LOOM (AS. *ge-loma*, tool, instrument, frame). The frame that holds the warp threads parallel and taut for the weaver. The frame of *real-tapestry looms* consists of two rollers, the warp beam and the cloth beam, mounted several feet apart, on uprights in a high-warp loom and on horizontals in a low-warp loom. (See TAPESTRY.) As the weaving progresses the rollers are turned at intervals so that the finished cloth is wound up on the cloth beam and the warp threads unwound from the warp beam. This is the essential basis of nearly all looms, and from such a frame have been developed the most complicated damask, brocade, and lace looms. Simpler forms of the loom have the warp wound over crosspieces that do not revolve, or, as on the high-warp loom shown in the famous ancient Greek vase painting of Penelope and Telemachus, have the warps weighted at the lower end instead of attached to a roller. While the warp of parallel taut threads is an essential feature of all looms, the manner in which the weft or filling is interlaced with, or woven across, the warp varies greatly. In *real-tapestry* and on many primitive looms the bobbins on which the weft is wound are passed by hand. These are *bobbin looms*, as contrasted with *shuttle looms*. The shuttle is a pointed box or case carrying the bobbin, and devised in order to make it easy to throw or knock the weft the full width of the loom. In *bobbin looms* the weft is ordinarily passed only a short distance; in tapestries, only as far as the particular block of color extends. Bobbin looms are themselves divided into two important classes: *treadle looms* and those without a treadle. The latter are usually called *high-warp looms*. In high-warp looms the shed, or separation between the warps, is effected by pulling leashes with the left hand. In treadle or low-warp looms the separation of the warps is effected by leashes attached to treadles, thus making a hand-foot loom instead of an all-hand loom, and leaving the hands entirely free for the manipulation of the weft. Two treadles, however, divide the warps into only two groups, restricting the product of the loom to *plain weaves* only (see WEAVING), some flat like etamine, others ribbed like real tapestry. As the number of treadles is increased more separate warp groupings or combinations can be effected, and twills are produced without difficulty. But for damasks and complicated weaves still further invention was necessary. So the weaver was given an assistant who pulled cords controlling the different groups of warp threads. This is the *draw loom*. The *Jacquard attachment* described later is the machine that took the place of the *drawboy;* it is used on both hand and power looms when the warp combinations are complicated. Classified historically and by order of development the different types of loom are *bobbin, treadle, shuttle, draw, Jacquard*, and *power*.

In the ordinary *hand loom with shuttle*, illustrated in Fig. 1, two rollers, 1, 2, are placed one at each end of the *frame*, *AAAA*, so that they will readily turn on the axes; and from one to the other the threads of the warp, *X*, are stretched after having been drawn through the eyes of the *heddles*, *Z*, of the loom harness, *BC*, and the *reed*, which is a frame suspended from the batten, 3, and are kept tight by weights, *g*, *g*. If the cloth to be woven is to be a plain cloth—i.e., one in which every second warp thread is above the filling thread, while the alternate threads are below and the positions of the warp threads are reversed for the next filling thread—then two heddle frames or harnesses are required and the warp threads are drawn through the eyes of the heddles, threads one, three, five, etc., being arranged on the first of the two harnesses while the threads two, four, six, etc., are arranged on the second. After being drawn in the harness the threads are reeded—i.e., passed through the interstices of the *loom reed* in pairs, and the reed to be used is the one to give the correct number of warp threads wanted to the inch in the finished fabric; it will hold these threads at a uniform distance apart for the full length of the warp during the process of weaving. The *loom harness* is suspended from a roller, 5, placed at the top and near the front of the loom frame, and each is fastened to one of a pair of treadles, *DD*, directly beneath; the weaver depresses first one treadle, which pulls down the harness frame with which it is connected and simultaneously raises the second harness frame with its attached treadle, separating the warp threads and forming a *shed*, *S*, as above described. The shuttle is thrown through the shed either by the hand of the weaver or by a quick jerk imparted to it from the weaver's hand by a combination of straps and springs. After the shuttle has deposited the filling in the shed the reed, which is held firmly in a frame swinging from above, called a *batten*, 3, is forced quickly by the hand of the weaver pressing the filling in place; the second treadle is now depressed while the heddle frames reverse their former position, changing the relative position of the warp threads, and the shuttle is passed through the new shed and the filling is again beaten up.

