WOOLEN AND WORSTED CAM-LOOMS

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INTRODUCTION

1. Weaving is the process of interlacing yarn, threads, strips, or strands of various materials in such a manner as to produce cloth or fabrics of an allied nature. All weaving operations are performed on machines called **looms**, which vary in construction according to the kind of fabrics they produce. The strictest interpretation of the term weaving includes the production of all articles woven by a loom of any type, varying from the finest muslin to heavy blankets, from tape to sail cloth, and even including wire screening and fencing; but the generally accepted association of the word is with textile fabrics composed of wool, cotton, silk, or other fibrous materials. Fundamentally, weaving is a comparatively simple process, but the great variety of movements applied to a modern loom for varying the product and accelerating the operation has resulted in many varieties of complicated looms, while the actual work of the weaver has been greatly simplified by automatic attachments and various other improvements in weaving machinery. Like many other textile processes, weaving was formerly accomplished by hand, and even today the hand loom is an important factor in some branches of the industry in certain localities. The application of motive power to driving looms has, however, become almost universal and has led to many improvements in their construction.

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2. Principle of Weaving.—Every woven fabric is composed of two systems of yarns—the *warp* and the *filling*. There may be two or more warps or two or more systems of filling. The majority of fabrics are, however, what are known as *single cloths* and are composed of one system of warp yarn and one system of filling yarn. The **warp** is that system of yarn that runs lengthwise of the fabric and consists of a large number of separate threads, or **ends**. The number of ends in the warp depends, of course, on the ends per inch in the cloth and the width of the fabric. Before being woven, the separate ends of the warp, which are of equal length and arranged parallel to each other in the form of a sheet of yarn, are wound tightly on a round wooden roll usually constructed with iron heads and journals. This roll constitutes a part of the loom and is known as the **loom beam** or simply the **beam.** In the process of weaving, the warp yarn is slowly unwound from the beam, which is placed at the back of the loom, while as the weaving progresses, the woven cloth is wound on a roll at the front of the loom known as the **cloth roll.** The **filling** is that system of threads that runs across the fabric from selvage to selvage and unlike the warp consists of a continuous thread or threads that are passed back and forth from one side of the cloth to the other and are interlaced with the warp. The filling is placed in the cloth 1 pick at a time by means of a moving part of the loom known as the **shuttle,** which travels back and forth across the loom from one shuttle box to the other. The filling is wound in the form of a bobbin or cop, which is placed on a spindle in the shuttle.

In order to produce a woven fabric each warp end is drawn through the eye of a **heddle** placed on any one of a number of wooden frames known as **harnesses.** These harnesses, which are carried in the center of the loom, are operated by a suitable mechanism so that any of them may be raised or lowered through the space of a few inches when desired. Since some of the harnesses are raised while others are lowered, a diamond-shaped opening, known as the **shed,** is made in the warp, through which the shuttle carrying the filling is thrown. The shed then closes, after which a new shed is formed by the raising and lowering of other harnesses and the filling inserted as previously, thus interlacing the filling with the warp and forming a woven fabric. These two operations are known as **shedding** and **picking.** The shuttle in being thrown from one side of the loom to the other leaves the filling some distance from the edge, or, as it is technically known, the **fell** of the cloth. It is necessary, therefore, after the insertion of each pick, to push the filling forwards to the cloth that has already been woven. This operation is known as **beating up** and is accomplished by an oscillating portion of the loom called the **lay** that carries a grate-like arrangement of vertical wires known as the **reed,** through which the warp is passed. The three operations of shedding, picking, and beating up are known as the *principal motions* of weaving and are common to all types of looms. In weaving any fabric these three operations are repeated over and over again as the cloth is made pick by pick.

3. Other motions are applied to looms, but they are of the nature of *auxiliary motions* and are not typical of any principle of the weaving process. The chief auxiliary motions are: (1) The *let-off motion* for controlling the beam and letting the warp unwind as fast as the cloth is woven while it at all times keeps the proper tension on the warp; (2) the *take-up motion* for winding the cloth on the cloth roll as it is woven by the loom; (3) the *filling stop-motion* for automatically stopping the loom in case the filling breaks; (4) the *protector motion* for protecting the warp yarn from being broken by the lay and shuttle in case the latter for any reason remains in the shed when the lay moves forwards to beat up the filling; (5) the *selvage motion* for manipulating the selvage ends at each side of the warp in such a manner as to produce smooth and firm edges on the cloth.

CONSTRUCTION OF CAM-LOOMS

4. The simplest power loom employed for woolen and worsted fabrics is the **cam-loom,** so called because the raising and lowering of the harnesses to form the shed is accomplished by means of cams. A cam-loom suitable for weaving flannels, cassimeres, trouserings, or other goods requiring only one kind of filling and not more than eight harnesses is shown in Figs. 1 and 2, the former being a front view and the latter showing the loom as seen from the rear. The loom consists primarily of two side frames *a*, *a*, connected by girts and supporting the arch a_1; these parts are securely bolted together so that a strong and suitable support is made for the various mechanisms of the loom. The crank-shaft *b* extends entirely across the loom and is carried in two bearings securely fastened to the side frames. This shaft is so bent as to form two cranks, which are connected by pitman arms b_3, Fig. 8 (*a*), with the lay *f*. The lay is supported by the lay swords f_1 and when actuated by the crank-shaft moves backwards and forwards beating up each pick of filling as it is inserted in the cloth. A hand wheel b_1 is fastened to one end of the crank-shaft, so that the weaver may turn the crank-shaft of the loom by hand, as is often necessary. The bottom shaft *c*, which extends entirely across the loom, is located approximately under the crank-shaft and is supported by bearings bolted to the side frames of the loom; it carries two castings c_1 [see Fig. 8 (*a*)], one on each side of the loom. These castings carry iron rolls c_3 called **pick balls,** which acting through suitable mechanisms in a manner somewhat similar to cams, impart motion to the picker sticks d_6, d_6. The upper end of the picker stick imparts motion to a rawhide picker e_3 working freely on a spindle e_1 at the back of the shuttle box *e*, which is at the end of the lay. One end of the picker projects into the shuttle box *e* and imparts motion to the shuttle. As there are two shuttle boxes and a picking

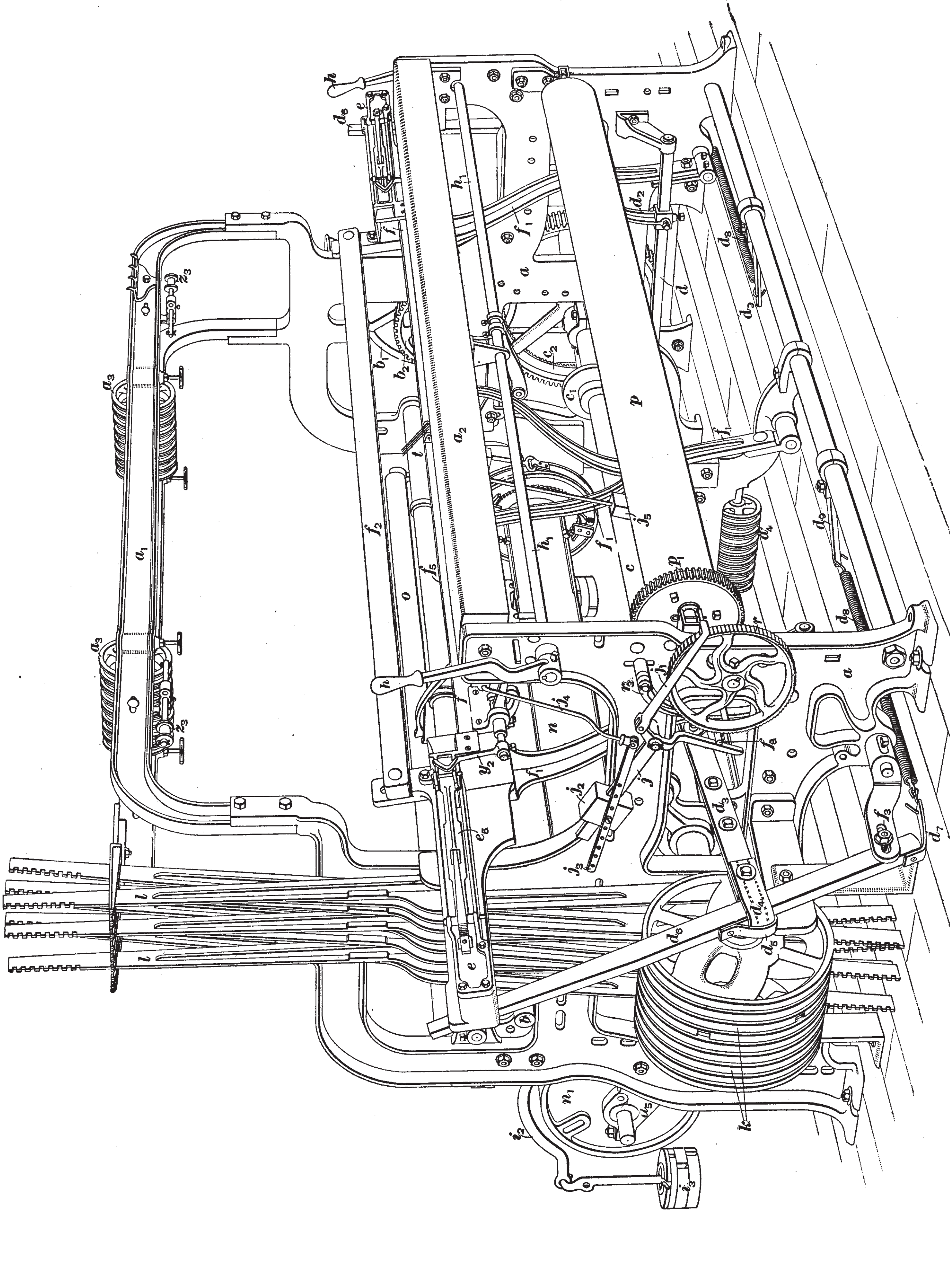

FIG. [illegible]

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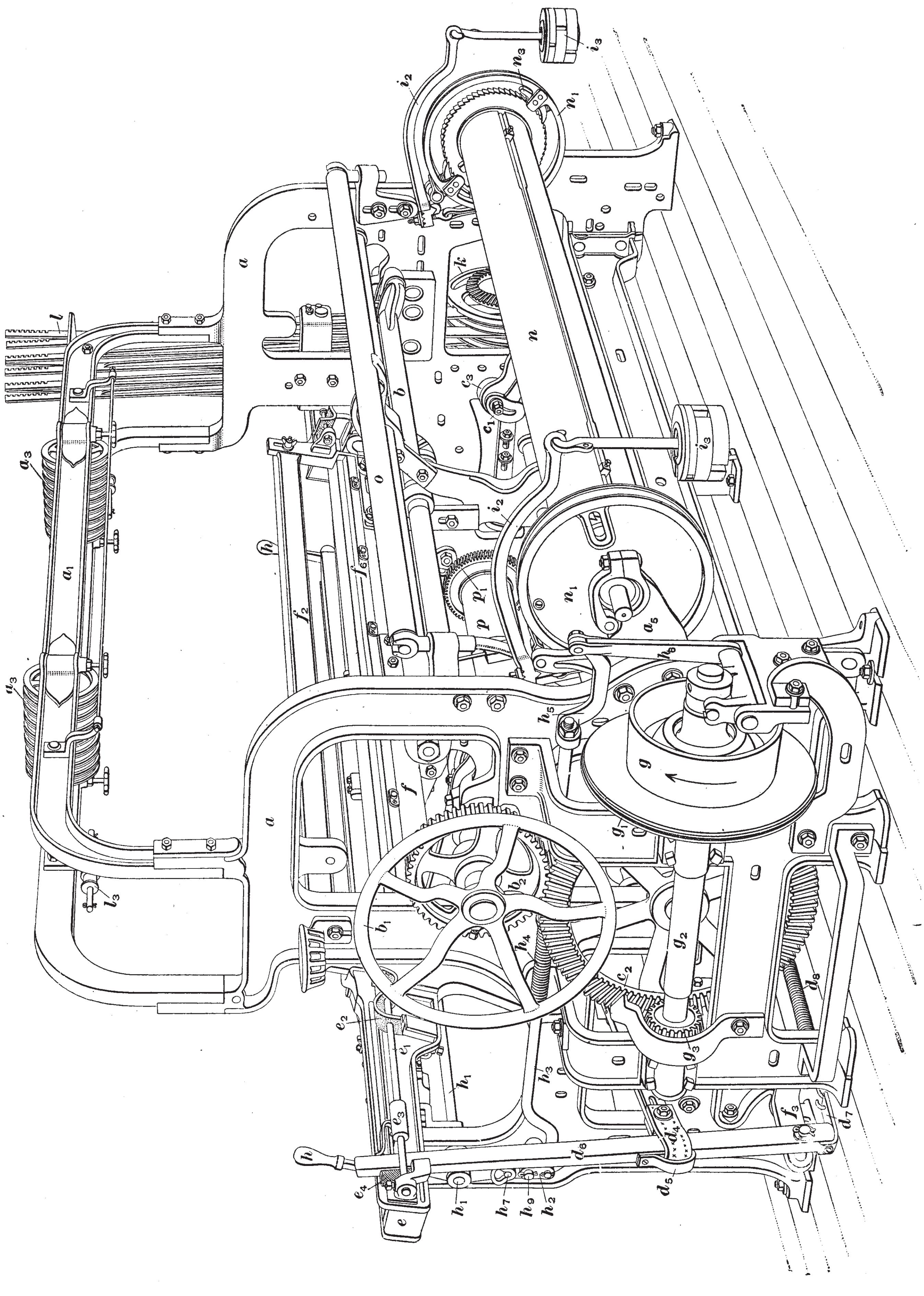

