WOOLLEN AND WORSTED MANUFACTURES. The spinning and weaving of wool was practised from an early period in Asia Minor, Greece, Italy, and some other countries. It is very probable that the first lessons which our ancestors received in this art were got from the Romans after the Conquest; but the origin of the manufacture as a great staple is generally supposed to date from the time of William the Conqueror, when some Flemish weavers came to England, and obtained the patronage of the queen. The trade, however, fell off during the troubles of succeeding reigns. In 1331, it revived again by another supply of Dutch weavers brought over by Edward III. In 1530, the introduction of the spinning-wheel gave a new impetus to the trade. French workmen, driven to England by the revocation of the Edict of Nantes in 1685, still further aided it by their skill in the making of fine cloth, and from that time to the

present it has steadily prospered. It is hardly necessary to state that the woollen trade has shared, in common with other leading textile manufactures, the great advancement they have received from the spinning-jenny, the mule, and the power-loom.

There are two great classes of manufactures using wool as a raw material: in the one where carded wool is employed, the goods are called 'woollen fabrics;' in the other, where combed wool is used, the goods are called 'worsted fabrics.' We shall first treat of the *Woollen Manufacture.*

As our articles on SPINNING and WEAVING are general, we shall here briefly state the chief stages in these processes, as applied to the manufacture of woollen cloth. A fleece of wool is first sorted by experienced sorters into several qualities, as first sort, or 'pick-locks;' second sort or quality; third sort or quality; and so on. Sometimes, it is only divided into three, sometimes into as many as six kinds. The 'scouring' is the next step, and consists in immersing the wool in an alkaline lye, which forms a soap with the natural grease of the fleece. This of course acts as a detergent, and cleans the wool thoroughly when it is washed in water. Upon the perfection with which the scouring is performed, depends in great part the beauty of the dye. It is often dyed at this stage, and is then said to be *wool-dyed;* if not dyed till it is woven, the cloth is said to be *piece-dyed.* For some purposes, it is dyed in the yarn.

Scoured wool, whether dyed or not, next undergoes the operation of 'willying.' The 'willy' is a machine used to cleanse the wool from dust and other loose impurities. In many cases, seeds with hooked scales like burs are so thickly entangled in the wool, that it requires to be passed through a 'burring'-machine, and afterwards examined by 'pickers.' This is especially the case with South American wool, including that of the alpaca. After this, the wool is sprinkled with olive oil, which renders the fibres soft, flexible, and better fitted for later operations. The next process consists in tearing open the matted portions, and separating the wool into small tufts by means of a machine called a *teaser, tucker,* or *devil.* It has a large cylinder studded over with iron pikes, which performs from 1000 to 2000 revolutions per minute, teasing the wool as it revolves, and throwing it out like flakes of snow.

The two next operations are called *scribbling* and *carding,* and are performed by two somewhat similar machines, the essential parts of which will be understood by referring to figs. 6, 7, and 8 in the article SPINNING. Each machine consists of a large cylinder surrounded by several small rollers, all covered with wire cards or brushes. These, acting like fine toothed combs, open out, mix, and blend the fibres into a uniform and continuous sheet or lap, in which state it leaves the *scribbler;* but in the *carder,* the sheet is at length converted into small rolls, say from a quarter to half an inch in diameter, which are afterwards joined together, and form the basis of the thread. In the next machine, called the *slubbing-billy,* these rolls are drawn out, slightly twisted, and, in short, half converted into yarn. The spindles upon which these *slubbs* or *slubbings* are wound pass them to the *spinning-mule,* where they are converted into finished yarn.

Comparatively recent improvements have made the operations of scribbling, carding, and slubbing continuous, mainly through the introduction of Apperly's patent feeder, and of a modification of the carding-machine called a *condenser,* which does away with the use of the slubbing-billy; so that what with the older machines is three separate processes, with the newer may be said to be only one. Each of the foregoing operations occasions a certain amount of 'waste' wool, which is worked up again into inferior goods. It was, in fact, to such waste that the name *shoddy* was originally applied. In the spinning process, the warp yarns, having to bear the strain of the loom, are made in a different way from those for the weft, and they are besides hardened with size.

