his double chain-stitch action, which formed the basis of the Grover & Baker machine. In 1856 James A. E. Gibbs (1829- 1902), a Virginia farmer, devised the chain-stitch machine, im­proved subsequently by J. Willcox and now known as the Willcox & Gibbs. These together—all American inventions—form the types of the various machines now in common use. Thousands of patents have been issued in the United States and Europe, covering improvements in the sewing machine; but, although its efficiency and usefulness have been greatly increased by numerous accessories and attachments, the main principles of the various machines have not been affected thereby.

In machine sewing three varieties of stitch are made—(1) the simple chain or tambour stitch, (2) the double chain stitch and (3) the lock stitch. In the first variety the machine works with a single thread; the other forms use two, an upper and an under thread.

The structure of the chain stitch is shown in fig. 3. The needle first descends through the cloth, then as it begins to ascend the friction of the thread against the fabric is sufficient to form a small loop into which the point of a hook operating under the cloth plate enters, expanding and holding the loop while the needle rises to its full height. The feed then moves the fabric forward one stitch length, the hook with its loop is also projected so that when next the needle descends its loop is formed within the previous loop. The hook then releases loop No. 1, seizes and expands loop No. 2, and in so doing draws up the previous loop into a stitch, chain-like on the under side but plain on the upper surface of the fabric. The seam so made is firm and elastic, but easily undone, for if at any point a thread is broken the whole of the sewing can be readily run out backwards by pulling the thread, just as in crochet work. To a certain extent this imperfection in the chain-stitch machine is overcome in the Wilcox & Gibbs machine, in which each loop, by means of a rotating hook, is twisted half a revolution after it has passed through its predecessor. The somewhat complicated course of the threads in the double chain stitch of the Grover & Baker machine is shown in fig. 4. The under thread was supplied from an ordinary bobbin and was threaded through a circular needle of peculiar form. The machine was wasteful of thread, and the sewing formed a knotted ridge on the

under side of the fabric.

The lock stitch is that made by all ordinary two-thread sewing machines, and is a stitch peculiar to machine sewing. Its structure is, as shown in fig. 5, very simple, and when by proper tension the threads interlock within the work it shows the same on both sides and is very secure. When, however, the tension on the upper thread is weak, the under thread runs along the surface as at *b,* held more or less tightly by the upper loops. It will be seen that to make the lock stitch the under thread has to be passed quite through the loop of the upper thread. That is done in two principal ways. By the first

plan a small metal shuttle, holding within it a bobbin of thread, is carried backward and forward under the cloth plate, and at each forward movement passes through the upper thread loop formed by

each succeeding stroke of the needle. Such is the principle devised by Hunt, introduced by Howe, and improved by Singer and many others. The second prin­cipal method of forming the lock stitch consists in seizing the loop of the upper thread by a rotating hook, expanding the loop and passing it around a stationary bobbin within which is wound the under thread. The method is the invention of A. B. Wilson, and is known generally as the Wheeler & Wilson principle. The rotary hook seen at *b,* fig. 6, is so bevelled and notched that it opens and expands the upper thread loop, causing it quite to enclose the bobbin of under thread, after which it throws it off and the so-formed lock stitch is pulled up and tightened either by an independent take-up motion as in later machines, or by the expansion of the next loop as in the older forms. The bobbin A, lenticular in form, and its case B, fig. 6, fit easily into a circular de­pression within the hook, against which they are held by the bobbin holder *a,* fig. 6.

Intermediate between the shuttle and the rotary-hook machines is the oscillating-shuttle machine introduced by the Singer Co. The shuttle is hook-formed, not unlike the Wilson hook, and it carries within it a capacious circular bobbin of thread *h,* fig. 7. This shuttle

is driven by an oscillating driver *db* within an annular raceway *α a,* and, instead of revolving completely like the Wilson hook, it oscillates only in an arc of 150°, so far as serves to catch and clear the upper thread. The oscillating-shuttle and rotary-hook machines work with great smoothness and rapidity.

Sewing machines are now made in hundreds of varieties for special kinds of work. Some, for example, are capable of performing the

most complicated operations in ornamental stitching, a horizontal right and left motion, in addition to the ordinary vertical motions, being for this purpose often imparted to the needle bar; others will sew button-holes at the rate of 8 or 10 a minute; while others again will sew on the buttons, making the required number of stitches, stopping automatically with the needle at its highest point, and cutting the threads off close to the underside of the work. In some cases two or more needles are fitted, producing parallel rows of stitches; with a machine having 12 needles a single operation may make as many as 24,000 stitches a minute. Special forms of machine are designed to meet the requirements of the glove-sewer, the umbrella-maker, &c. In sewing carpets the great weight of the material makes feeding difficult, and therefore machines have been invented that move along the carpet, which itself remains stationary. The earlier forms were hand-worked ; the two lengths of carpet were stretched across the room, and the machine travelled along the seam, followed by the operator, who turned it by means of a hand- crank. One of these machines was capable of doing the work of eight or ten hand-sewers. With later forms, operated by electricity or

other power and running along a track, the carpet is stretched and sewed so rapidly that one power machine does the work of eight or ten hand machines. The introduction of sewing machines has re­volutionized the boot and shoe industry, and books are stitched by machine, the Brehmer wire-sewing machine and Smyth thread-sewing machine being prominent representatives of this class.

SEX (Lat. *sexus;* possibly connected with *secure,* to cut), the character of being either male or female, which can be attributed to the vast majority of animals, but less correctly to the higher plants, where the so-called male and female organs, or flowers, are part of the sexless generation (see Reproduction: *Plants).* The primary distinction of sex resides in the essential organs of reproduction (*q.v*.)*.* An organism that contains the germinal tissue or mass of tissue known as the testis, and producing the