FIG. 2

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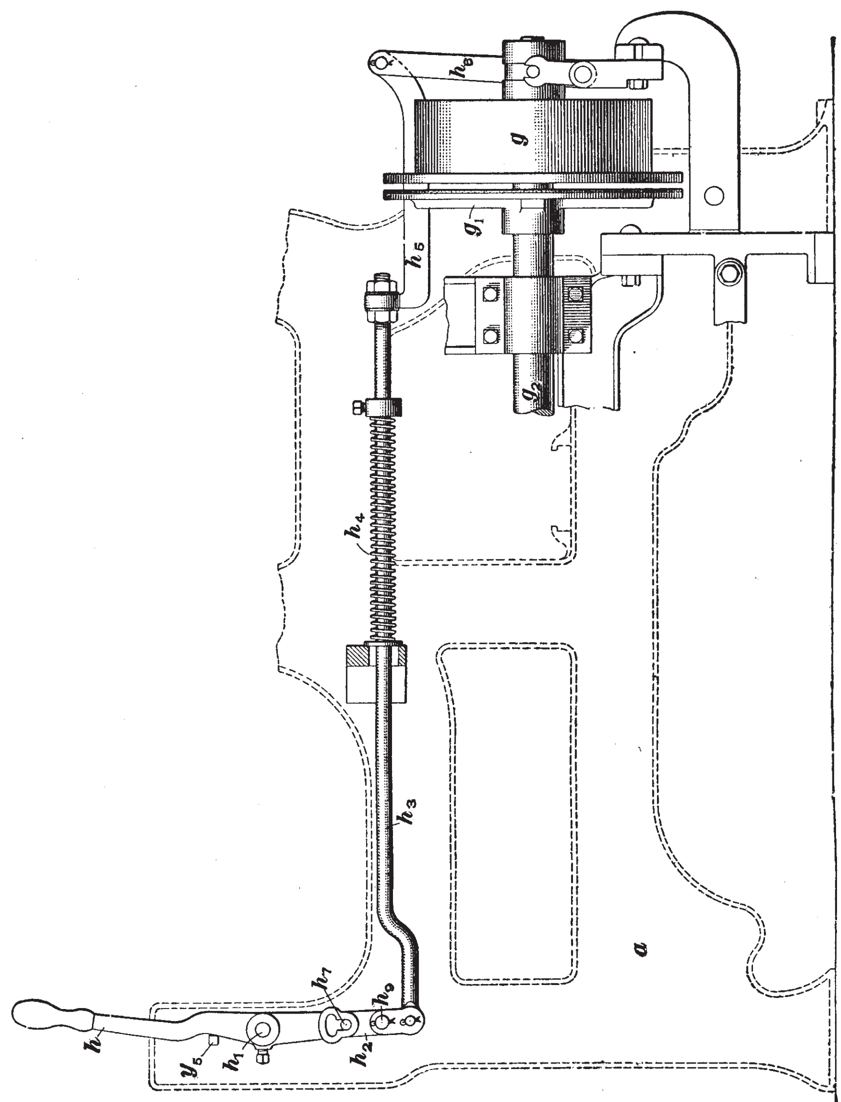


FIG. 3

motion on each side of the loom, the shuttle is thrown back and forth from one shuttle box to the other. The top of the lay, over which the shuttle travels in moving from one box to the other, is usually made of a thin strip of steel or hardwood f_5, and is known as the **race plate,** or **shuttle race.**

The shed, or opening in the warp, for the insertion of each pick of filling is formed by means of cams k placed on a shaft at the side of the loom and driven by means of bevel gears from the bottom shaft. These cams operate harness levers, or jacks, l that raise and lower the harnesses (not shown in Figs. 1 and 2) through which the warp is drawn, thus forming the sheds for the insertion of the filling. The loom beam n on which the warp is wound rests in bearings a_5 supported by the frame of the loom. The warp passes from the beam over the whip roll o, through the harnesses, which are connected to the shedding mechanism, and then through the reed (not shown), which is an arrangement of vertical wires supported at the bottom by the lay and at the top by the reed cap f_2. As fast as the cloth is woven it is drawn over the breast beam a_2 and wound on a cloth roll p by means of the take-up motion, which is operated from the lay by a mechanism imparting motion to the rachet r.

5. The driving gearing is as follows: Motion is imparted to the loom by means of a belt running on a self-oiling face-friction pulley g, Figs. 2 and 3, on the shaft g_2. Fastened to one end of the driving shaft g_2 is a twenty-two-tooth bevel-pinion gear g_3 meshing with a gear c_2 of ninety-six teeth set-screwed to the bottom shaft of the loom. The gear c_2 is of peculiar construction, having teeth arranged to mesh with the gear g_3 and also having teeth on its circumference meshing with the gear b_2 after the manner of an ordinary spur gear. The gear b_2 is fastened to the crank-shaft of the loom and has forty-eight teeth; since this is exactly one-half the number of the teeth in the gear c_2, the speed of the crank-shaft will consequently be twice that of the bottom shaft. The reason for this relative speed is that in making one revolution the bottom shaft inserts 2 picks into the cloth, and as the lay must beat up each of these picks separately, the crank-shaft must make two revolutions while the bottom shaft is making one.

The shedding mechanism must always be so arranged that a shed will be made for each revolution of the crank-shaft. Looms in which the crank-shaft makes two revolutions to one of the bottom shaft are said to be geared two to one; some looms for special purposes are equally geared. Many looms have the driving pulley directly on the crank-shaft, but these are fast-speed looms. Where looms are run at slow speed, some reducing motion must be used so that the driving pulley may run at a sufficient speed to efficiently transmit the required power to the machine. The speed of a loom is always considered as the speed of the crank-shaft; therefore, when a loom is geared as shown in Fig. 2, in order to find the speed it is necessary to multiply the revolutions of the loom pulley by the teeth in the pinion gear and divide by the number of teeth in the crank-shaft gear: $\frac{220 \times 22}{48} = 100.83$. In this case 220 revolutions per minute of the loom pulley will place approximately 100 picks per minute in the cloth.

The friction driving pulley g, Fig. 3, is loose on the driving shaft g_2 and, by means of a lever h_6 fitted with a yoke that engages with a groove cut in the hub of the pulley, may be forced in contact with the friction plate g_1, which is fastened to the shaft. The lever h_6 is controlled by either of the shipper handles h, h, which are setscrewed to a shaft h_1 extending across the loom. When the shipper handle is drawn forwards, the pin h_7 operates the lever h_2 that swings on the stud h_9 and draws forwards the rod h_3, which operates the casting h_5 attached to the lever h_6. A spring h_4 is so arranged as to hold the pin h_7 securely in the notch in the lever h_2 when the shipper handle is drawn forwards, so that the jar and vibration of the loom will not cause the pin to be released from its retaining notch. This spring also instantly disengages the friction in case the shipper handle of the loom is operated by any of the stop-motions that will be explained later. Looms are often equipped with tight-and-loose pulleys instead of a friction, but the latter is to be preferred for heavy looms using wide belts, as by its use the constant shifting of the belt is avoided and at the same time the power is communicated to and removed from the loom in the least possible time. Friction pulleys are necessary also if a very short belt must be used.

PRINCIPAL MOTIONS OF WEAVING

SHEDDING MECHANISM

6. The harnesses through which the ends of the warp have been drawn must be connected to some mechanism by means of which certain of them may be raised and others lowered, so as to make a division or opening in the warp. Through the opening, or shed, thus formed, the shuttle is thrown and the pick of filling inserted. The relative position of the harnesses is then changed; some, or all, of those that were raised are lowered while others are raised, so that a new shed is formed, through which the shuttle is again thrown and another pick of filling inserted. The harnesses are raised and depressed in a definite order, so that a certain weave or method of interlacing the filling with the warp will be followed out; for instance, with the warp drawn through the harnesses in regular order from front to back, if all the odd-numbered harnesses are raised for one pick and all the even-numbered ones for the next pick, a plain weave will be formed in the cloth. In this case one pick will pass under all the odd-numbered ends and over all the even-numbered ends, while with the next pick the reverse will be true.

By arranging the lifting of the harnesses, therefore, various methods of interlacing the warp and filling so as to produce twilled or other effects may be obtained. Harness-shedding mechanisms can only be used when a large number of warp ends are raised and lowered in the same order, since all of the ends drawn in the heddles placed on a single harness must work alike. If only two harnesses are operated,

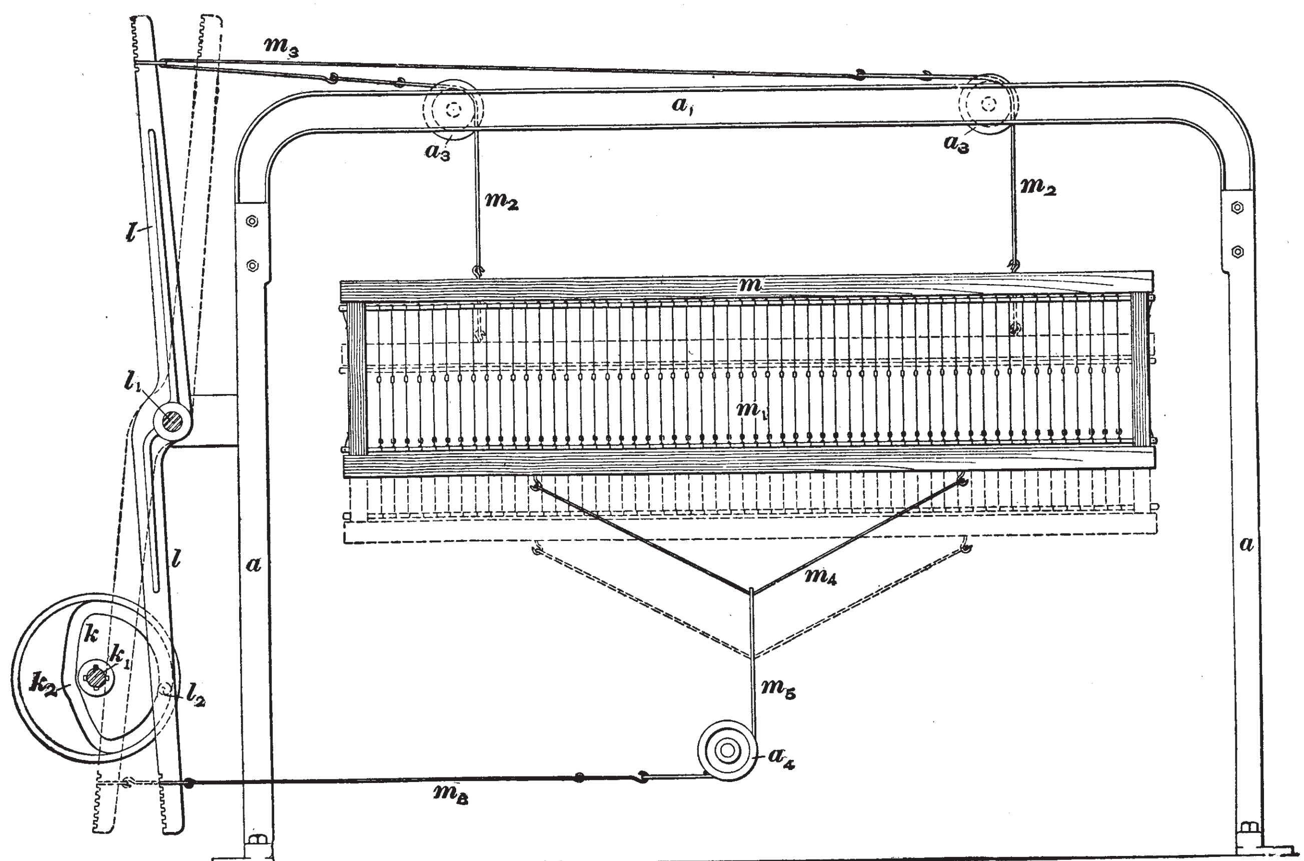


FIG. 4

there can be but two orders of raising and lowering the warp threads; if three harnesses are used, there may be three sets of warp threads raised and lowered independently of each other, and so on, the number of harnesses used always governing the number of ways in which it is possible to operate the warp ends.

7. Side-Cam Shedding Motion.—On cam-looms, the raising and lowering of the harnesses is accomplished by means of cams. These, if placed at one side of the loom, are known as **side cams**; but if placed under the harnesses, are known as an **under-cam motion.** Fig. 4 shows the usual arrangement of side cams on woolen looms. Each of the several harnesses m carries a number of wire heddles m_1 threaded on two heddle bars, one at the top and one at the bottom of the harness frame. Each end in the warp that is to be raised and lowered in the same manner as this particular harness is drawn through the eye of a heddle placed on the harness. The harness is attached by means of leather straps m_2 passing over sheaves a_3, a_3 and hooked wires m_3, to a small iron stirrup slipped over the upper end of the harness lever, or jack, l, which is movable on a fulcrum at l_1. The lower end of the jack is connected to the harness by means of a similar stirrup, a wire m_6, a strap m_5 passing around a sheave a_4, and a wire yoke m_4. Motion is imparted to the jack l and thus to the harness by means of a cam k attached to a rotating cam-shaft k_1. A cam-bowl l_2 on the jack works in the cam-course k_2 of the cam, and as the latter rotates, the lower end of the jack is forced inwards and drawn outwards and the harness m raised and lowered, thus raising and lowering the warp threads drawn through the heddles. By constructing the cam with a cam-course of proper shape, the harness may be made to move in any desired manner so that it will remain up or down while a given number of picks are being placed in the cloth. The position of the cam, jack, and harness when the latter is lowered, is shown in Fig. 4 by the dotted lines. In this illustration the connections of only one harness are shown.

the dotted lines simply showing the same harness in another position, but ordinarily cam-looms operate from two to eight harnesses, each with its corresponding jack, cam, etc.