In the eighteenth century a series of inventions started a revolution in the art of weaving. The first was a mechanical arrangement to throw the shuttle, instead of the weaver's hand. In 1733 John Kay, of England, invented a device known as the flying shuttle and picking stick, by which the shuttle received a blow and was driven through the shed, and after the

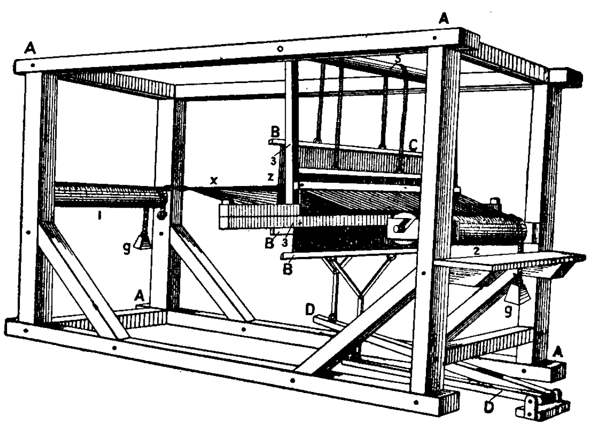

FIG. 1. HAND LOOM.

shed had been changed was struck in a similar way at the other end and driven back. By this invention a much more rapid motion was obtained than was possible with the hand shuttle.

At the time of the introduction of the flying shuttle the loom was supplied with a *shuttle box* at each end of the *batten;* these *shuttle boxes* are receptacles which receive the shuttle as it is driven across and release it as it is driven back into the box at the opposite end; they are placed on a level with that part of the batten called the shuttle race and can receive but one shuttle at a time, so it is obvious that should the weaver wish to introduce more than one color of thread in the filling, the loom must be stopped in order to change shuttles for each change of filling. In 1760 Kay invented the *drop box,* an attachment consisting of a tier of shuttle boxes, one above the other. The several compartments of the drop-box attachment could be filled with shuttles, each containing a different color of filling, and when a certain color was wanted the box, or compartment, containing that color could be brought to the level of the shuttle race and the shuttle driven across and back until another color was wanted. The modern *box loom,* or loom having more than one box (as the *single-box* loom has) at each end of the *lathe,* as the batten is now generally called, may have two, four, or six

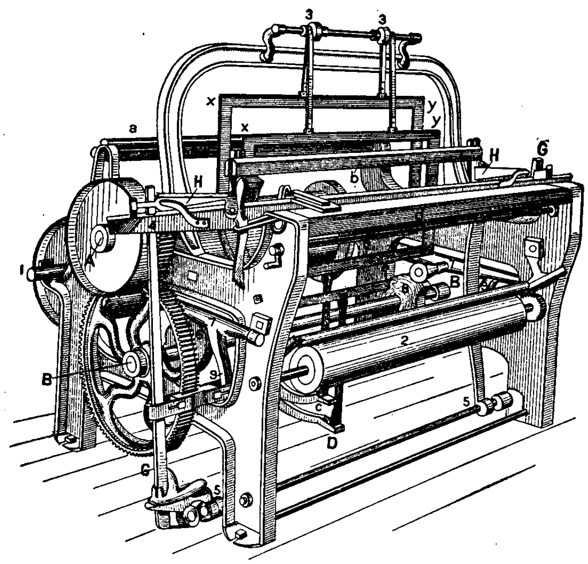

FIG. 2. POWER LOOM.

boxes at one end and one at the other, or two, three, or four boxes at each end; the latter are called *pick-and-pick* looms, as the shuttle may be sent across for a single pick of one color and changed at the opposite end for one with a new color, while with a loom having one box at one end it is readily seen that only multiples of two threads of filling can be used no matter how many boxes are at the opposite end, the shuttle being obliged to cross and return before the color can be changed by the drop box.