The difference between woollen and worsted fabrics is owing in great part to the way the yarn for each is spun. Yarn for woollen cloth is very slightly twisted, so as to leave the fibres as free as possible for the felting process; worsted yarn, on the contrary, is hard spun, and made into a much stronger thread. On account of the feebleness of woollen yarn, it is more difficult to weave it by power-looms than either worsted, cotton, linen, or silk.

Woollen cloth is now woven chiefly by power-looms. See LOOM and WEAVING. When the cloth is taken from the loom, it has a bare look, and is called the *raw thread.* It first requires to be *brayed* or *scoured,* to remove the oil added to the wool before spinning, and the size added to the warp. This is done by immersing it in some ammoniacal detergent liquid, such as urine and hog's dung, and squeezing it between rollers, or beating it in the fulling-stocks, and then rinsing it in clean water. The cloth then passes to the *burler,* who removes any knots or burls, and helps any imperfections. The next process to which it is subjected is the *milling* or *fulling,* and it is a very important one. In some mills, this is still done by beating the cloth in the *fulling-stocks,* which are heavy wooden mallets, raised by wheels with projecting cams; but a newer *fulling-machine* has come into use, in which the cloth is felted by passing it in a confined space between heavy rollers. With either machine, a thick solution of soap is used, and in the fulling-stocks an ordinary broadcloth will take 60 hours to mill, but a considerably shorter time suffices in the fulling-machine. The result of the operation is, that the fibres of wool become so interlocked—so thoroughly felted—as to leave no appearance of thread. The shrinkage of the cloth in the milling is sometimes nearly a half in the width, and about a fourth in the length. Another scouring follows the milling, and after that the nap or pile of the cloth is *raised* by Teasels (q. v.). These curious thistle-like heads are set in frames, which are arranged upon a large cylinder—the whole apparatus being called a *gig-mill.* As the cylinder revolves, the spines of the teasels raise the nap, which is afterwards cut by a process termed *shearing.* For this purpose, a cutting-machine with spiral blades arranged round an iron cylinder, is used; and when it revolves, the spiral cutters, acting against a straight steel blade, shear off the nap of the fabric like scissors. The cloth is then boiled, or 'scalded,' to impart a lustre to it, and to prevent spotting with rain. After this it is dyed (if this is not previously done in the wool), and finally it is pressed between polished iron plates in a powerful hydraulic press. With respect to the dyeing of black cloth, it may be as well to explain that the term *woaded colours,* so commonly used in the trade, originally meant that Woad (q. v.) was used in conjunction with indigo as the basis of the colour—a combination which produces the best and most durable colour. Of late years, however, the name has been applied to the colour of the fabric when indigo itself has been used as its basis. It is only the finest cloths that are now dyed in either of these ways—logwood, a salt of iron, and galls being much more generally employed to produce a black.

Names are given to various kinds of woollen cloths according to the style in which they are finished, the special material of which they are made, and the purpose for which they are intended. *Broadcloths* are classed into 'superfines,' running from 54 to 62 inches wide; 'mediums' from 54 to 58 inches; 'double milled' from 54 to 56 inches; and Venetians, which are twilled fabrics, from 54 to 58 inches. The general term broadcloth also includes the following varieties, which, for the most part, have less highly-finished surfaces—viz. meltons, beavers, pilots, cloakings, china striped cloths, India cloths, elastics, lustres, and union cloths which have cotton warps and woollen wefts. *Narrow cloths*, which average about 27 inches wide, include cassimeres, a thin, fine, twilled fabric; doeskin, also twilled, a strong, smooth-finished, sometimes treble-milled cloth, now usually dyed black for trouserings; Tweeds (q. v.), which have very much taken the place of fancy doeskins; and several other varieties. Then there are special kinds both broad and narrow—such as army cloths, rifle cloths, police cloth, upholstery cloth, carriage cloth, coffin cloths, and many more. Flannels, blankets, and some kinds of shawls, are also included among woollen goods.