The harness may be made to move through a greater distance by moving the stirrup toward the end of the jack by means of the notches in the ends of the latter. The harnesses that are farthest from the fell of the cloth should be allowed to move through a greater distance than those nearer to the cloth, in order that they may raise and depress the warp yarn at the same angle, so that a clear and open shed may be made. This is usually accomplished by stepping the stirrups in regular order from a low notch on the upper end of the front jack to a high notch on the jack operating the back harness. Care should be taken to place the stirrup at the bottom of the jack in the same relative notch as the top stirrup, so that each will be equidistant from the fulcrum of the jack; otherwise, the straps and wire connections to the harness will be strained and broken in shedding. The cams operating the back harnesses are also constructed so as to give a greater lift to the harness. The straps m_2, m_5 are perforated so that the harness may be hooked at any desired height in order to make the warp yarn just clear the race plate of the lay when the harness is in its lowest position, and so that the harness may be strapped tight or loose as is desired.

In Fig. 5, the passage of the warp n_4 from the warp beam n, over the whip roll o, through the heddles m_1 of the harnesses m, and over the breast beam a_2 to the cloth roll p is shown; this figure also illustrates how the shed is formed by the harnesses. It will be noticed that some of the harnesses are raised while others are lowered; consequently, the warp ends drawn through the heddles of the harnesses that are raised are also raised, while those drawn through the heddles of the harnesses that are lowered are also lowered. Through the opening thus formed in the shed, the shuttle s is thrown, traveling back and forth across the loom upon the lay f, which is supported by arms f_1 known as **lay swords.** As successive sheds are formed by raising and lowering other harnesses and the filling inserted in

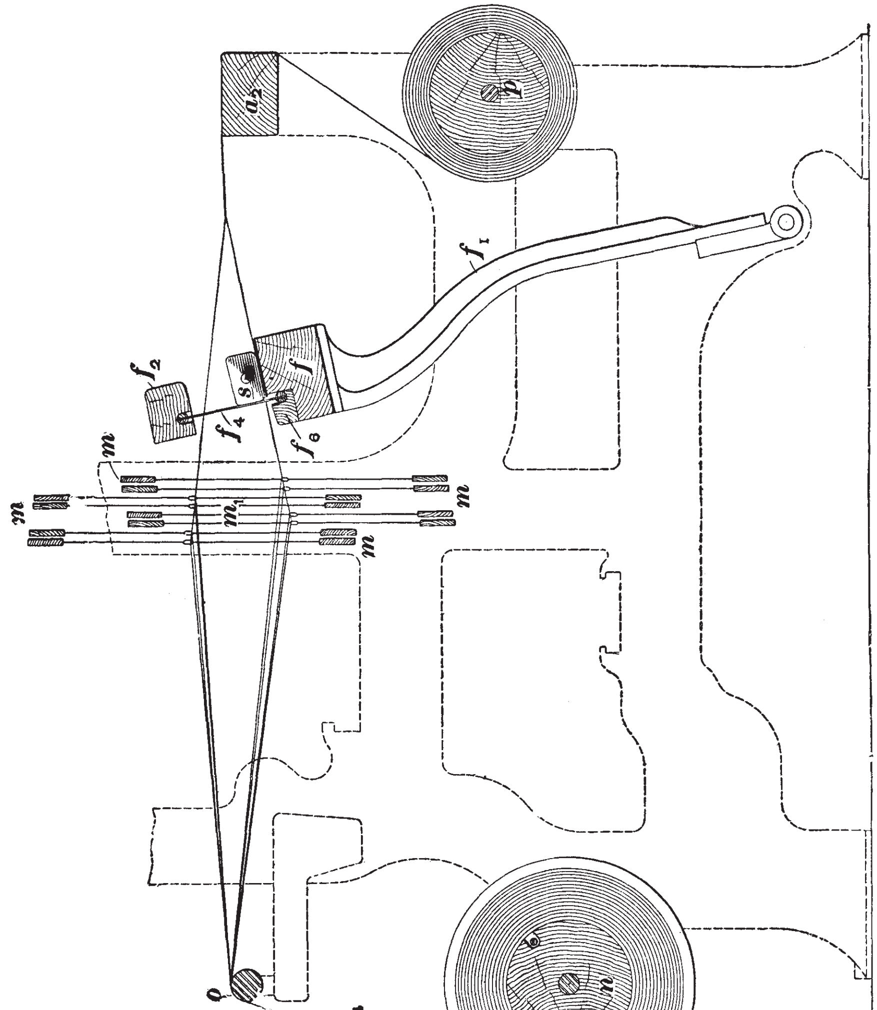


FIG. 5

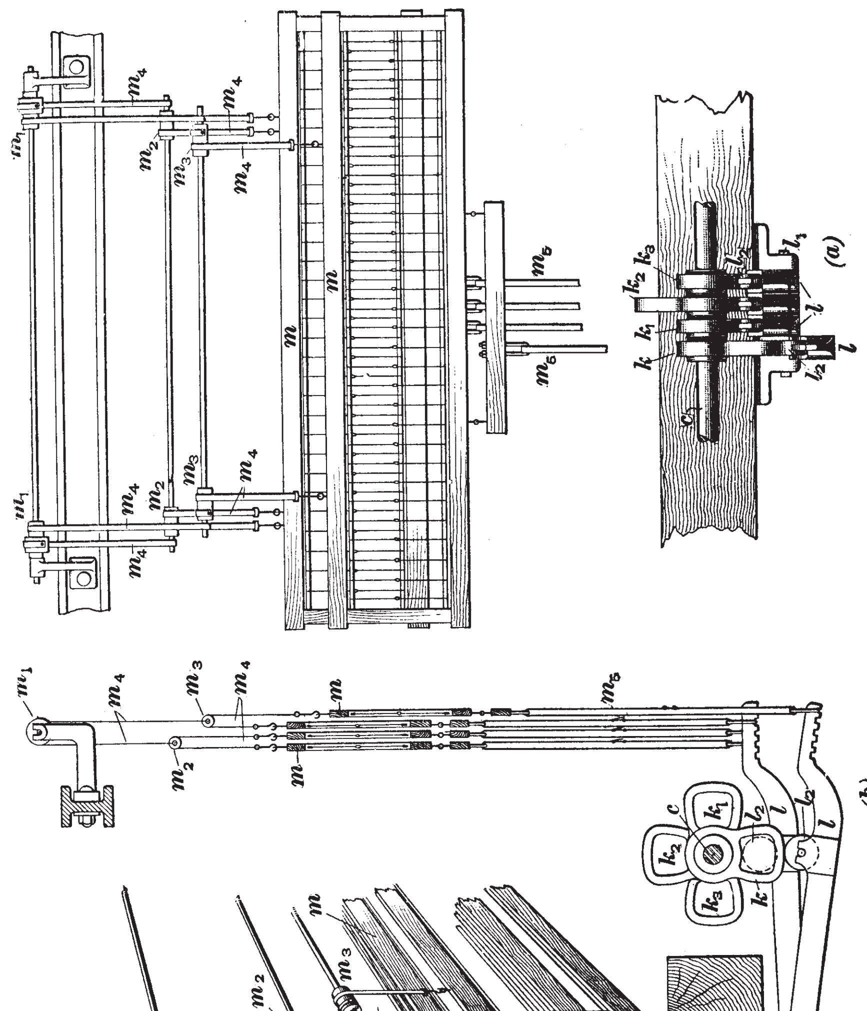


Fig. 6

these sheds to form the cloth, the warp n_4 is unwound, the yarn is drawn through the heddles, and the woven cloth is wound on the cloth roll p.

8. Under-Cam Motion.—The under-cam shedding motion is rarely applied to looms designed for woolen and worsted fabrics. Fig. 6, in which (a) is a front and (b) a side view, shows an under-cam motion for operating four harnesses and illustrates the principle involved in this method of shedding. Four cams k, k_1, k_2, k_3, each constructed to lower the harness for one shed and allow it to be raised for three consecutive sheds, are fastened to a rotating shaft c. They operate four levers, or treadles, l, the two not shown being hidden from view by the one shown raised. The treadles are fulcrumed at l_1 and attached to the harnesses m by means of straps m_5. The cam-bowl l_2 being in contact with the circumference of the cam results in the treadle and harness being lowered when that part of the cam farthest from the shaft comes in contact with the cam-bowl. The harnesses are, as is more clearly shown in the perspective view, Fig. 6 (c), so hung by straps m_4 from wooden rolls m_1, m_2, m_3 supported by the arch of the loom that when one harness is depressed its motion serves to raise the harness that was depressed on the previous pick, thus making a positive motion from cams that are really only partially positive in their action.

9. Construction of Cams.—Cam-shedding mechanisms are only adapted to weaves having comparatively simple interlacings, since each end that interlaces with the filling in a manner different from other ends requires a separate cam to operate the harness through which it is drawn. For instance, if a weave is complete on 5 ends, that is, if it contains 5 ends each interlacing with the filling differently from the other 4 ends, it will require five cams in order to raise and lower the five harnesses, through one of which each of these ends must be drawn so that each end will interlace with the filling according to the method indicated by the weave.

Cams may be constructed to so operate the harnesses that the warp ends controlled by them will be raised or depressed for any reasonable number of picks and in any order desired. The shaft on which the cams are placed is usually speeded so that it will make one revolution while the crank-shaft of the loom is making a number of revolutions equal to the number of picks in one repeat of the weave.

This is necessary because one revolution of the cam-shaft must make the sheds for each pick of the weave and the crank-shaft must move the lay forwards to beat up each of these picks separately. As the weaves usually woven on cam-looms are complete on the same number of ends and picks, it follows that the shaft on which the cams are placed makes one revolution while the crank-shaft makes as many revolutions as there are cams on the cam-shaft. For instance, if the cams are constructed and the loom adapted for a weave complete on 4 ends and 4 picks, four cams are necessary and the crank-shaft will make four revolutions while the cam-shaft is making one; if the weave requires six cams and there are 6 picks in one repeat of the weave, then the crank-shaft will make six revolutions to one of the cam-shaft, and so on. It should be distinctly understood that the number of cams is not actually the governing element, but the number of picks to one repeat of the weave; the number of cams simply serves as a guide when the weave is complete on the same number of ends as picks.

In constructing a harness cam, in order to find the correct shape of the cam-course for any desired motion of the harness, there are several important points that must be taken into consideration before any attempt is made to draw the cam. The diameter of the cam-shaft, of the hub of the cam, and of the cam-bowl must first be considered; then the throw of the cam must be determined; and finally the manner in which the harness is to be lifted should be considered. Suppose that it is desired to construct a cam to raise the harness for 2 picks and lower it for 2 picks, 4 picks constituting one repeat of the weave. The shaft on which this cam is to be placed is $1\frac{1}{2}$ inches in diameter; then the first operation is to describe a circle a $1\frac{1}{2}$ inches in diameter (see Fig. 7). If the hub of this cam is to be $2\frac{1}{2}$ inches in diameter, another circle b must be described with the same center as the previous one but $2\frac{1}{2}$ inches in diameter. Suppose that the cam-bowl fastened to the harness lever is 1 inch in diameter. Another circle c must now be described

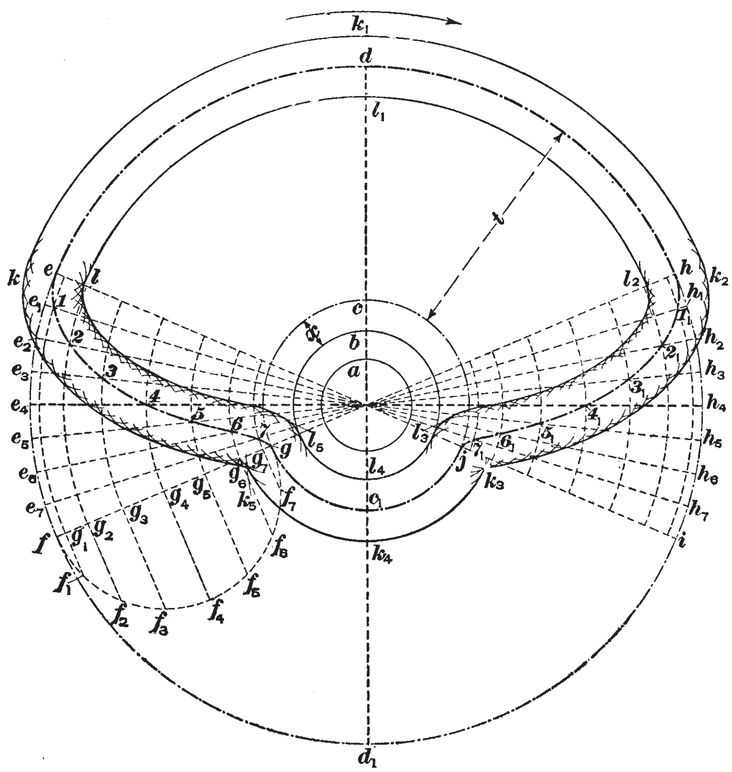


Fig. 7

using the same center and such a radius that the distance x between the circles b and c shall be equal to one-half the diameter of the cam-bowl, or $\frac{1}{2}$ inch. This circle represents the position of the center of the cam-bowl when it is nearest the hub of the cam and the harness is in its lowest position.