The first successful *power loom* was invented in 1785 by Edmund Cartwright (q.v.). Several unsuccessful attempts had previously been made to produce a practical power loom; early in the seventeenth century there is reported to have been set up in the city of Danzig "a rare invention for weaving four or five webs at a time without any human help." This mechanism and its author met the fate of many later inventors, for it is further recorded that "the invention was supprest because it would prejudice the poor people of the town and the artist was made away secretly." In 1778 another power loom was constructed by a Frenchman named De Gennes, which possessed many of the features of the modern loom; but it never came into practical use. In 1762 a power loom was set up in a weaving mill in Manchester, but it proved a failure.

Cartwright's first loom was crude, especially as the inventor was unacquainted with practical mechanics or with the art of weaving; but he continued his efforts until he produced a satisfactory machine. In this pursuit he spent all his time and money, and, as it did not come into general use until his patents had expired, he received no financial return for his labors. In 1808, however, Parliament voted him £10,000. It was said that he spent fully four times that sum in perfecting his loom.

During the century after Cartwright's invention the development of the loom received the attention of hundreds of inventors, and at the beginning of the twentieth century we find a vast number of different types in operation, all embodying, however, the fundamental principles of the original.

The simplest type of modern power loom is shown in Fig. 2. The *loom frame* supports two horizontal shafts, *A*, *B*, one above and a little back of the other and so geared together that the upper shaft, to which the power is applied, makes two revolutions to one of the lower. The upper shaft is supplied with two cranks, one at each end, near the frame, to which the *lathe,* 4, is attached with short connecting rods, and as the shaft revolves it imparts to the lathe a reciprocating motion as the latter swings on the pivot, 5, 5, at the bottom of the loom frame. The lower shaft is supplied with certain attachments called cams, near the centre, which work in contact with the *loom treadles, C, D;* the latter are connected to the harness frames, *xy*, *xy*, suspended from a roller, 3, 3, above, and as the shaft revolves first one is depressed and then the other, forming sheds with the warp as in the hand loom. The lower shaft is also supplied with certain appliances, 6, 6, which act on two special *rocker shafts,* 7, 7, one at each end of the loom, placed at right angles to and in a horizontal plane above the lower shaft and each having an arm, 9, to which is connected a *picker stick, G, G;* these picker sticks are so arranged that when the lower shaft revolves the action on the short rocker shafts causes the picker stick on one side to be jerked quickly towards the warp which is being woven and to throw the shuttle from that side of the loom through the shed into the *shuttle box, H, H,* at the opposite end, where it remains until the filling is beaten up by the action of the lathe, and the harnesses change position, forming a new shed, when the second picker stick is acted on as was the first and the shuttle is driven back to its former position and the operation is repeated continuously.

In this loom the warp is not stretched directly from the *warp beam,* 1, to the *cloth roll,* 2, as in the hand loom, but is carried upward at an angle from the warp beam over a support called the *whip roll, a,* from which it is stretched, through the harness and reed—which are held firmly in the lathe by the *handrail, b*—to the *breast beam, d,* over which the cloth passes downward to the cloth roll; it will be seen that by this arrangement the loom is made to take up much less space than it would in any other form. The modern power loom also combines a number of appliances which were made necessary by the application of power and which make it possible for the weaver to keep a number of looms running, while the hand weaver could run but one. Of these special attachments may be mentioned the *filling stop motion*, which automatically causes the loom to stop should the filling become exhausted in the shuttle or break; the *shuttle protector*, which is so arranged that should the shuttle for any reason fail to reach its place in the shuttle box to which it has been driven, the loom is stopped and held so that the lathe will not cause any of the warp threads to be broken should the shuttle happen to be caught in the shed and the loom not stop; the automatic *take-up* and *let-off motions*, which let the warp unroll from the warp beam at the required speed and wind up the woven cloth automatically, regulating the number of filling threads to the inch. There has also recently been perfected the *warp stop motion*, which is arranged to act on the driving motion of the loom and to cause the loom to stop immediately should one of the threads of the warp become broken.

