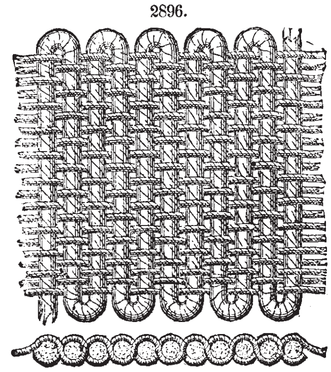
LOOMS, CONSTRUCTION AND USE OF. Weaving is the art of interlacing threads or other fibres in such a manner as to form a continuous fabric. A loom is a mechanical contrivance for accomplishing this. If a piece of plain cloth or calico be examined, it will be found to consist of a number of threads placed parallel to each other, which are interlaced alternately by a single thread passing from side to side of the cloth, Fig. 2896. This separate thread which runs crosswise the fabric is usually called the *weft* or *woof*. The lengthwise threads are called the *warp*. The warp-threads are usually much finer than the weft-thread, and the fibres are usually spun together in a similar manner to a two- or three-stranded cord. The weft-thread, on the contrary, is but slightly spun, and consists ordinarily of but one strand. By this means the weft is made soft and yielding, and is better adapted to fill the interstices of the cloth; while the warp-thread is made firmer, and not only adds more strength to the fabric, but is much better suited to undergo the weaving process. In the throwing or spinning of silk (see SILK MACHINERY) this difference of twisting is expressed by calling the weft-thread "tram," and the warp, owing to its excessive twist, is termed "organzine."

2896.



The essential portions of all looms are as follows: 1. A substantial frame for holding the warp; 2. Means for separating the threads of the warp to admit of the passage of the weft, and of so governing the warp-threads as to cause them to interlace with the weft in the desired manner; 3. A means of carrying the weft-thread horizontally across and between the warp-threads while the latter are suitably opened; 4. A means of forcing or packing the weft tightly into the angle formed by the opened warp, and so rendering the fabric tight and compact.

It will be observed that in the last three requirements the chief operations of weaving are briefly summed up, namely: the opening of the warp, the passage of the weft, and the beating of the weft into position. Then the warp opens again, an interchange of its threads occurs, and the same operations are repeated. The simplest means of meeting these demands exists in the old hand-loom, which is still often used in weaving silk, rag carpets, and various home-made fabrics, and the principal parts of which are common to all looms. In describing the various processes of weaving, such mechanism as is essential to them, and only devices found in all weaving apparatus, are detailed. Under LOOMS, POWER, are given the various modern forms of loom by which these processes are carried out.

In every loom, between opposite ends of the framework are placed two cylindrical beams, *A* and *B*, Fig. 2897. The beam *A* is the *warp-beam*, on which the warp is wound, and *B* is the *cloth-beam*, upon which the cloth is wound as it is woven. The warp-threads are placed parallel to each other, and are carried from the warp-beam *A* and attached to the cloth-beam *B*. This is done by threading the knotted ends of the threads upon a small rod or lath, wedging it into the slot or groove formed

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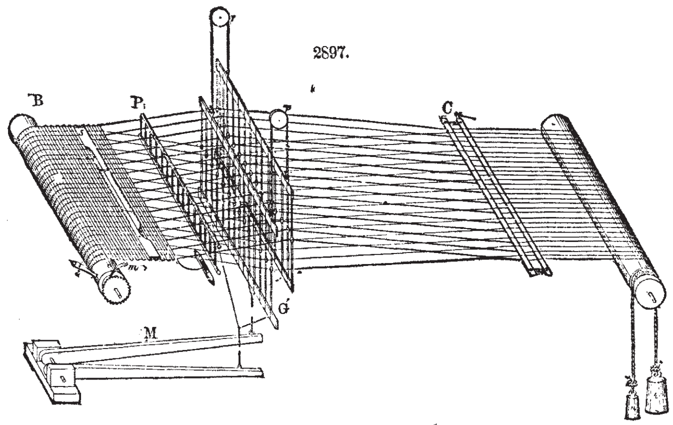

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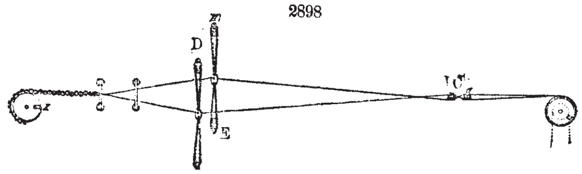