It is next necessary to determine the amount of throw that the cam shall have, and in this connection the required lift of the harness and the leverage through which the cam is to act must be considered. Suppose that in this case it is desired to impart a vertical movement of 5 inches to the harness and that the cam is to operate through a harness jack after the manner shown in Fig. 4. If the distance from the fulcrum of the jack to the point where the harness strap is connected is 30 inches and the distance from the fulcrum of the jack to the center of the cam-bowl is 24 inches, the cam must have a throw of $\frac{5 \times 24}{30}$, or 4, inches from heel to toe in order to raise the harness 5 inches. Having found the throw of the cam, another circle is described with the same center and a radius of such magnitude that the distance t shall be 4 inches. This circle represents the path of the center of the cam-bowl when it is traversing that part of the cam farthest from the center and the harness is raised to its highest position. This cam is to be constructed for a weave complete on 4 picks and will consequently make only one revolution to every 4 picks placed in the cloth. The next operation, therefore, is to divide the circle representing the position of the center of the cam-bowl when it is farthest from the center of the shaft into four equal parts, as shown by the heavy dotted lines $d\,d_1$ and $h_4\,e_4$. Each of these divisions represents the distance that the cam will turn during the time the crank-shaft of the loom is making one revolution and 1 pick of filling is being placed in the cloth; the shape and position of the cam-course, then, in any one of these divisions governs the action of the harness while that particular pick of filling is being inserted.

This cam is to be constructed so that the harness will remain raised for 2 consecutive picks and lowered for 2 picks; therefore, two of the divisions, say $e_4\,d$ and $d\,h_4$, will be used while the harness is up, and two, $h_4\,d_1$ and $d_1\,e_4$, will be used while the harness is down. In the first case, the center of the cam-bowl will be moving along the circle d; and in the latter case, along the circle c_1. It is evident that some allowance must be made for the time consumed by the harness in passing from the bottom to the top shed and vice versa, as it would be obviously impossible for the cam-bowl to pass instantaneously from its lowest to its highest position or vice versa; nor would such a motion be desirable, as the harness should be moved as smoothly and easily as possible. One-half a pick is usually allowed for each change of the harness, although sometimes more is allowed so as to make the movement of the harness as slow as possible consistent with having it change in time. In this case, this equals one-half of one of the four divisions into which the cam was divided. One-half of this distance is laid off on each side of the lines indicating where the harness is to pass from one shed to the other. Thus, if the cam is rotating in the direction indicated by the arrow, the distance $i\,h$ is equal to one-half of 1 pick and one-half of this is laid off on each side of the radius passing to point h_4, indicating the distance the cam will turn while the harness is being raised. During this period the center of the cam-bowl must move from j to h. In the same way, the distance $e\,f$, which is also equal to $\frac{1}{2}$ pick, represents the distance that the cam will move while the harness is passing from the top to the bottom shed. During this period the center of the cam-bowl must move from e to g.

In rising and falling, the harness should start to move slowly, its speed gradually increasing until the center of the shed is reached, when it should uniformly decrease until the motion is completed. If the cam is shaped to move the harness in this manner, a minimum of strain is placed on the warp yarn when it is at its greatest tension, that is, when the harness is up or down, and at the same time the change is accomplished in a minimum of time by moving the harness quickly in the center of the shed, while the yarn is not subjected to so great a strain. This motion is obtained by dividing the arcs $e\,f$ and $h\,i$ into an arbitrary number of equal parts, say eight. From the points $e_1, e_2, e_3, e_4, e_5, e_6, e_7$ and $h_1, h_2, h_3, h_4, h_5, h_6, h_7$ thus obtained radii are drawn to the center of the cam. With a radius equal to one-half the throw of the cam and a center on any convenient radii of the circle, describe a semicircle $f\,f_4\,g$, one end of which shall lie in the circle $d\,d_1$ and the other in the circle $c\,c_1$. Divide this semicircle into the same number of equal parts in which the arcs $e\,f$

and $h\,i$ were divided. From the points $f_1, f_2, f_3, f_4, f_5, f_6, f_7$ draw lines $f_1 g_1$, $f_2 g_2$, $f_3 g_3$, $f_4 g_4$, $f_5 g_5$, $f_6 g_6$, $f_7 g_7$, perpendicular to the radius on which the center of the semicircle was located, in this case the line $f\,g$. With the center of the cam as a center, strike arcs through the points g_1, g_2, g_3, g_4, g_5, g_6, g_7 cutting the lines drawn from the equal divisions of the arcs $e\,f$ and $h\,i$. Through the points *1, 2, 3, 4, 5, 6, 7* obtained by the intersection of these arcs with the radii draw a smooth curve connecting e and g. In the same way, connect h and j with a line drawn through 1_1, 2_1, 3_1, 4_1, 5_1, 6_1, 7_1. The shape of the cam is now practically determined, the heavy dot-and-dash line e–d–h–j–c_1–g representing the path that the center of the cam-bowl must travel during one revolution of the cam, or 4 picks of the loom. To find the actual shape of the cam-course with which the cam must be cast, or cut, it is only necessary to take a radius equal to that of the cam-bowl and with successive centers on the path of the center of the cam-bowl strike arcs on each side as shown. Lines k–k_1–k_2–k_3–k_4–k_5 and l–l_1–l_2–l_3–l_4–l_5 drawn tangent to these arcs show the exact shape of the cam-course required to move the cam-bowl so that its center will constantly follow the line e–d–h–j–c_1–g.

10. Considering the action of the cam, suppose that the center of the cam-bowl is at j and that the cam rotates as shown by the arrow; the cam-bowl moves from j to h with a variable motion, raising the harness from the bottom to the top shed. At the point 4_1 the greatest speed is attained, and at this point the harness is exactly in the center of the shed. The cam-bowl then moves from h through d to e. Since this portion of the path is the true arc of a circle having the center of the cam as a center, the harness remains stationary at the top shed. This portion of the cam is known as the **dwell of the cam** and allows the shuttle to be thrown through the shed without interfering with the warp. In passing from e to g the harness is lowered in exactly the same manner as it was raised and, while the cam-bowl passes from g through c_1 to j, the harness is stationary at the bottom shed, this part of the cam being also a dwell. With careful observation of the method employed in constructing the cam in Fig. 7, no difficulty should be experienced in constructing a set of cams for any weave. It should be noted that if a cam is to be constructed for an under-cam motion, it is unnecessary to determine the line k–k_1–k_2–k_3–k_4–k_5. Cams for the harnesses farthest from the fell of the cloth should be made with a somewhat greater throw than those for the front harness, the part of the cam nearest the hub being made smaller, so that the harness will fall lower, and the outer diameter of the cam-course being made greater, so that the harness will rise higher, in order that the yarn drawn through this harness shall be raised and lowered at the same angle as that drawn through the front harness.

The cams in Fig. 1 are so constructed that in one revolution they raise the harness for 2 picks, lower it for 2, raise it for 2, and lower it for 2, being really what might be termed *double cams*. The cam-shaft makes one revolution to eight of the crank-shaft or one to four of the bottom shaft.

11. Setting Harness Cams.—A set of harness cams may be fastened together or to the cam-shaft so that the harnesses will be raised in any desired order. For example, suppose that a set of cams is constructed so that each cam will lift the harness for 1 pick and lower it for 3 picks. These cams may be fastened to the cam-shaft in such a relative position that on the first pick the first harness will be raised, on the second pick the second harness will be raised, on the third pick the third harness, and on the fourth pick the fourth harness, thus forming a regular twill in the cloth; or they may be put together so that on the first pick the first harness will be raised, on the second pick the second, on the third pick the fourth, and on the fourth the third, thus forming a broken twill in the fabric; or any other order, such as four, three, two, one, in which four numbers can be arranged may be used.

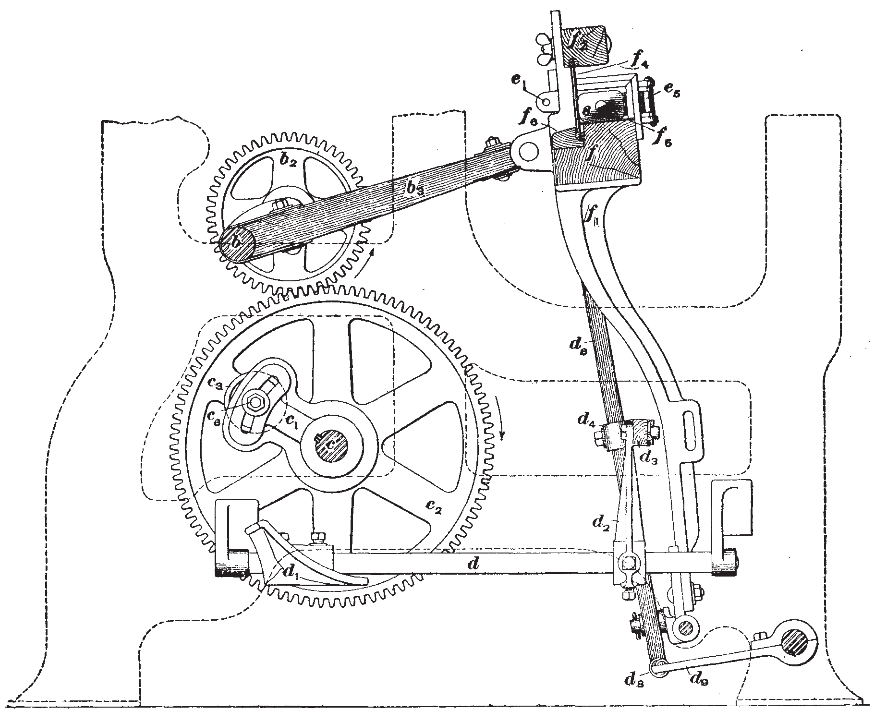
When the cams are placed together, they should be so arranged that the change part of one cam that raises the harness will overlap the change part of the cam or cams that are lowering a harness exactly one-half, so that the harness that is rising will pass the harness that is being lowered exactly in the center of the shed. In order that this may be accurately accomplished, the cam-shaft is key-seated and fitted with a solid spline, while each cam has as many keyways cut in its hub as there are cams on the shaft, as shown in Fig. 4. Thus, the cams may be arranged to raise the harnesses in any desired order, but as the keyways are cut in the proper place it is impossible to fasten the cams to the shaft in a wrong position.

12. Timing the Harness Cams.—After the cams are placed together so as to raise the harnesses in the required order, they must be timed so that the shed will be opened and closed at the proper periods. The lay is first brought forwards until the reed nearly reaches the fell of the cloth; then the bevel gear on the bottom shaft is loosened and the cam-shaft turned until the harness or harnesses that are rising are exactly level with the harness or harnesses that are being lowered. When the cam-shaft is in this position, the bevel gear should be securely fastened to the bottom shaft again. Instead of noting when the changing harnesses are level, it serves the purpose as well and is sometimes more convenient and more accurate in case the harnesses are not properly leveled, to note the position of the jacks and tighten the bevel gear on the bottom shaft when the cam-shaft has been moved so that two or more jacks moving in opposite directions are even with each other. The position in which the lay is placed depends on whether an early or late shed is desired; ordinarily, the changing harnesses should be level when the reed is about 1 inch from the fell of the cloth, but if an early shed is desired, this distance is increased, whereas if it is desired to have the shed late, the lay is placed closer to the fell of the cloth when the cam-shaft is set. The earlier the shed, the greater the strain on the warp, since the distance that the filling is forced through a crossed shed is then greater; that is, after the changing harnesses have passed each other, the shed is crossed on the pick of filling, which, in being forced to the fell of the cloth, encounters greater resistance from the warp; hence, if the pick must be moved a greater distance after the shed crosses before it reaches the fell of the cloth, the strain on the warp yarn is increased. By making the shed close later, this strain is reduced, and if the changing harnesses were not level until the reed reached the fell of the cloth, it would be eliminated.

13. Regulating the Shed.—When the harnesses are properly timed, the loom should be turned over by hand until the shed is open to its widest extent. When it is said that a loom is turned over by hand it is meant that the weaver operates the loom by hand. Each harness that is lowered should now be hooked to the harness straps so that the yarn will just barely clear the race plate of the lay. The loom should be turned over 1 pick at a time until all of the harnesses have been so regulated. Before this is done it is important to see that the stirrups are properly stepped on the harness jacks, so that the one connected to the front harness will be in the bottom notch and the one for the last harness in the top notch of the upper half of the jack, with the others uniformly graded between. This method of stepping the stirrups is subject to modifications, as, for instance, in cases where fewer harnesses are used than there are jacks in the loom, but in all cases the harnesses should be so connected as to give an even and clear shed. The harness should be strapped to the bottom of the jack in the same relative position and strapped neither too tight nor too loose, but with just enough tension to guard against lost motion or the straining of the straps. If a harness is strapped too high, the yarn will not lie close enough to the race plate and the shuttle is liable to be thrown from the loom or at least to travel from one box to the other with a crooked motion, which should be avoided in a well-running loom. If a harness is strapped too low, so that the yarn presses on the race plate, the yarn will be chafed and broken by the action of the lay in moving forwards and backwards. Care should be taken to have each harness strapped to the jack so that all the warp yarn will be lowered to exactly the same position relative to the race plate. It should be noticed also whether the yarn is higher on one side of the loom than on the other.