The public taste has changed very much of late years with respect to the finish of woollen cloths. Formerly, a firm, close, and hard fabric, with a highly-dressed or glossy surface, was in demand; now, a softer and more pliable finish, without gloss, is in favour. Foreign manufacturers think, however, that a soft, rich, elastic cloth is apt to lose in strength what it gains in appearance, and do not finish so highly as the English. The desire for fancy woollens is another marked feature of the taste of the present day, and compels manufacturers to expend considerable sums in the preparation of designs and colours. It has also led to the enlargement of old, and the establishment of new art-schools in both the woollen and worsted centres in Yorkshire.

Of all the changes, however, which the present generation has witnessed in this trade, the most remarkable is doubtless the production of cheap cloths by the use of shoddy; although cotton warps have also done much in the same direction. Prepared shoddy is obtained, for the most part, by tearing up woollen rags by a *swift*, with ten or twelve thousand iron spikes upon it, revolving inside an iron cylinder. Shoddy now enters to a greater or less extent into the composition of all but the very finest woollen cloths. It began to be used about 60 years ago, but the prejudice against it is scarcely yet overcome. In spite of this feeling, it has become so necessary, that to stop the supply, would be to shut one-third of the woollen mills in the kingdom. The excellent finish now given to woollen cloths containing a large proportion of shoddy, and also cloths with cotton warps, is quite surprising; and, moreover, their cheapness has brought comfortable clothing within the reach of the humblest classes. Cloths with too large an amount of shoddy in them are easily torn; but if a judicious admixture of pure wool has been employed, they wear comparatively well. Formerly, the only use of woollen rags was to make flocks for wall-papers, for saddlers' stuffing, and some minor purposes—the greater part being used as manure.

In the British Islands, the various branches of the woollen manufacture are very extensively diffused. According to a factory return made in 1871, it was carried on in 22 counties of England, 12 of Wales, 27 of Scotland, and 16 of Ireland. The principal seat of the manufacture of superfine broadcloth is the west of England—Gloucestershire and Wiltshire especially—where it has existed for centuries. But Yorkshire is the great seat of the woollen manufacture, if we take in all the kinds, Leeds and Huddersfield being the great centres. One-half of all the operatives in the woollen factories of the kingdom are employed in Yorkshire, and here, too, the trade has increased most rapidly, both in the last and in the present century, owing mainly, it is believed, to the success of the manufacturers in producing cheap goods. Blankets are made chiefly at Witney, in Oxfordshire; at Dewsbury, in Yorkshire; and some places in the south of Scotland. Halifax and the surrounding district is the chief centre for flannels, but they are also made largely in Wales. In Scotland, the woollen manufacture is a very extensive one, but it has, for the most part, been already described under TWEEDS.

The following statistics of the woollen industry of the United Kingdom are for the year 1875:

NUMBER AND EFFECTIVENESS OF WOOLLEN FACTORIES.

	Number of Factories.	Total Number of Spindles.	Total Number of Power-looms.
England and Wales—			
Factories employed in spinning,	480	563,512	....
Factories employed in weaving,	45	....	1,875
Factories employed in spinning and weaving, . . .	771	2,248,551	43,150
Factories not included in either of the above descriptions, .	187	....	....
Total, ...	1483	2,812,063	45,025
Scotland—			
Factories employed in spinning,	102	228,119	....
Factories employed in weaving,	40	....	7,326
Factories employed in spinning and weaving, . . .	105	378,444	4,432
Factories not included in either of the above descriptions, .	10	....	....
Total, ...	257	606,563	11,758
Ireland—			
Factories employed in spinning,	35	10,780	....
Factories employed in weaving,	....	....	....
Factories employed in spinning and weaving, . . .	25	30,076	307
Factories not included in either of the above descriptions, .	....	....	....
Total, ...	60	40,856	307
Grand total of woollen factories, . . .	1800	3,459,482	57,090

NUMBER OF OPERATIVES EMPLOYED.

