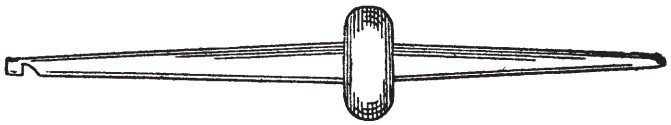
SPINNING (from O. Eng. *spinnan*, to spin, cf. Ger. *spinnen*, &c., the Teut. root is *spen*, to draw out, cf. span, spider), the forming of threads by drawing out and twisting various fibres. There is ample evidence of the great antiquity and wide diffusion of the art of spinning, for spinning necessarily precedes weaving (*q.v.*) whenever short fibrous materials have to be made into threads, and weaving is one of the primal and most universal employments of mankind. Either remains of implements employed in spinning, or spun threads, are found wherever traces of prehistoric man make their appearance. The simple spinning apparatus which was used in the earliest ages continued to be used by civilized communities till comparatively recent times, and it may therefore be said that no art which has been so long and widely practised remained so unprogressive as that of spinning. On the other hand, since about the middle of the 18th century, when human ingenuity bent itself in earnest to improve the art, there have not been developed in the whole range of mechanical industries machines of greater variety, delicacy of action, and manifold productive capacity than those now in use for spinning.

The primitive thread-making implement consisted of a wooden spindle, from 9 to 15 in. long, which was rounded and tapered at both extremities, as in the accompanying figure. Near the



Primitive Spindle.

top there was usually a notch in which the yarn was caught while undergoing the operation of twisting, and lower down a whorl, or wharve, composed of a perforated disk of clay, stone, wood, or other material was secured to give momentum and steadiness to a rotating spindle. Long fibres were commonly attached to a distaff of wood, which was held under the left arm of the operator, but short fibres were spun from carded rolls. After attaching some twisted fibres to the spindle, a rotatory motion was given to the latter either by rolling it by hand against one thigh, or by twirling it between the fingers and thumb of the right hand, after which the fibres were drawn out in a uniform strand by both hands and converted into yarn. When the thread was of sufficient strength, the spindle was suspended by it until a full stretch had been drawn and twisted, after which that portion was wound upon the body of the spindle, and the operation continued until the spindle was filled. The quantity thus rolled up gives the name to a now definite measure of linen yarn, namely "the spindle," or 14,400 yards. Simple as was this primitive apparatus, a dexterous spinner could produce yarn of an evenness, strength and delicacy such as has scarcely been exceeded by elaborate modern appliances. The yarns for the gossamer-like Dacca muslins of India were so fine that 1 lb weight of cotton was spun into a thread nearly 253 m. long. This was accomplished with the aid of a bamboo spindle not much bigger than a darning needle, and which was lightly weighted with a pellet of clay. Since such a tender thread could not support even the weight of so slight a spindle, the apparatus was rotated upon a piece of hollow shell. The spindle as here described was, so far as is

known, the sole apparatus with which yarn was spun until comparatively recent times.

The changes in modern spinning have had for their object: (1) the providing of mechanical means to rotate the spindle, (2) an automatic method of drawing out the fibres, and (3) devices for working a large group of spindles together, at speeds before unattainable.

The first improvement consisted in cutting a ring groove in the wharve, mounting the spindle horizontally in a frame, and passing a band from a large wheel round the wharve. A rotatory motion was then given to the spindle by turning the wheel with the left hand. After attaching the filaments to the spindle they were attenuated with the right hand, and when fully twisted the thread was moved to form a right angle with the spindle and coiled upon it. Such a wheel has long been known in India, and from a drawing in a 14th-century manuscript in the British Museum it is obvious that it was not unknown, although far from being in general use, in Europe at that early date. It came ultimately to be known in England as the "bobbing wheel," and was in constant use down to the beginning of the 19th century for spinning coarse and fine yarns. But fine yarns received two spinnings; the first consisted in drawing out and slightly twisting the fibres into what is still known as a roving, and by the second spinning the roving was fully attenuated and twisted. In 1533, a citizen of Brunswick is said to have cranked the axis of the large wheel and added a treadle, by which the spinner was enabled to rotate her spindle with one foot and have both hands free to manipulate the fibres.