PICKING MOTION

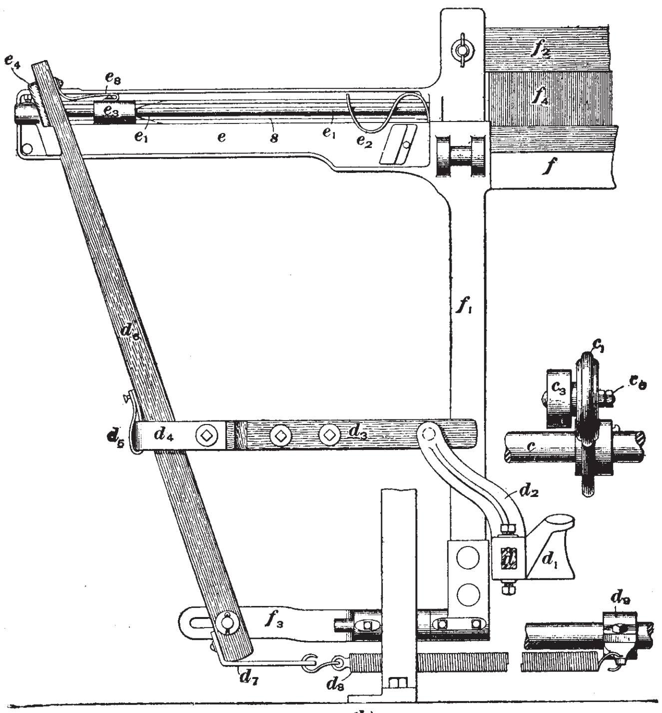
14. Picking, or the operation of throwing the shuttle through the shed with the filling, is one of the most important motions of weaving. The picking motion is somewhat different from any other mechanism of the loom and is a motion in which a considerable amount of force is exerted in a comparatively short space of time; this is necessary in order that sufficient momentum may be imparted to the shuttle to carry it across the loom from one shuttle box to the other. At the same time a straight, easy, and smooth motion should be given to the shuttle, since if the shuttle travels in a jerky or crooked manner the best results are not obtained. There are several styles of picking motions applied to power looms, but on woolen and worsted looms the one known as the **ball and shoe picking motion** is generally used. The usual arrangement of the ball and shoe pick is shown in Fig. 8 (*a*) and (*b*), of which the former is a sectional view of the mechanism, while the latter shows the appearance from the rear of the loom. A casting c_1 securely fastened to the bottom shaft c carries on a stud at its extremity an iron roller c_3 known as a **pick ball.** As the bottom shaft rotates, the pick ball comes in contact with a shoe d_1 fastened to the picking shaft d, which is generally rectangular in section except where it is round so as to be carried in bearings at the front and back of the loom. A pick arm d_2 is also securely fastened to the picking shaft, and by means of the sweep stick d_3 attached to the pick arm with a stud and a leather or cloth lug strap d_4 that encircles the picker stick d_6 and is bolted to the sweep stick, any movement of the pick arm may be communicated to the picker stick. The lug strap is supported by a small leather loop d_6 attached to the picker stick with a small screw. The picker stick is fulcrumed on a stud fastened to a casting f_5, which in turn is fastened to a short rocker-shaft to which the lay sword f_7 is also attached. This allows the picker stick to have a movement in unison with the lay as well as the motion that is imparted to it for throwing the shuttle.



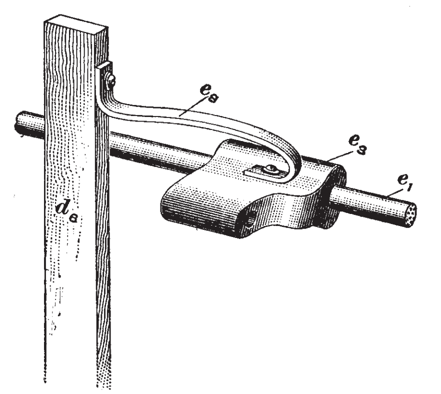
(a)

FIG. 8

At the top, the picker stick is attached to a rawhide picker e_3 by a strap e_8 or else is passed through a hole in the picker. The picker is free to slide back and forth on a spindle e_1 placed at the back of the shuttle box and projects into the box so that it engages the shuttle s. Fig. 8 (c) is a perspective view of a rawhide picker and shows the method of attaching it to the picker stick and picker spindle.


e_4
e_8
e_3
e_1
e
8
e_1
e_2
f_2
f_4
f
f_1
d_6
c_1
c_3
e_6
c
d_5
d_4
d_3
d_2
d_1
d_9
f_3
d_7
d_8

(b)


e_8
e_3
e_1
d_6

(c)

Fig. 8

Motion is imparted to the shuttle as follows: The picking shoe is so shaped that when struck by the revolving pick ball it will be forced downwards, thus imparting a partial rotary motion to the picking shaft. This motion throws the pick arm toward the center of the loom, thus drawing the sweep stick in and swinging the picker stick on its fulcrum. The picker stick drives the picker along its spindle, and as the picker presses against the shuttle the latter is thrown across the loom. These movements are, of course, accomplished with considerable speed and force, owing to the shape of the picking shoe and the rapid movement of the pick ball. A piece of leather strap e_2 is generally placed on the picker spindle for a buffer, to prevent the picker from being damaged at the end of its forward throw by striking the casting in which the picker spindle is fastened. After the shuttle has been thrown from the box, the picker stick is drawn back by means of a spring d_8 that is attached at one end to a leather strap d_7 screwed to the heel of the picker stick and at the other to an adjustable casting d_9, by means of which the tension of the spring can be regulated. To prevent the picker stick from being damaged by striking the end of the box when it is drawn back, and to act as a buffer to the picker when it is struck by the shuttle reentering the box, a roll of cloth e_4 is generally placed in the end of the shuttle box. The pick balls at both ends of the shaft c are set diametrically opposite each other, and as the picking motion is duplicated on the other side of the loom, the shuttle is thrown back and forth across the loom through each shed made by the shedding mechanism, thus interlacing the filling with the warp.

15. Timing the Picking Motion.—To time the picking motion the loom should be turned over until it is on the top center; that is, with the cranks vertically upwards. The nuts c_6 that fasten the pick ball c_3 to the casting c_1 should then be loosened and the pick-ball stud moved forwards or backwards in the slot until the picker stick just starts to move, and tightened in that position. If the loom is so arranged that it picks first from one side and then from the other, as in the case of the loom under consideration, it should be turned over 1 pick before setting the picking motion on the other side.

16. Shuttles.—The shuttle that carries the pick of filling through the shed is usually made of some close-grained hardwood, such as apple, Southern dogwood, persimmon, etc. The wood should be reasonably heavy and well seasoned so that the shuttle will not warp or crack after it is turned. Extremely heavy wood is not so desirable as that of medium weight, while light, soft, or coarse-grained wood is totally unsuitable. The shuttle is shaped as shown in Fig. 9, being conical at each end and hollowed

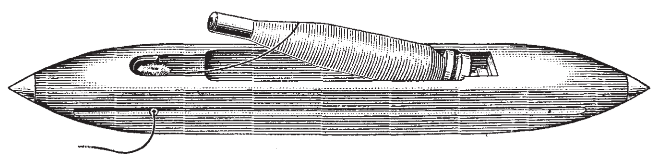


Fig. 9

in the center so as to receive the bobbin of filling yarn. At each end a metal tip is inserted to protect the shuttle when striking the picker and to present a smooth point to the yarn so that it will not break out the warp while passing through the shed. The shape of the shuttle is of great importance, since it must move across the loom in as nearly a straight line as possible so that it will not fly out.

It should be of a width and length depending on the shuttle box of the loom for which it is intended and should be provided with a suitable spindle for holding the bobbin of yarn. This spindle should be so arranged that it may be raised through an arc of about 30° so that empty bobbins may be removed and replaced with full ones.

When in the shuttle, the spindle should be held firmly by a flat steel spring, so that it cannot rise automatically. At the front end of the shuttle an iron or porcelain pot-eye is inserted, through which the filling is drawn from the bobbin. A groove in the side of the shuttle prevents its cutting the filling by rubbing it against those parts of the shuttle box with which the shuttle comes in contact. In the front end of the shuttle near the eye a $\frac{1}{4}$-inch hole should be bored straight through the bottom of the shuttle. A small bunch of yarn drawn through this hole until the filling will just run through the loose ends serves as a brush, or friction, on the filling, and these prevent its running off the bobbin too freely. This bunch of yarn should be cut off smoothly on the bottom of the shuttle.

BEATING UP

17. The third and last of the principal movements of weaving is known as **beating up.** As the shuttle is thrown through the shed it leaves a pick of filling between the warp threads but some distance from the fell of the cloth; it is therefore necessary to push the filling up to the cloth that has been previously woven. This is performed by means of the lay, Fig. 10 (*a*) and (*b*), which has an oscillating motion and carries the reed, through which the warp ends are drawn. The lay consists of a heavy beam of wood f supported by the lay swords f_1, which are generally fulcrumed on a rocker-shaft extending entirely across the loom near the floor, but which in some looms are fulcrumed on shorter studs. Generally there are two lay swords, one on each side of the loom just inside the side frames, but on broad looms three are often used for the sake of the extra support afforded the lay. The top of the lay is generally faced with a piece of steel f_5 known as the race plate or shuttle race, but on light looms the race plate may be only a strip of hardwood. The race plate should be so beveled that when the lay is in the position farthest from the fell of the cloth it will be parallel to the bottom shed; that is, to the warp yarn passing to the fell of the cloth from the harnesses that are down. The oscillating motion of the lay is imparted to it by the crank-shaft of the loom. This shaft is bent so as to form two cranks just inside the frames of the loom and in line with the lay swords. The cranks are connected to the lay by wooden

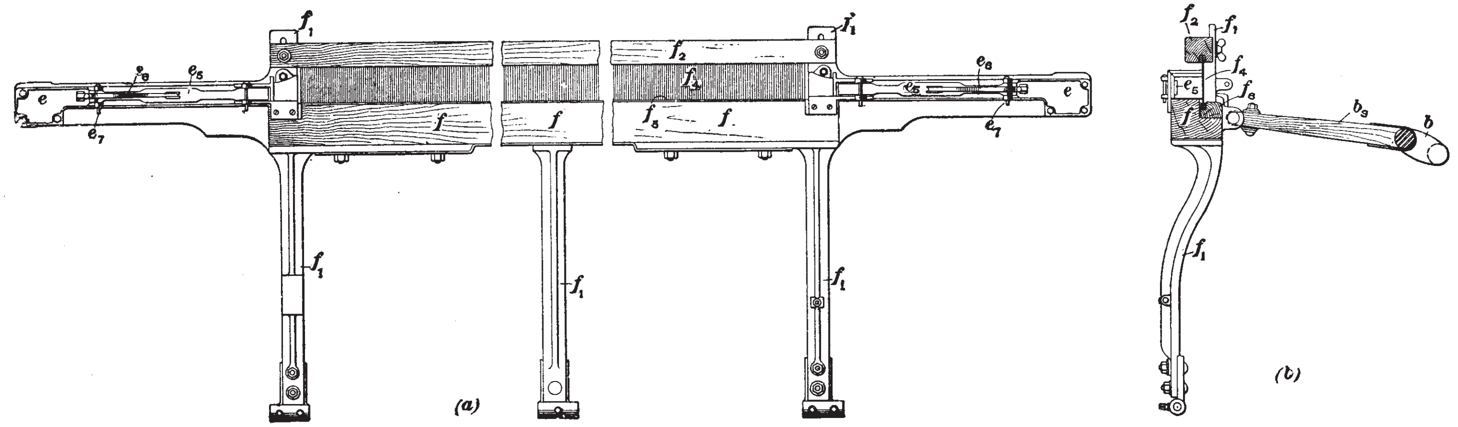


Fig. 10

pitman arms b_3 fastened by means of iron straps encircling the cranks and the connection on the lay sword. By means of these connections the rotary motion of the crank-shaft imparts a forward and backward, or oscillating, motion to the lay.

18. Reed.—The reed f_4 is an arrangement of vertical flat steel wires spaced a given distance apart and securely fastened at the top and bottom by two strips of wood bound together with a waxed cord, as shown in Fig. 11. The space between two wires is known as a **dent.** Reeds are made with any desired number of dents per inch, according to the requirements of the cloth that is to be woven. The reed has three important functions: (1) It separates the ends of the warp and distributes them evenly throughout the entire width of the fabric. (2) It beats the filling up to the fell of the cloth after each pick has been inserted, being attached to the oscillating lay. (3) It forms a rest for the shuttle in passing through the shed and in conjunction with the race plate guides it from one box to the other. When placed in the lay the lower edge of the reed rests in a groove and is securely fastened by means of a strip of wood f_6 that is firmly bolted against it, as shown in Fig. 10 (b). The top of the reed rests in a groove in the reed cap f_2 that is bolted to extensions of the lay swords.

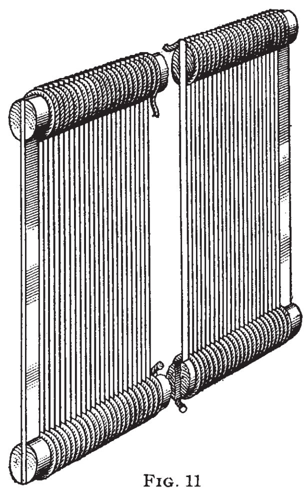


FIG. 11

19. Shuttle Boxes.—The shuttle boxes, as will be seen in Fig. 10 (a) and (b), are simply extensions of the lay at each side of the loom, forming receptacles for the shuttle during the time that the latter is at rest. In Fig. 12 a perspective view of a shuttle box is shown. The bottom of the shuttle box is a continuation of the race plate, while the back of the box should conform to the line of the reed.

