</td>
<td>325,244</td>
<td>120,901</td>
</tr>
</tbody>
</table>

The woollens and worsteds exported in 1820, 1830, and 1840, had a value of 5,577,753l., 4,723,662l., and 5,327,852l., respectively. In 1845, 1850, and 1855, the value rose to sums varying from nine to ten millions sterling annually. The figures for the year 1869, given somewhat in detail, will show in what way the manufacture subdivides itself into kinds. The exports in the year just named were as follow:—

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woolen cloth of all kinds</td>
<td>579,135 pieces</td>
</tr>
<tr>
<td>Mixed stuffs, blankets, &amp;c.</td>
<td>93,780 yards</td>
</tr>
<tr>
<td>Mixed stuffs entered at value</td>
<td>£493,526</td>
</tr>
<tr>
<td>Worsted stockings</td>
<td>272,332 dozen pairs</td>
</tr>
<tr>
<td>Worsted strip</td>
<td>291,764 pieces</td>
</tr>
<tr>
<td>Woolen and worsted yarns</td>
<td>349,830 ews.</td>
</tr>
</tbody>
</table>

The value of all these exports exceeded 16,000,000l. The United States were the largest purchasers of the woven goods; the yarn went in greater quantity to Germany.