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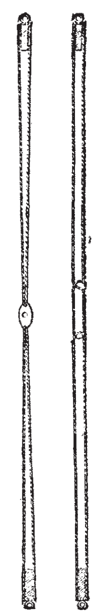


in the beam *B* for that purpose, which is shown in section at *x*, Fig. 2898. In order to keep the threads in their relative position and parallel to each other, two rods are inserted between the warp-threads *C*, in such a manner that each thread passes *over* one of the rods and *under* the other alternately, as shown. Thus a cross or lease is formed by the threads between the two rods, which not only keeps the threads in proper order, but enables the weaver to detect with ease the proper position of any broken thread he may have to repair. This arrangement of the threads is formed during the process of warping. After the warp has passed the lease it is then passed through *the heddles*, as shown at *D* and *E*, Fig. 2899. The heddles are composed of a number of threads stretched between two *laths*, *G*, Fig. 2897, and they have loops made in the middle of them, or an eye called a *mail* is threaded upon them instead. These loops or eyes are for the purpose of passing the warp-threads through. There are two heddles shown, one of which receives every alternate thread of the warp, and the other receives the remainder. If either of them be raised, it will also raise the warp-threads which have been threaded through the loops or mails of it, and thus make an opening or *shed*, as it is usually called, for the passage of the shuttle. Heddles are made of various forms, materials, and strength, according to the particular fabric or purpose for which they are required. In Fig. 2899 are shown two common modes of forming them, one with a loop and the other with an eye or mail. For weaving silk warps, the mails are usually made of glass; but for cotton and other materials, steel or brass is generally used. The healds or heddles are made by means of very ingenious machines, known as heald-knitting or -making machines. The upper laths of each heddle are connected to cords which pass over pulleys as shown, and thus they balance each other. The arrangement of laths and heddles is called the *loom-harness*. The lower laths are connected with the treadles *M*, by means of which the heddles are alternately raised and lowered.

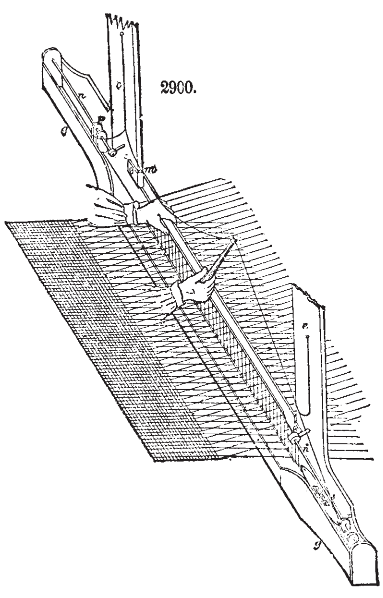
The warp-threads, after they have been threaded through the heddles, are passed through the *reed* *P*, which is composed of narrow strips of metal or flattened wire. These strips were formerly of reed, and hence the name. The reed is fixed into the lower part of a frame, called the *batten*, Fig. 2900, which is suspended from two *gudgeons*, and is capable of being moved a short distance to and fro, in a line parallel to the warp-threads. At each side of the batten, and about level with the bottom of the openings in the reed, are placed two shuttle-boxes, *g g*. These boxes have a spindle fitted lengthwise over the centre of them, upon which the picker, a kind of hammer, is made to slide. The two pickers are connected together by a slack cord *m*, to the centre of which the "picking-stick" is attached. Two short ends are connected to the picker-cord to keep it suspended and free to work. The boxes are suited to the size of the shuttle, which is driven with considerable velocity from one box to the other by means of the picking-stick and pickers. It is known as the fly-shuttle, and was patented by John Kay in 1733. Fig. 2900 shows the batten detached from the loom, in which *p p* are the pickers, which slide upon the spindles *n n*, *s* the shuttle placed in the shuttle-box. The pickers are variously made, but principally of hide dressed so as to resemble horn.

The loom being ready for the actual operation of weaving, the weaver takes his seat, and places the shuttle in one of the boxes, after pushing the picker back to the far end of the box. A short length of the weft-thread is allowed to hang out of the eye of the shuttle, so that it may be caught on the edge of the warp as the shuttle enters the shed for the first time. He then takes hold of the batten by the left hand in the position shown in Fig. 2900, and holds the picking-stick in his right hand. The shuttle is shown to be in the right-hand box; in this case the weaver places his right foot upon the right treadle, and depresses it, which causes the left treadle to rise, and an opening or shed is formed in the warp, as shown. He first pushes the batten backward a few inches, which causes the opening in the warp to appear in front of the reed as well as at the back, and thus gives room for the shuttle. He next, with a smart jerk of the right hand, throws the shuttle through the warp and into the opposite shuttle-box, where it comes into contact with the picker, and drives it to the far end of the box. Then he draws the batten toward him, which brings with it in front of the reed the weft-thread. He then treads upon the left treadle, and at the same time pushes the batten backward, which opens the shed ready for throwing the shuttle back to the right-hand box. When the shuttle is thrown he again draws the batten toward him, which pushes the weft-thread against the last thread, or shute. Thus the operation is continued by repetitions of the three motions necessary to the production of cloth, viz., opening the shed by means of the treadles, throwing the shuttle, and beating together the weft-threads by the reed which binds them together compactly and evenly.