It is not possible accurately to fix the dates at which all improvements in spinning appliances were made; it is certain that many were known and used long before they were generally adopted. Thus the flyer, which twists yarn before winding it upon a bobbin, is shown in a drawing by Leonardo da Vinci, together with a device for moving the bobbin up and down the spindle so as to effect an even distribution of the yarn. During the 16th century a machine of the foregoing type was widely used, and came to be known as the Saxony wheel. It changed spinning from an intermittent to a continuous operation. The spindle had affixed upon its outer end a wooden flyer, whose forked legs were far enough apart to enclose a double-flanged spool, and at short intervals bent wires, known as the heck, were inserted in each leg for the purpose of guiding the thread evenly upon the spool. This spool was loosely threaded upon the spindle and one of its flanges was grooved to take a driving band from the large wheel, hence the spindle and the spool were separately driven, but the former at a higher speed than the latter. The twisted filaments were drawn through an eye in the flyer, led along one of its legs, and made fast to the spool. By operating the treadle the flyer twisted all the fibres about a common axis once for each revolution, and the spool wound up the length thus spun: the thread being slipped from tooth to tooth of the heck at regular intervals to direct it evenly across the spool. During the 17th century a second and similar spindle and flyer were added, and these left the spinner free to manipulate one thread with her right, and another with her left hand. It was in this condition that the most advanced form of yarn-making was carried on until a great series of inventions revolutionized spinning, and laid the foundations of the factory system which now prevails.

The remaining part of the problem which lay before inventors was to draw out masses of parallel fibrous material, and twist them into uniform strands by mechanical means. The first stage in the evolution of mechanical spinning was effected by the invention of Lewis Paul, of Birmingham, who obtained a patent in 1738, and who was assisted by John Wyatt. The essential features of this invention consisted in passing carded slivers between pairs of parallel rollers, each succeeding pair of which moved faster than the preceding pair, to attenuate the sliver to the required extent. From Paul's specification it would appear that he attempted to turn the rollers about their horizontal and vertical axes simultaneously, in order to draw out the fibres and twist them at one operation. But he also mentions a plan for which he procured a patent twenty years later, namely, the use of only one pair of rollers working in conjunction with a bobbin which drew off the thread faster than the rollers delivered the sliver, and coiled the thread about itself. The bobbin, therefore, attenuated, twisted and wound the material. Neither plan proved a commercial success. Thomas Highs, of Leigh, and others, laboured upon the problem, but it was left to Richard Arkwright, a barber, of Preston and Bolton, to achieve what his predecessors vainly struggled for. He obtained patents, in 1769 and 1775, for a machine which was subsequently known as the water-twist frame by reason of water-power being applied to drive it. Arkwright's first machine did not contain any really new feature, for it consisted of Paul's drawing rollers, and the spindle, flyer and spool from the Saxony wheel, but the spindles and rollers were grouped in sets of four. Later the water-twist frame was changed into the "throstle" frame, which in turn has almost ceased to be used. In 1829 C. Danforth (1797–1876), an American spinner, invented a dead spindle, on the top of which he placed a hollow cap to serve as the winding point, and inside the cap he rotated a spool: a plan still used by worsted spinners. In 1828 Mr Thorpe, also an American, invented the ring spinning frame, whose principal feature consisted in the substitution for the flyer of a flanged annular ring, and a light C-shaped traveller. By means of the traveller a thread was held in the best position for winding upon a spool, as well as put under the necessary tension. Later inventors have so altered the construction of the ring, traveller and spindle that a speed of upwards of 11,000 revolutions per minute can now be attained. This represents the highest development of continuous spinning.

Whilst endeavours were being made to perfect continuous spinning, attention was also directed to perfecting the intermittent process as represented by the bobbing wheel. Between the years 1764 and 1767, James Hargreaves, of Standhill, invented the spinning jenny, by the aid of which sixteen, or more, threads could be spun simultaneously by one person. All the spindles were placed vertically and rotated from a drum, but the rovings were mounted in a movable carriage and passed between a clamp that opened and shut like a parallel ruler. After securely clamping the rovings and attaching them to the spindles, the carriage was drawn out slowly by one hand and the spindles revolved by the other. The rovings were thus stretched to the proper degree of tenuity, and sufficiently twisted. This was followed by the inward run of the carriage, when the stretch of spun threads was wound upon the spindles, and the operation repeated. Hargreaves therefore returned to the first principles of spinning, namely, simultaneous drawing and twisting. But although the jenny gave a greatly increased output, it was ill adapted for fine spinning. During the years 1774 to 1779, Samuel Crompton, of Bolton, combined, in the mule, the drawing rollers of Paul with the stretching of Hargreaves. But his rollers did not fully attenuate the rovings before twisting them, as is the case with continuous spinning, neither was stretching alone relied upon. From its introduction this machine was able to spin finer and more elastic threads than any of its rivals, but for a time the preparation of suitable rovings was a source of great trouble. The immediate consequence of the decision of the court of King's Bench, in 1785, to throw open to the public Arkwright's preparatory machinery, was to enormously increase the usefulness of the mule. Since Crompton's time a host of inventors have laboured to render all parts of the mule thoroughly automatic; this has led to many changes and additions, but none of its essential features have been discarded. The inventions of Paul, Arkwright, Hargreaves and Crompton are at the foundations of all modern systems of spinning; details regarding them are given in the article on COTTON-SPINNING MACHINERY. (T. W. F.)