The bottom and back of the box are of course stationary, but the front of the box consists of a movable piece of metal e_5 known as the **binder,** which is pivoted on a pin e_7 at the front of the box and is so shaped as to gradually check the speed of the shuttle as it enters the box; a flat steel

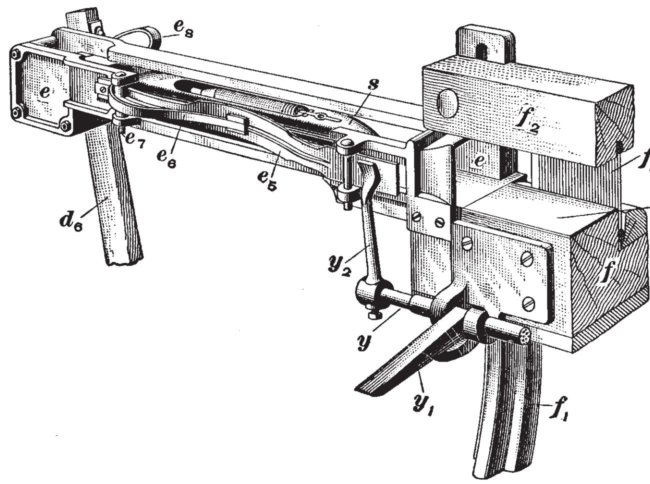


FIG. 12

spring e_6 presses the binder against the shuttle with sufficient force to prevent its rebounding from the box. The best results are obtained if the binder is so shaped as to be in contact with the whole of the flat part of the face of the shuttle. The binder should not have a sharp swell, since in that case the shoulder of the shuttle will become worn by striking it constantly, nor will the shuttle be checked in the best manner.

AUXILIARY MOTIONS OF WEAVING

LET-OFF MOTION

20. The object of the **let-off motion** is to allow the warp to be unwound from the beam as fast as the cloth is woven and yet at all times keep a proper tension on the warp yarn. There are two kinds of let-off mechanism commonly applied to power looms—the *friction let-off*, which is applied to the great majority of woolen and worsted looms and also to a large extent to cotton looms, and the *automatic let-off motion*, which is more generally applied to looms for weaving cotton goods than to those used for

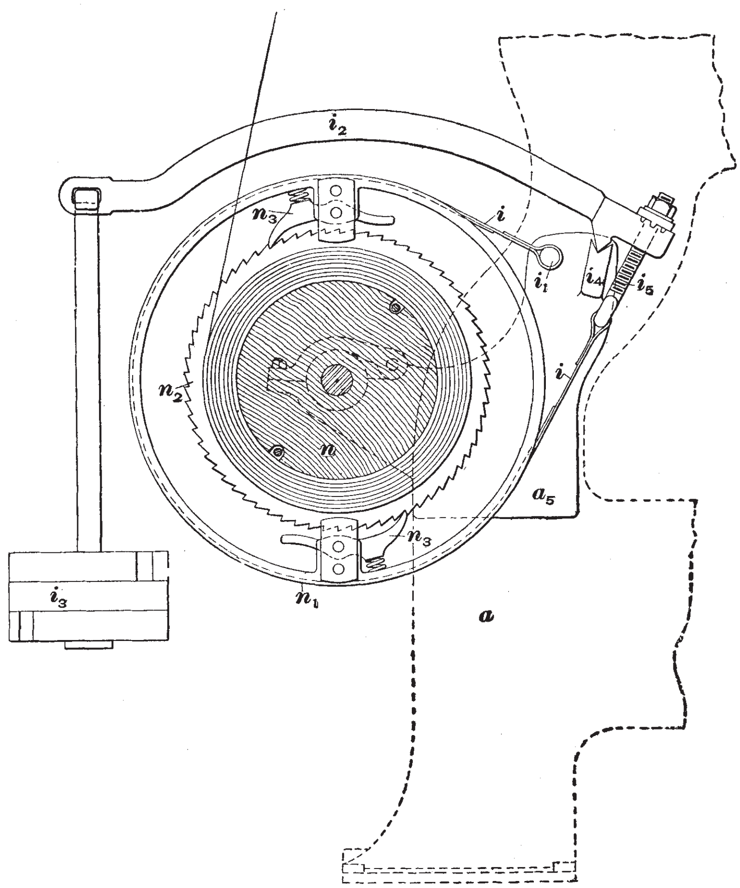


FIG. 13

weaving woolen and worsted fabrics and consequently needs no further mention.

Fig. 13 is an illustration of the type of friction let-off most commonly applied to woolen looms. The warp is wound on the loom beam n, which is constructed with two slightly flanged beam heads n_1. The beam rests in supports a_6 at the back of the loom on journals cast on the beam heads instead of on the shaft of the beam, so that the beam will always turn true, even if the shaft of the beam has become bent through accident or misuse. The necessary tension of the warp is obtained by applying friction to the beam heads, which is accomplished by means of steel bands i fastened to studs i_1.

These bands pass entirely around the beam, resting in the recessed circumference of the beam heads, and are attached at the other end to a lever i_2 fulcrumed on a knife edge at i_4. Any amount of friction may be placed on the beam, and consequently any degree of tension on the warp, by hanging suitable weights i_3 on the ends of the levers i_2. A leather strap is generally riveted to the inside of each steel friction band in order to make the let-off more even and uniform. If there is no leather strap on the friction band, a strip of cloth should be wound several times around the beam head between the band and the beam. The height of the lever i_2 may be adjusted by means of a threaded bolt i_5 and nut attached to the end of the friction band. This is necessary if the lever touches the beam head.

21. Ratchet Beam Head.—The beam head shown in Fig. 13 and applied to the loom beams commonly used for woolen and worsted looms is constructed as follows: Ratchets n_2 are securely fastened to the ends of the beam by iron rods running clear through the beam and by lugs embedded in the wood. The beam head, on which the friction band of the let-off motion works, is loose on the shaft of the beam but is held from turning by means of two pawls n_3 fastened to the beam head and engaging with the ratchet on the beam. These pawls prevent the beam from turning forwards and unwinding the warp without turning the beam head and operating the friction; but should the weaver desire to turn the warp back after picking out or for any other reason, the loom beam may be readily turned without lifting the weights on the let-off, the pawls taking up the required number of teeth in the ratchets. The warp may be slackened by raising the pawls from contact with the ratchets.

TAKE-UP MOTION

22. The object of the **take-up motion** is to wind the cloth over the breast beam and on to the cloth roll as fast as the filling is inserted and the cloth woven. On looms of the type under description, the conditional take-up is often used. In any take-up motion, the speed at which the cloth is drawn over the breast beam governs the number of picks per inch that are placed in the cloth; the greater the speed, the fewer the picks per inch, and vice versa. In the type of take-up motion known as the **conditional,** the number of picks per inch in the cloth depends on the tension of the warp in weaving, which is governed by the amount of friction on the let-off motion and by the position and amount of weight on the take-up motion.

The take-up motion applied to the cam-loom shown in Fig. 1 is of the conditional type, the mechanism being as follows (see Fig. 14): An elbow lever j is fulcrumed on a stud j_6 fastened to the frame of the loom; one arm of this elbow lever carries a sliding weight j_2, while the other arm rests against a pin f_8 fastened to the lay sword f_1 of the loom. Attached to this elbow lever is a pawl j_1 so shaped at one end as to engage with the ratchet r, which is fastened to a short shaft carried in a bearing on the frame of the loom. On the other end of this short shaft is fastened a small gear r_1 that engages with a gear r_2, which, in turn, engages with a gear p_1 on the cloth roll p of the loom, around which the woven fabric is wound. As the lay moves backwards, the pin f_8 on the lay sword will move the lever j backwards, thus raising the weight j_2 and forcing the pawl j_1 forwards, so that it will take up a tooth on the ratchet r; as the lay moves forwards, the pin f_8 moves from the arm of the lever and the weight tends to return the lever j to its former position, but since the pawl has taken up a tooth on the ratchet, in so doing it must turn the ratchet and wind the cloth on

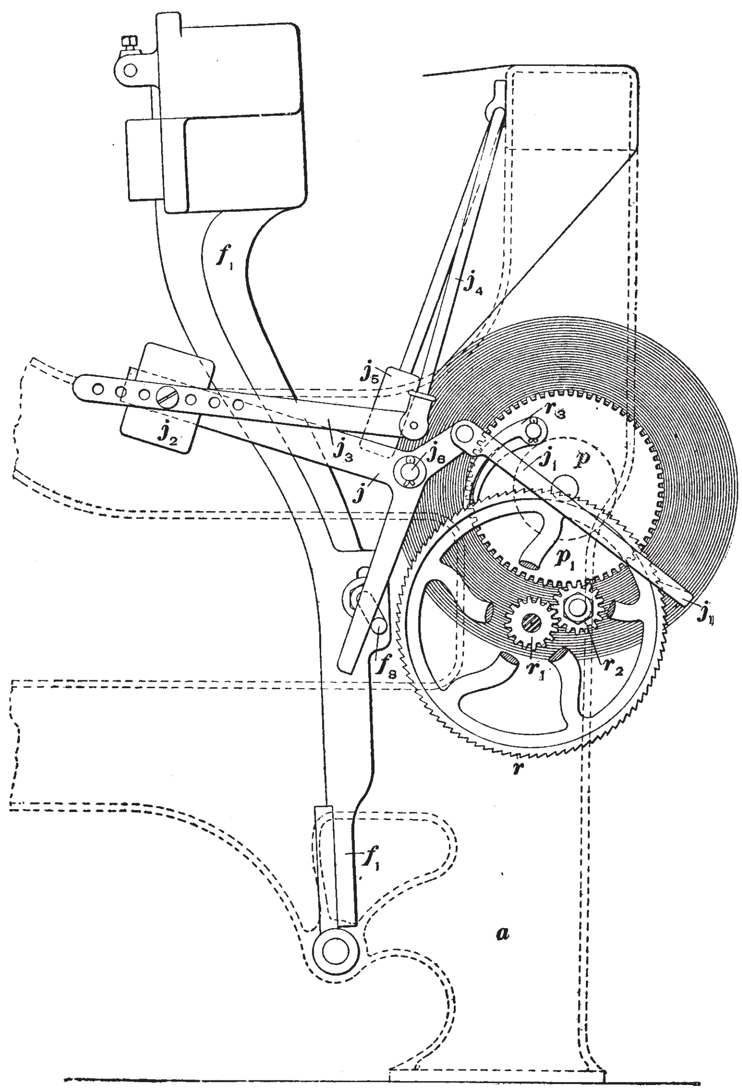


FIG. 14

the cloth roll. By this means, the cloth is kept at a constant tension. As more cloth is woven, the weight will drop; but when it has fallen a sufficient distance for the lever to come in contact with the pin f_8 it will be raised again by the pin and the pawl will take up one or more teeth in the ratchet. A stationary, or set, pawl r_3 on a stud in the frame of the loom engages with the teeth of the ratchet and prevents the tension of the cloth from pulling the ratchet around in the opposite direction while the pawl is taking up more teeth. This is a double pawl so constructed that one part will rest half way between two teeth when the other part is engaging a tooth; by this means the ratchet is held from turning back if it is moved forwards the distance of one-half tooth. The weight j_2 slides on an arm of the lever j and is held in position by means of the rod j_3, to which it is pinned. This rod is connected with a bent rod j_4 to which a weight or pad j_5 resting on the cloth wound on the cloth roll is attached. The object of this mechanism is to gradually force the weight toward the end of the lever j as the roll of cloth grows in diameter, since when the cloth roll is of a small diameter less power is required to keep the cloth at the same tension than when the cloth roll grows larger and the tension of the cloth is acting on a roll of greater diameter. With a small roll the weight j_2 will be close to the fulcrum j_6 of the lever j, but when a large quantity of cloth is wound around the roll the weight will assume a position at the end of the lever, as shown in Fig. 14.

The number of picks per inch in the cloth must be regulated by experiment; if more picks per inch are desired a greater tension will be required on the warp, but if less picks are required the tension of the warp must be reduced. The tension is regulated by the let-off motion, more weights on the friction producing greater tension of the warp, and vice versa. The position of the weight j_2 also governs the number of picks per inch to a certain extent, since if it is pinned to the rod j_3 in a hole near the end of the rod it will exert a greater strain on the cloth roll than if pinned to the rod in a hole nearer the fulcrum of the lever j.

FILLING STOP-MOTION

23. The object of the **filling stop-motion** is to stop the loom if the filling breaks or becomes exhausted; were it not for this motion the loom would continue to run without filling being inserted in the warp until this was observed by the weaver. The type of filling stop-motion applied to woolen and worsted looms operates in the center of the lay midway between the shuttle boxes; it is therefore known as the **center stop-motion** to distinguish it from a stop-motion applied to cotton looms, which operates at one side of the lay between the cloth and the shuttle box.