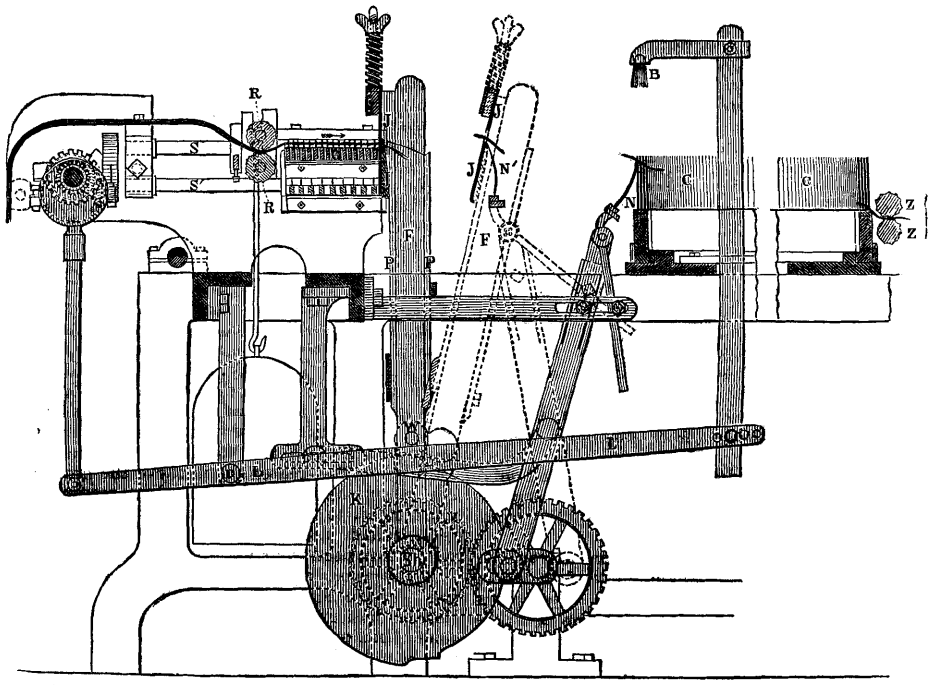
	England and Wales.	Scotland.	Ireland.	Total.
Males—under 13, .	4,391	579	7	4,977
" 13 to 18, .	10,726	2,770	194	13,690
" above 18, .	39,002	8,467	581	48,050
Total, .	54,119	11,816	782	66,717
Females—under 13, .	2,841	446	2	3,289
" above 13,	48,411	15,466	722	64,599
Total, .	51,252	15,912	724	67,888
Total, Males and Females,	105,371	27,728	1,506	134,605

This does not give a full idea of the vast number of persons to whom this great industry gives employment, but only those engaged in spinning and weaving. A very large number are occupied in sorting and stapling, and other operations before the wool goes to the mills and factories, and also in dyeing and scouring it, either as wool or as woollen yarn and cloth; and in many districts much work is done by hand-loom workers in their cottages.

None of these come under the operations of the Factory Act, and are consequently omitted in the returns.

The imports of woollen and worsted yarns (not distinguished in the returns) were in 1861, 1,577,000 lbs.; in 1877, 14,109,586 lbs. The exports of woollen and worsted goods in 1872 and 1877 were as follows: Woollen and worsted yarns, 39,734,924 lbs. in 1872, and 26,972,536 in 1877; woollen and worsted cloths, &c., 385,703,913 yards in 1872, and 238,902,940 in 1877; flannels, blankets, carpets, &c., 26,830,023 yards in 1872, and 23,538,896 in 1877. The total value was £37,028,628 in 1872, and £20,952,659 in 1877. The progress of the woollen manufacture has been less rapid and extensive than that of other textile fabrics, which is believed to be owing to its processes being more numerous and complex, to the greater variety of machines and of workpeople required, and to the high price of the raw material.