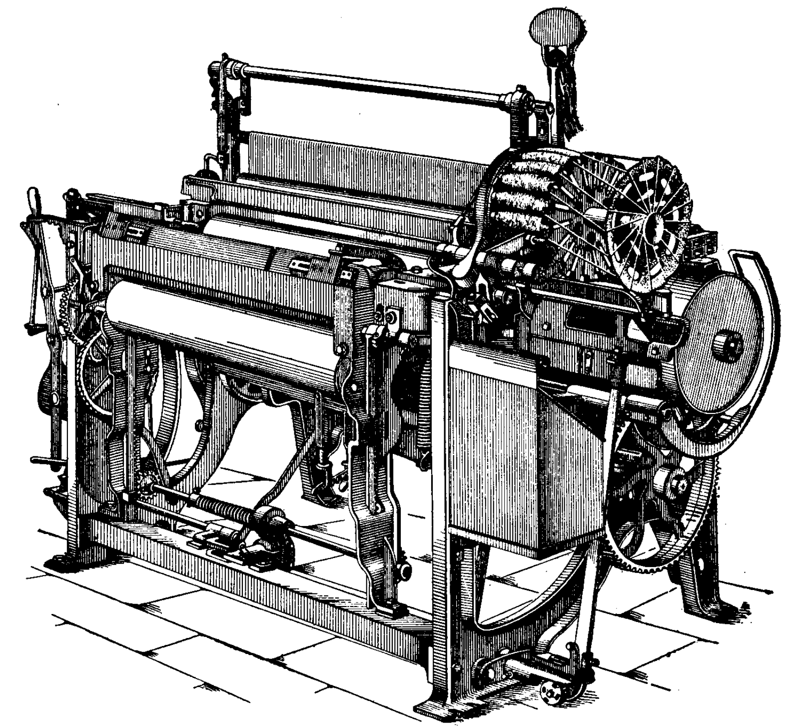

Fig. 3. NORTHROP LOOM.

In the *Northrop loom*, Fig. 3, the loom shuttle and one of the shuttle boxes are made without any bottom, and above this shuttle box is arranged a magazine or hopper, kept supplied with a large number of full bobbins; as the filling in the shuttle runs out, the mechanism of the loom so acts on one of the fresh bobbins of yarn that it is forced downward into the shuttle and in turn forces the empty bobbin out through the holes in the bottom of the shuttle and the shuttle box, and the loom continues to run as if no change had been made.

Looms for fabrics which require not more than five harnesses to produce the weave are generally called *cam looms*, for the reason that the harness is operated by the action of cams on the loom treadles. For fabrics which require more than five harnesses special *fancy looms* are arranged; these usually have a *head motion*—a mechanism which regulates the pattern to be woven and may control the movement of as many as 30 harnesses; *dobbies* and *witches* are special head motions.

The Jacquard attachment, Fig. 4, invented by Joseph Marie Jacquard (q.v.), may be applied to almost any style of loom and is simply a head motion to control the loom harness and to form the shed. It consists of a set of perpendicular *hooks, AB, AB*, connected with and controlled by a set of horizontal *needles, C, C;* above these hooks—which are placed in 4, 6, 8, or 12 rows to the machine, which may have from 200 to 1200 or more hooks—is a set of knives, 1, 1, called a *griffe*, with one knife for each row of hooks. To the lower extremity of each hook is attached a loop of twine called the *neck cord, d*, which is passed through the *bottom board*, 2, 2, having perforations immediately under each hook; from the neck cords hang the *leash strings, E, E*, and there may be from one to half a dozen of these to each hook. These leash strings are passed through a board placed horizontally a little above the warp to be woven, called the *comber board*, 3, 3, having rows of perforated holes to correspond with the number of warp threads. This board is divided into sections, and in what is called a straight tie-up of the harness there are as many leash strings to each hook as there are sections; in the illustration given there are four sections.