The Knowles center stop-motion is illustrated in Fig. 15 (*a*) and (*b*), which are views of the mechanism as seen from each end of the lay. A casting f_9 fastened to the lay carries a four-pronged filling fork t so swiveled as to rise and fall in a vertical plane. Directly under the filling fork a deep slot is cut in the lay, in which the fork freely falls when a pick of filling is not in the shed to support it. A dagger socket t_2 carrying a dagger t_3 is swiveled on a part of the same casting as the filling fork and is connected to it by means of a rod t_1. A casting a_6 bolted to the breast beam of the loom carries at its extremity a curved plate w, on which the dagger t_3 rests and is held by a weak spring t_4 that tends to make it follow the curve of the plate as the lay oscillates. When the lay moves back, the plate raises the dagger t_3, which in turn operates the rod t_1 and raises the fork t so that the shuttle may pass underneath it. If the shuttle leaves a pick of filling in the shed, the fork will be prevented from entering the groove in the lay, and as the latter moves forwards the dagger t_3 will be held from the plate w and will pass over the tumbler u, so that the loom will continue to run. Should the filling be absent, however, the fork will enter the groove, and as the lay comes forwards the dagger t_3 will follow the curve of the plate until it comes in contact with the end of the tumbler u. The force of the dagger striking the tumbler presses the latter forwards and downwards, and a pin u_1 attached to it forces down the tumbler finger h_8,

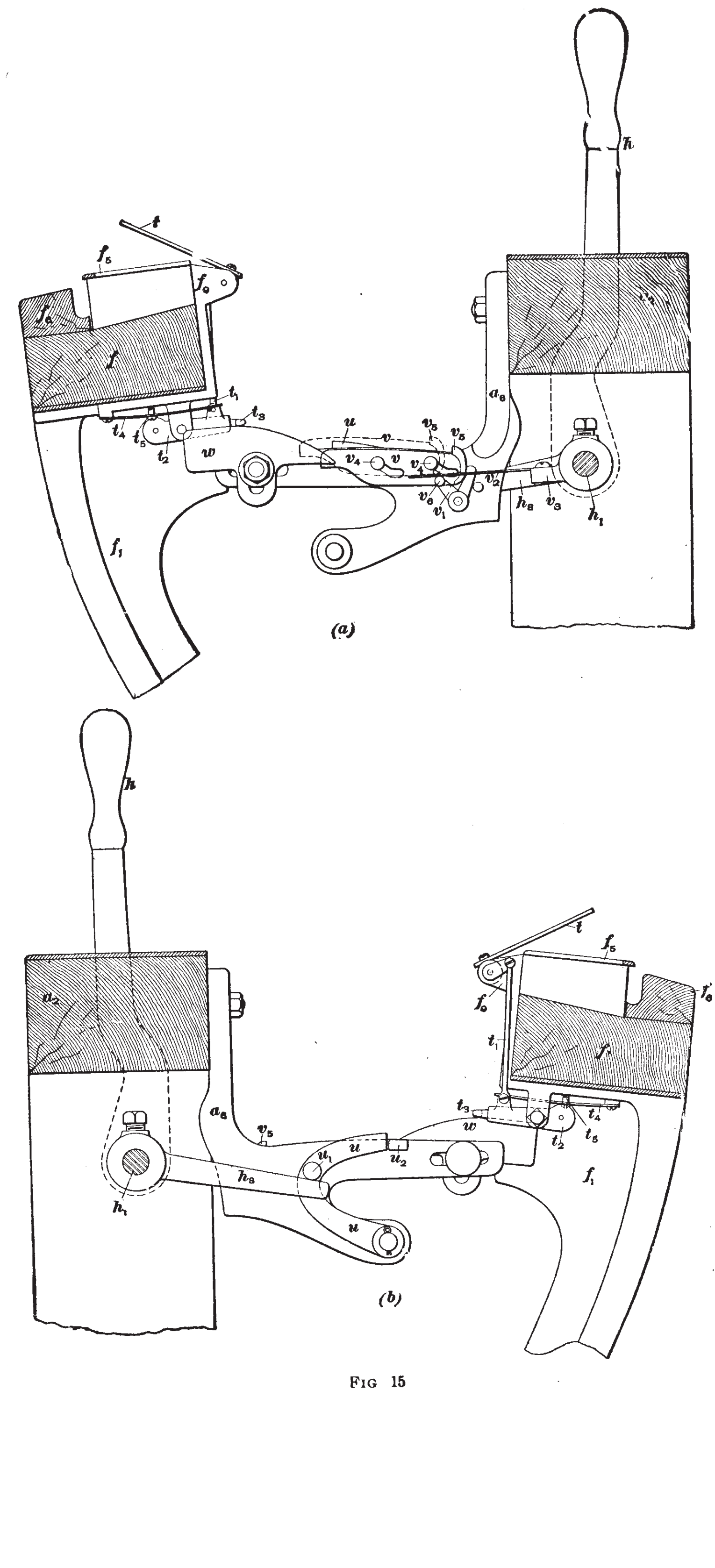


Fig 15

which is setscrewed to the shipper shaft h_1, thus producing a sufficient rotary motion of the shaft to disengage the shipper handle from its notch and allow the loom to stop.

When the loom is stopped and the lay turned back by the weaver, the filling is apt to get from beneath the filling fork, and when the loom is started again, if a special device were not provided, there would be nothing to prevent the dagger from coming in contact with the tumbler and stopping the loom on the first pick. This would also occur on the first pick of the loom, before any filling was inserted in the shed. The device for preventing this consists of a sliding shield v fastened loosely to the casting a_6 by means of pins v_4 that engage with slots cut diagonally in the shield, so that when the latter is pushed forwards it will rise and assume the position indicated by the dotted lines. The shield is pushed forwards by means of a flat spring v_2 attached to a casting v_3 setscrewed to the shipper shaft h_1. As the shipper shaft is turned when the loom stops, this spring forces down a pin v_6 on the shield tumbler v_1, which in turn pushes the shield v into the position shown by the dotted lines. As the lay moves forwards on the first pick, the dagger t_3 will therefore clear the tumbler u and slide over the top of the shield, even if no filling is under the fork t. A projection v_5 on the shield is engaged by the dagger after it has passed the end of the tumbler and the shield is forced back into position, so that the stop-motion will operate if the filling is absent on any pick after the first.

24. Setting and Adjusting the Filling Stop-Motion.—The curved plate w should be adjusted by loosening the bolt that fastens it to the casting a_6 and setting it in such a position that when the lay is at the limit of its backward movement the filling fork t will clear the shuttle by $\frac{3}{16}$ inch. The forward end of the curved plate should be adjusted so that the dagger will just touch the top of the casting a_6 before coming in contact with the tumbler u. This space should not be too great, for in this case the dagger is liable to rebound and miss the end of the tumbler.

The spring t_4 should be adjusted by means of a screw t_5 so that it will exert only sufficient pressure to cause the dagger t_3 to follow the cam and engage the tumbler. The tension of this spring should not be great enough to cause the filling to sink into the lay, as this is liable to make kinks in the filling. With the belt off the loom or the connections of the shipper handle with the friction pulley disconnected, the shipper handle should be thrown on and the casting h_8 raised until the tumbler just comes in contact with the projection u_2 on the casting a_6. It should be setscrewed in this position, but care should be taken not to have the connection too tight, or the loom is liable to be jarred off; that is, the vibration of the loom will cause the shipper handle to slip from its retaining notch and stop the loom. When the shipper handle is thrown on, the casting v_3 should be loosened and turned until the pressure of the spring v_2 is just sufficient to raise the shield v to the limit of its movement; the casting should then be tightened in this position.

PROTECTOR MOTION

25. If for any reason the shuttle fails to travel completely across the race plate and remains in the shed, it is evident that as the lay moves forwards the shuttle will be trapped in the shed and the pressure of the lay against it will result in the warp ends being broken out. Not only is the shuttle liable to be stopped in the center of the shed, but sometimes it will fail to be properly boxed and the rear end will project into the shed so that the lay in beating up will break the ends of the warp at the edge of the cloth. Whenever either of these conditions occurs it is known as a *smash*, and it is the object of the **protector motion** to prevent such smashes. A rod y, Fig. 16 (a) and (b), known as the *protector rod*, is supported by bearings fastened to the lay l and has setscrewed at each end a finger y_2 that presses against the binder e_5 of the shuttle box. Two daggers y_1 are also secured to the protector rod just in front of the lay swords; they are designed to engage with the grooved ends

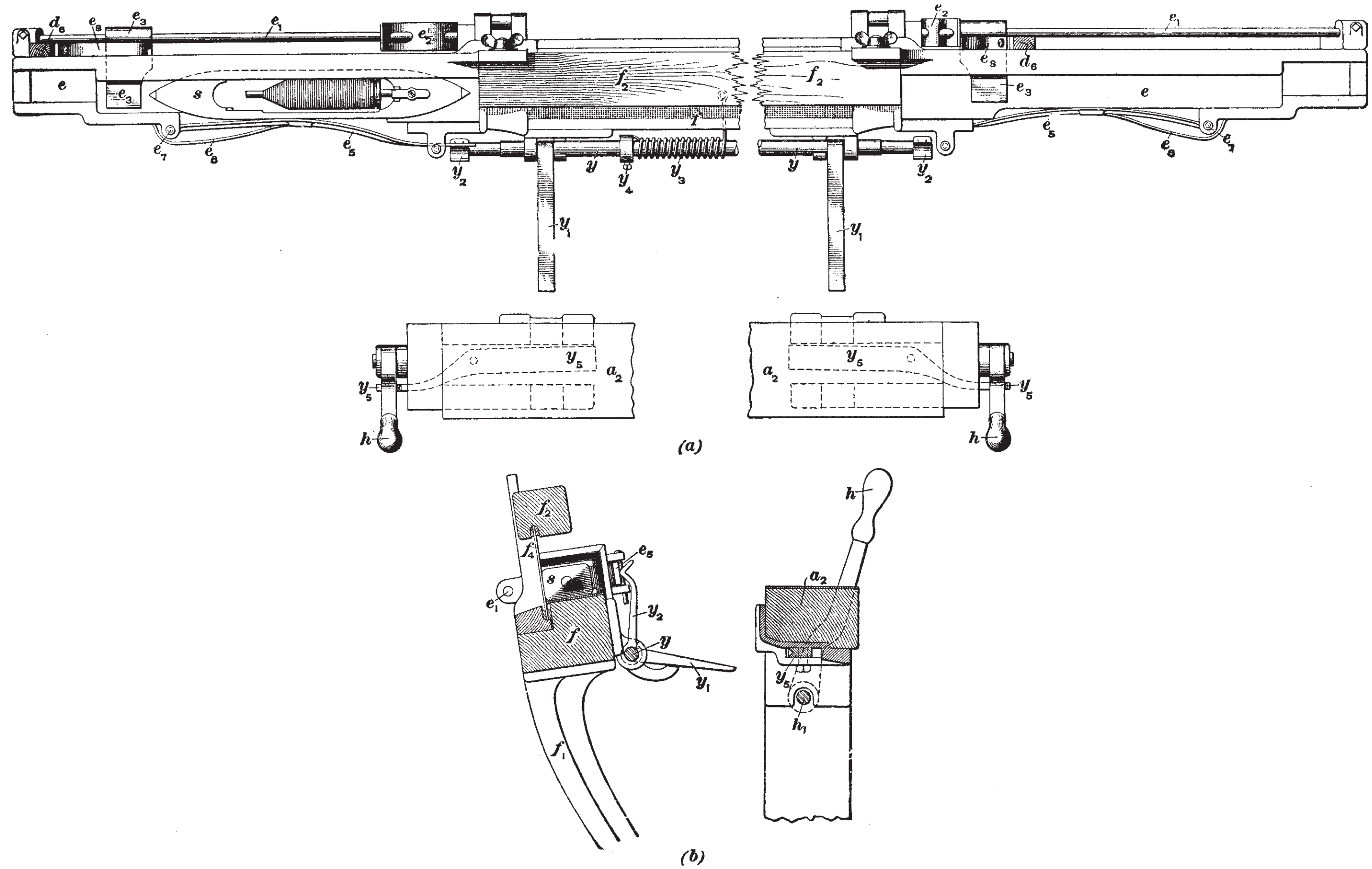
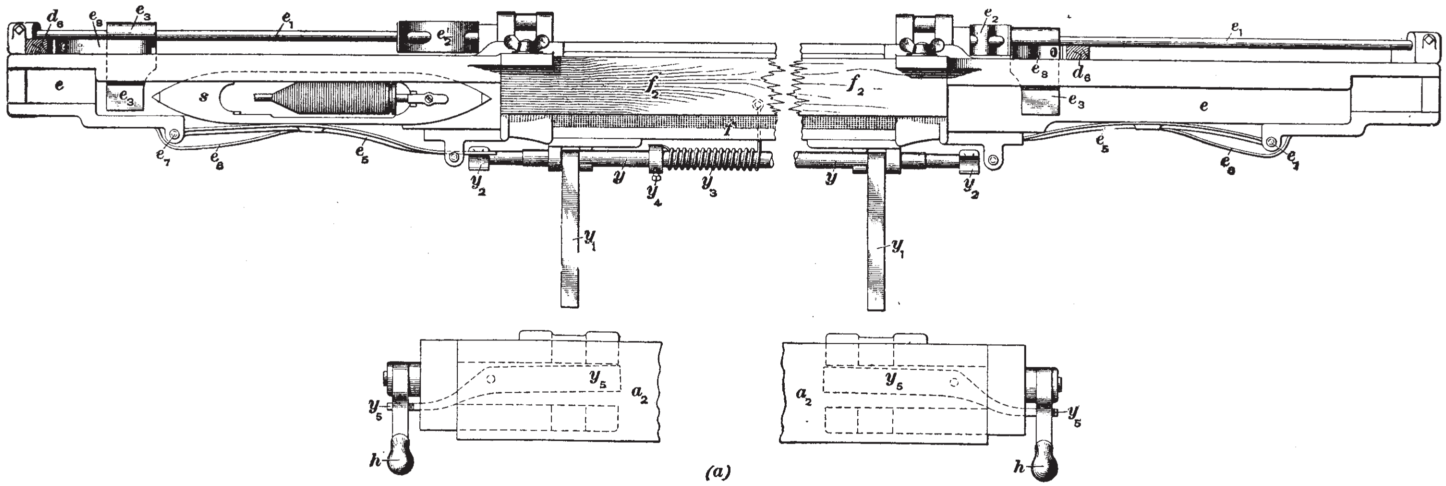