Worsted Manufacture.—Worsted yarn, as has been already said, is spun in a different way from woollen yarn. In the former, the fibres are arranged as parallel as possible; in the latter, they are crossed in every direction, so as to assist the felting or milling of the cloth. For worsted the wool is first combed, and this was formerly done by hand-combs, a process which has only recently been entirely given up. The introduction of machines for combing wool has formed quite an epoch in the worsted trade. They are of two kinds—those used for combing long, and those used for combing short wool. Heilmann's machine, made in 1846, was the first which did its work successfully. Lister's machine, now much used for combing long-stapled wool, is an improvement upon Heilmann's. It is shewn stripped of some of its details in the annexed cut. At G there is a series of gill-combs, which, by means of a screw on the upper gill-shaft S, travels from left to right, and as each gill-comb



Wool-combing Machine.

reaches the jaws J, J, it drops to the lower shaft S', which has also a screw. On this the gill-combs travel in the opposite direction, each being in turn raised to the upper gill-shaft by a cam. These gill-combs, which are heated by gas, are thus travelling in a circuit so to speak. The arrangement of toothed gearing by which the movements of the machine are regulated, we shall pass over, and trace the course of the wool. It is fed to the grooved rollers R, R, from which it passes to the gill-combs at G. As each gill travels forward to the jaws J, J, these close, detach from it a 'handful' of wool, and move forward on their frame F to the position shewn by the dotted lines. At the same instant, the carrier-comb N' takes up the position shewn also by dotted lines, lifts from the now opened jaws the 'handful' of wool, and carries it forward to the large circular comb C, into the teeth of which it is pressed by the brush B. The comb C moves slowly round to the right till leather bands and rollers at Z, Z, remove the combed wool or 'top' in a continuous sliver. Another arrangement strips the comb of the 'noil' or short wool.

The remaining processes in worsted spinning closely resemble those for cotton, and are sufficiently described under SPINNING; the products of these are: 1. Fleece (Lincoln wool). 2. Combed 'top.' 3. Noils, or short wool. 4. Sliver from first drawing-frame. 5, 6, 7, 8, 9, and 10. Slubbings from second, third, fourth, fifth, sixth, and seventh drawing-frames. 11. Roving from roving-frame. 12. Spun Yarn.

Figured worsted yarns are woven by various kinds of looms (see JACQUARD LOOM and LOOM); plain kinds are woven in looms like those for woollens. Unlike woollens, when worsted goods leave the loom, they require only a superficial dressing.

Worsted stuffs are usually classified according to the materials of which they are composed, viz.: 1. Fabrics composed entirely of wool. 2. Fabrics

composed of wool and cotton. 3. Fabrics composed of wool and silk. 4. Fabrics composed of wool, silk, and cotton. 5. Fabrics composed of alpaca and mohair mixed with cotton or silk. The *first* of these classes includes the fabrics so well known under the name of 'merinos,' and so called because they were first made of Spanish wool: for the 'double-twilled' kinds, the French still maintain their superiority; but for the 'single-twilled,' the Yorkshire makers are considered the best. This class also comprises shalloons, says, serges, lastings—all stout and heavy fabrics—besides durants, buntings, moreens, damasks, reps, Russells, camlets, and many others, both for dress and furniture. Mousseline de laine was, as its name implies, originally all wool, but it is now more generally mixed with cotton, and printed.

The *second* class includes two fabrics, of which the consumption for female dresses has been immense—viz., Coburg and Orleans cloths, the former being twilled, and the latter plain. Many of the names used in the all-wool class are retained in this, with the addition of the word 'union,' as union merino, union shalloon, union damask, &c. Winceys, now so popular for ladies' winter dresses, on account of their warmth, are made of wool and cotton, from yarns of a heavier and coarser kind than those used for cloths like Coburgs. Winceys are largely made at Aberdeen, Perth, Glasgow, and other places in Scotland, as well as in Yorkshire.

