

rection of its root; for the skin, while moving towards the tip of the hair, slides freely upon it, but, moving in the other direction, against the inclination of the barbs, it brings the hair with it. It will be easily understood that when a number of hairs are pressed together those which lie in opposite directions to each other and in contact will interlock at these barbs or teeth and thus resist any effort to tear them asunder. When once this close contact and interlocking is established between any two or more hairs, they remain attached, but the others that are differently arranged, or not in contact, will still be free to move upon each other; and therefore, if subjected to continual blows, pushing, and pressure, the unattached hairs will be continually shifting until they reach others in suitable positions for clinging together, either by crossing obliquely or by lying in the same line and overlapping at their ends or any other portion. When the hair has a natural tendency to curl, the felting is still more readily brought about by the additional interlacing. Although the felting property is possessed in a preëminent degree by wool, it belongs to the hair or fur of other animals, including the goat, ox, hare, rabbit, and beaver.

The first mechanical process for the production of felt was invented by J. R. Williams, an American, about 1820. Many patents have since been taken out for the various details of felting machinery, but the main principle is the same in all. The wool is carded more or less perfectly into laps of the length and breadth of the web to be made. One layer of these laps is placed upon another to secure the desired thickness of the fabric, and the two outside layers are often of a finer quality than the interior. The bulky sheet is now passed between rollers which are partly immersed in water, and some of them are heated internally with steam. The material is subjected to a beating and oscillatory motion as well as to pressure. The completed fabric is dyed and finished like ordinary cloth. The details of manufacture were at one time strictly guarded trade secrets, each factory having its own processes and specially made machinery.

Felt is used for many purposes. It is employed as a covering for floors and as an upholsterer's material. It is made up not only into hats, but into cloaks and other garments. Carriage linings, polishing cloths, pianoforte hammers, surgical dressings, and many other objects requiring a soft, thick cloth are made from felt. The felt used for women's hats is cut from the piece, but that employed in the manufacture of men's hats is made in special shapes. The material used for men's hats is usually the fur of raccoons, beavers, or rabbits, mixed with some good felting wool. See HATS.

Various fabrics which are technically known as felt, and which possess in greater or less degree the qualities of this material, are manufactured for use in different industries. In these coarse grades of felt cow's hair is often an important ingredient. The felted sheathing used as a nonconducting covering for retaining the heat of steam boilers is a substance intermediate between felt and paper. It is made from woollen refuse and other cheap materials reduced to pulp, beaten and dried. *Lining and roofing felts* are used in the construction of buildings and act as nonconductors of heat and sometimes of moisture and sound. Such felts

**FELT** (OHG. *filz*, Ger. *Filz*, OChurch Slav. *plüsti*, felt; probably connected with OHG. *falz*, Ger. *Falz*, fold). A fabric formed without weaving by taking advantage of the natural tendency of the fibres of hair and wool to interlace with and cling to each other. As to the origin of the knowledge of felt making, its beginnings antedate by many centuries the Christian era, and the fabric is mentioned by the earliest writers. In fact, St. Clement is the patron saint of the felt makers, since he was said to have put carded wool between his feet and the soles of his sandals at the beginning of a journey and found it transformed into cloth at its end. On account of greater simplicity of its structure, it is probable that felt was made long before the art of producing cloth by spinning and weaving had been discovered.

The felting quality of fibres of hair or wool results from their structure. When examined by the microscope, the hair of all animals is found to be more or less jagged or notched on its surface; in some animals it is distinctly barbed; and this structure is so directed that the teeth or barbs all point towards the tip of the hair. If a piece of human hair (in which this structure is less marked than in most animals) be held between the finger and thumb, and rubbed in the direction of its length, it will invariably move between the fingers in the di-

are made chiefly from coarse animal fibres, such as cow's hair, with varying proportions of mill waste, and incorporated with pitch or asphalt.

The *asbestos lining* and *roofing felt* is made of pure asbestos, saturated with asphalt, the body fibre in certain brands containing no organic matter. The process of manufacture is similar to that employed in making paper. *Paper-maker's felt* is not a true felt, but a coarse, loosely woven material which has been neither teased nor spun. Little detailed information regarding the manufacture of felt appears to be available in printed form, and such references as can be found are scanty and, for the most part, were written long ago. An interesting chapter on "Felt and Felting" will be found in Murphy, *The Textile Industries*, vol. ii (London, 1912).

**Statistics.** According to the thirteenth census of the United States, there were in the country, at the end of 1909, 43 establishments devoted to the manufacture of felt goods, producing goods valued at \$11,852,626. The principal products were felt cloths, boot and shoe linings, upholstery felts, trimmings and lining felts, felt shirts, and endless belts for paper manufacture.