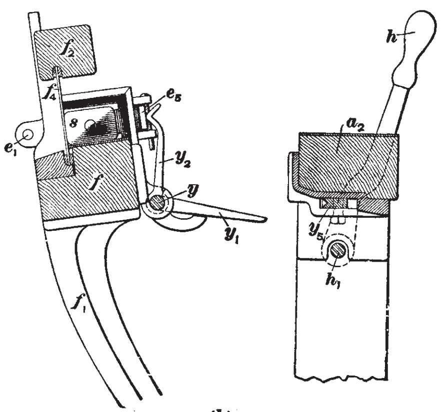
Fig. 16

of the levers y_5, the other ends of which are in contact with the shipper handles h of the loom. A spring y_3 fastened to the lay and to a casting y_4 setscrewed to the protector rod tends to keep the fingers y_2 constantly pressed against the binders, and the daggers y_1 in a raised position. When the shuttle is properly boxed, it will press the binder e_5 outwards, in so doing moving the finger y_2 through a distance sufficient to impart a slight rotary motion to the protector rod y, so that the dagger y_1 will just clear the grooved end of the lever y_5. If, however, the shuttle fails to reach the box or fails to enter the box far enough to press out the binder, the fingers, rod, and daggers will remain undisturbed, so that the latter will remain in a raised position, and as the lay comes forwards, they will engage with the levers y_5, which in turn will force the shipper from its retaining notch and stop the loom, the daggers at the same time holding the lay so far from the fell of the cloth that it will not be able to break the warp ends by driving the shuttle against them. Blocks of rubber are often placed in the rear of the levers y_5 to cushion the blow of the daggers and thus prevent breaking any of the parts of the loom. When the shuttle is again placed in the box, all the parts resume their normal position and the loom is ready to run.

26. Setting the Protector Motion.—When setting the protector motion, it should first be noticed if the daggers are in line with each other; that is, if both are fastened to the protector rod in the same relative position. Then the shuttle should be placed well in the box and the finger on the protector rod adjusted so that the daggers will pass about $\frac{1}{4}$ inch below the grooved end of the levers y_5. The shuttle should now be placed in the opposite box and the same operation performed. Then take the shuttle out of the loom, and pull the lay forwards, noting carefully if each dagger engages with the grooved lever properly. On some looms only one dagger is used, which is placed in the center of the lay, the knock-off lever y_5 being made correspondingly longer.



(a)



(b)

Fig. 16

ends on one side of the loom, and the other the selvage ends on the opposite side. The selvage heddles z_2 are attached to these bosses by means of straps and hooks, and at the top similar straps and hooks are led over a roller z_3. The action of the crank gives the shaft z and the bosses z_1 a partial rotary motion that raises and lowers the selvage ends independently of the rest of the warp. The amount of motion imparted to the selvage heddles should be so regulated by means of the pin in the slotted casting c_4 that the selvage yarn will be lifted through the same distance as the rest of the warp. In setting the selvage motion, the loom should be turned over until the harnesses that are changing are level, and the selvage ends set level at this point.

TEMPLES

28. In order to hold the cloth to its full width, so that the contraction due to the interlacing of the filling with the warp will not reduce the width of the cloth too greatly as compared with the width of the warp in the reed, thus straining the selvage ends, the edges of the cloth are passed through **temples**, which are devices that not only hold the cloth to its full width, but also allow it to pass freely to the cloth roll. Fig. 18 (*a*) shows a view of a Knowles temple, consisting of a casting x fastened to a bar x_1 that is carried by brackets a_7, a_8 screwed to the breast beam of the loom. As shown in the illustration, the bar x_1 is pinned to the bracket a_7, while the bracket a_8 has a projection a_9 that holds the bar x_1 in position. The spring q, the tension of which may be adjusted by means of the screw q_1, tends to force the bar x_1 backwards, but at the same time allows the bar to be forced forwards if the lay of the loom comes in contact with the temple. This prevents any damage that might occur if the temple came in contact with the reed.

The temple consists primarily of a tapering stud x_2, Fig. 18 (*b*), in which a number of grooves, usually five, seven, or nine, are cut somewhat obliquely; in these grooves

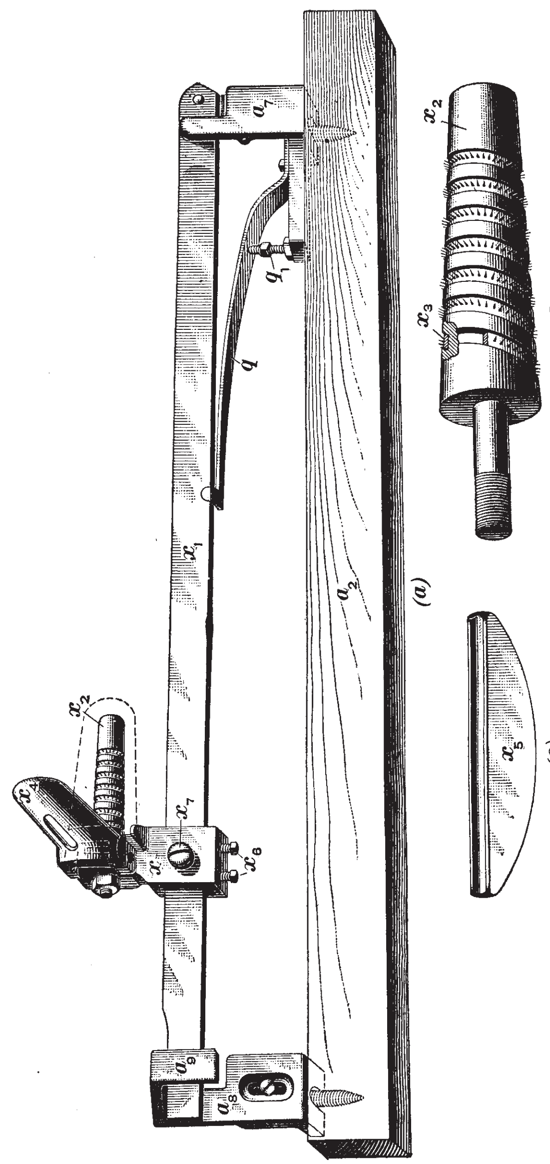


Fig. 18

are placed rings x_3 in which fine pins are inserted, so that the rings may engage with the cloth and at the same time be allowed to turn as the cloth passes through the temple. The stud x_2 together with the pin rings is sometimes called the **burr** of the temple. The rings near the free end of the roll are smaller than the others so that they alone will not hold the cloth nor have a tendency to make holes in the fabric. As the pin rings x_3 are placed obliquely on their supporting spindle, the effect will be that while each pin is in contact with the passing cloth it will be moving in a direction oblique to the center line of the loom, so that when a pin extracts itself from the cloth it is nearer the selvage than when it first entered in contact with the cloth. As all the pins act in the same manner, the combined effect will be that the cloth, on either side of the loom, will be pulled outwards and thereby stretched transversely. A cap x_4, which is shown in a raised position in Fig. 18 (*a*), covers the burr and holds the cloth securely in contact with it, the burr being just beneath the cloth and the cap just above the cloth.

In order to adjust the temple at any angle on the bar x_1, a small swivel x_5, shown in Fig. 18 (*c*), is inserted between the bar and the casting x, so that by adjusting the screws x_6, after first loosening the screw x_7, the temple may be set at any angle and afterwards tightened again. Fig. 18 (*a*) shows only one temple, but it should be remembered that there is one on each side of the loom, so that both edges of the cloth are held out as nearly as possible to the full width of the warp in the reed, as shown in Fig. 19, which illustrates the method of applying a pair of temples to a loom. The tension of the spring should always be carefully adjusted so that the temple will follow the cloth perfectly; that is, as the lay beats up and forces the fell of the cloth back, sometimes as much as an inch, the temple should recede also the same distance, and when the pressure of the lay is removed, it should follow back with the fell of the cloth. If, when the reed recedes and the fell of the cloth follows it, the cloth rubs back over the burr, marks or other damages are apt to

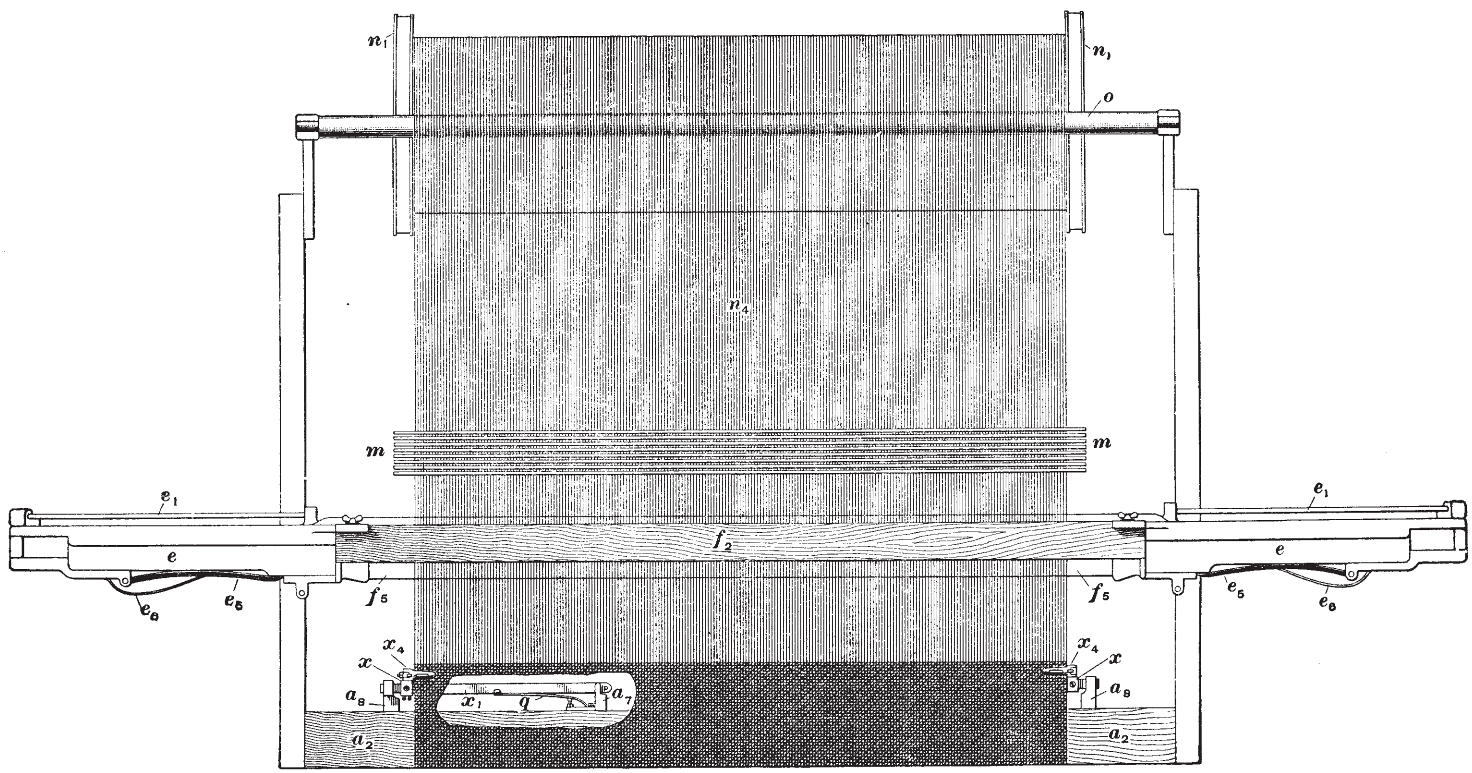


Fig. 19

be made near the selvage of the cloth. The temples may be set for any width of cloth by simply loosening them on the bar x_1 and sliding them in or out as may be desired. They should always be so set as to hold the cloth out as wide as possible, so that the selvage ends will pass as nearly as possible in a straight line from the whip roll through the reed to the edge of the cloth. The temple should also be set as close to the fell of the cloth as possible, and the heel of the temple adjusted so that no contact can take place with the reed, but so that the lay will move the temple back before it strikes the reed.

PRODUCTION

29. In estimating the **production** of a loom, a suitable allowance must be made for the necessary stoppages for renewing the filling, tying in broken warp ends, cleaning, and placing new warps in the loom. This allowance must vary according to the class of goods that is being woven and the quality of the warp and filling yarns. An allowance of from 10 to 15 per cent. will be found sufficient in most instances.

To find the production of a loom:

Rule.—*Multiply the speed of the loom by the number of hours the loom is operated and by 60 (minutes in 1 hour). Divide the product thus obtained by the number of picks per inch being inserted in the cloth multiplied by 36 (inches in 1 yard). Deduct from this result a suitable allowance for stoppages.*

Example.—A loom is operated 45 hours per week at a speed of 96 picks per minute. If the cloth being woven contains 48 picks per inch and the loom is stopped 10 per cent. of the time, what is the production per week?

Solution.— $$\frac{96 \text{ picks per min.} \times 45 \text{ hr.} \times 60 \text{ min.}}{48 \text{ picks per in.} \times 36 \text{ in.}} = 150 \text{ yd.}$$

10 per cent. of 150 yd. = 15 yd. 150 yd. − 15 yd. = 135 yd. Ans.