The *third* class includes the rich Poplins (q. v.) and Tabinets (q. v.), made chiefly in Dublin, and giving employment there to about 1200 hands. Paramatta or Henrietta cloth, Canton cloth, and others, are made both of silk and wool, and cotton and wool. Some Coburgs, Orleans, Russells, and Damasks are likewise made with silk warps.

The *fourth* class—viz., mixed goods, in which silk, wool, cotton, and sometimes linen are used—includes peculiar kinds of some of the fabrics named above, and also vestings, linings, cravats, shawls, scarfs, quiltings, boot and shoe cloths, barèges, &c.

The *fifth* class includes alpaca lustres and mixtures—plain, twilled, and figured; alpaca poplins, umbrella and parasol cloth; mohair lustres, glacés, Verona serges, barèges, &c.

The term 'worsted' is said to have derived its origin from a village of that name in Norfolk, where this manufacture was first carried on. Up to the end of last century, worsted goods were a staple trade of Norwich; but the neglect of the factory system there led to its being transferred to Bradford, which has become renowned as the metropolis of the worsted manufacture. It is also extensively carried on at Halifax and other places in Yorkshire.

The following statistics of the worsted manufacture are gathered from the government inspectors' reports for 1875, and refer to that year:

NUMBER AND EFFECTIVENESS OF WORSTED FACTORIES.

Divisions.	Number of Factories.	Number of Spindles.	Number of Power-looms.
England and Wales—			
Yorkshire, . .	520	1,981,086	65,739
Other counties, .	128	147,804	9,802
Total, . .	648	2,128,890	75,591
Scotland, . . .	43	53,330	6,156
Ireland, . . .	1	572	....
Total—United Kingdom,	692	2,182,792	81,747

NUMBER OF OPERATIVES EMPLOYED.

	England and Wales.	Scotland.	Ireland.	United Kingdom.
Males—under 13, .	14,074	95	..	14,169
" 13 to 18, .	10,694	564	1	11,259
" above 18, .	29,227	2,393	2	31,622
Total, .	53,995	3,052	3	57,050
Females—under 13,	15,394	265	..	15,659
" above 13,	62,441	6,938	9	69,388
Total, . .	77,835	7,203	9	85,047
Total, . .	131,830	10,255	12	142,097

The same remarks apply here as in the case of the return of persons employed in the woollen manufactories, given under that head, and with still greater force, for there are a very great number of small trades connected with the worsted manufacture. As the numbers at the top of page 267 shew, the imports of both worsted and woollen yarns have greatly increased of late years, and is no doubt greatly owing to the ingenuity of the Belgians in spinning good yarns from cheap wools, Belgium being the country from which by far the greater portion comes. In 1877, woollen and worsted cloths to the value of about £5,236,000 were imported.

With respect to the exports, the following will shew the increase which has taken place from 1860 to 1874: 1860—Worsted yarn, 26,455,000 lbs. (£3,578,000); worsted stuffs, 148,685,000 yards (£7,013,000). 1865—Worsted yarn, 30,221,000 lbs. (£5,074,000); worsted stuffs, 233,078,000 yards (£13,361,000). 1874—Worsted yarn, 34,263,916 lbs. (£5,472,612); worsted stuffs, 261,135,081 yards (£11,888,072). In 1877, the exports had seriously declined—worsted yarn, 26,972,536 lbs. (£3,609,456); worsted stuffs, 194,777,034 yards (£7,725,414).

The rapid increase of the worsted manufacture as compared with the woollen, is no doubt to be ascribed to the greater simplicity of the processes, to the recent introduction of combing-machines, but most of all to the introduction of cotton-warps in 1835, which not only cheapened the goods, but vastly increased their variety.

Information regarding such special branches of the woollen and worsted industries as carpets, shawls, hosiery, tartans, bonnets, &c. will be found under their separate heads. We may state here that the Scotch bonnet-trade, carried on at Kilmarnock and Stewarton, employs from 2000 to 3000 hands, and sends out about 500,000 bonnets annually.