Below the comber board and at the place where the shed is to be formed each leash string is supplied with an eye called a *mail, F, F'*, through which the warp thread to be controlled is passed; and to the lower end of each leash string is attached the *lingo, g, g'*, a small weight to draw it down. The neck cord, leash strings, mail, and lingoes make up the Jacquard harness. The needles are held in place by a *needle board*, 4, which is made with rows of holes through which the ends of the needles pass about three-eighths of an inch, pointing to the front, and a *spring box*, 5, 5, at the back having a series of spiral springs, one for each needle, which, pressing the needle to the front, keep the hooks in a vertical position. The pattern to be woven is regulated by an endless chain of heavy pasteboard cards, *L, L, L*, which pass over a square prism, called the *cylinder, OPQR,* which is caused to revolve intermittently by swinging in and out like a pendulum in an arc, the cord of which is a little longer than the cylinder is square; as the cylinder swings out the *catch, x,* engages one of the pins, *O′, P′, Q′, R′,* causing the cylinder to make a quarter revolution, bringing a new card into position. The cylinder is perforated with rows of holes to correspond with the needles of the machine, and when the bare cylinder is allowed to come in contact with the needle board the needles projecting through the latter readily enter the perforations without moving the hooks; but the pattern cards are so perforated that for all warp threads that are to be raised above the filling in the woven pattern holes are cut for the needles which control them

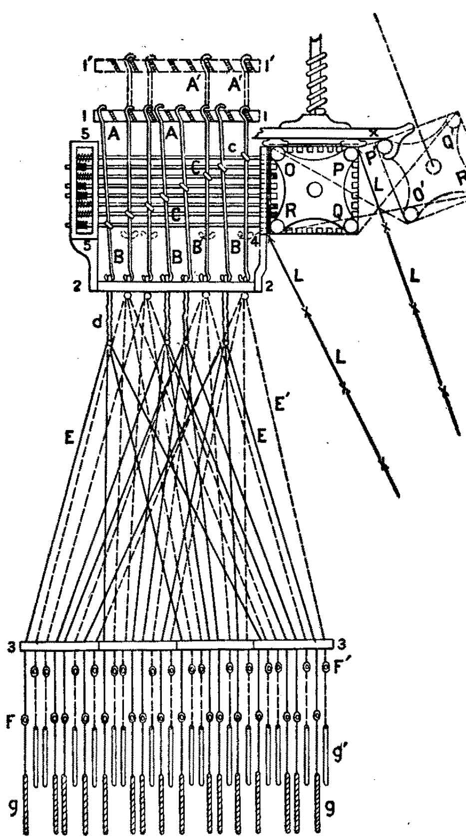

FIG. 4. JACQUARD ATTACHMENT.

to pass through, the holes being cut to superimpose the holes in the cylinder; but holes are not cut in the cards for the needles controlling those warp threads which are not to be raised. After the chain of cards is placed on the card cylinder and the pattern card, which just covers one face of the cylinder, is brought in contact with the needles projecting through the needle board, those needles which are opposite the holes cut in the card pass through and enter the perforations in the cylinder as if no card were there, while wherever there was no hole cut the needle is forced back, and with it the top of the hook which it governs, to a position so that the griffe, 1, 1, as it is raised, 1′, 1′, passes the hooks and the knives only engage and lift the hooks which have not been pushed back by the card; and every hook in the machine which has not been pressed back is raised by the griffe and with it the harness attached to it and the warp threads which it controls. Thus it is obvious that any desired interlacing of the threads in the fabric can be obtained by the way in which the pattern cards are perforated, each separate card regulating the warp threads for the entrance of one thread of filling, and there being as many cards necessary as there are filling threads in one repeat of the pattern; some very elaborate designs have required the use of 20,000 to 30,000 cards for a single design.

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