Although the fly-shuttle has been in use since 1733, the old mode of throwing the shuttle by hand is in frequent use, principally among silk-weavers. The fly-shuttle is made straight in form, as shown in Fig. 2901. It is usually made of boxwood, and is tipped at each end with smooth steel points. There is an oblong hole mortised out of the shuttle for the reception of the weft-bobbin. In silk-weaving this bobbin is called a quill, but is generally made of a small reed about the length of a quill-barrel. The reed still retains the name of quill, although quills are not used now, owing to their extra cost. Two small wire springs are attached to the quill, which cause a light friction and thereby a slight tension of the thread. The weft-thread is made to pass out at the side of the shuttle through an eye made of glass or earthenware, which is fixed there for the purpose.

The shuttle when thrown by hand is somewhat curved, as shown in Fig. 2902, that form being more suitable to follow the motion of the hand. In throwing it, the thumb is placed on the shuttle-race, while the hand is held open below to catch the shuttle. The batten is drawn toward the weaver by the thumb, although it naturally falls toward him by its own gravity, being usually worked a little out of the vertical line for that purpose. Sometimes springs are placed to draw the batten forward, in which case the weaver with the back of the hand merely pushes the batten backward, while the spring gives the blow.

Let-off and Take-up Motions.—It has been shown that the ends of the warp-threads are secured to the cloth-beam by being inserted into a groove. In the hand-loom the beam is held in position



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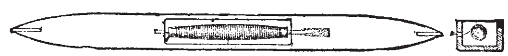

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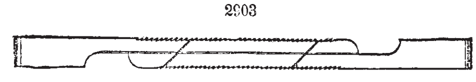

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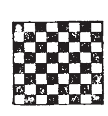

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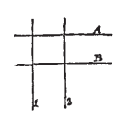

by means of a ratchet-wheel and pawl, and as the cloth is woven it is wound up by a short lever. In order to keep the warp-threads of a proper degree of tension, the warp-beam is shown provided with two weights, or two pairs of weights, one being much heavier than the other, and attached to the same cord, the heaviest weight being hung so as to draw the warp in a contrary direction to the cloth-beam, and thereby cause the tension upon the threads. The rope to which the weights are attached is wound around the warp-beam several times to give it sufficient friction. Now, when the treadles are depressed and the shed is opened for the passage of the shuttle, the heavier weight is slightly raised and falls again, when the shed is closed. As the cloth is woven, the weight is gradually drawn upward, and the small counterpoise falls. When this latter touches the ground, it follows that its rope becomes slackened, and thereby takes the friction off the other rope and allows the warp-beam to move, although the tension caused by the heavier weight is always acting upon the warp. This motion is made in many different forms—sometimes by means of levers, in which case the weights can be adjusted to any degree of tension. The tension becomes greater as the warp is unwound, through the diameter of the beam being lessened, while the weight remains working at the same leverage. Thus it requires occasional adjustment in weaving very long warps, where the diameter of the warp-beam may become lessened perhaps one-half. This circumstance has given rise to let-off motions being continued to equalize the strains. These will be more specifically referred to under Looms, Power.

In like manner the take-up motion is effected. In hand-loom weaving, the weaver draws the cloth-beam round occasionally, after weaving a few inches. In power-loom weaving this becomes a very important matter, and a great variety of motions have been invented to perform it.

The Temple.—In the process of weaving it is found that some cloth has a tendency to draw in or become narrow. This effect must be counteracted, otherwise very irregular work will be the result. The contrivance used for the purpose is called a temple, and has been made in a great variety of forms. The device used in the hand-loom is represented in Fig. 2903. It consists of two flat pieces of wood, adjusted and laced together according to the width of the cloth by a cord as shown. At both ends of the temple a number of pin-points are fixed. These points are placed in the two selvages of the cloth, and it is thereby held stretched out and prevented from contracting, as it otherwise would do. As the cloth is woven the temple is moved. In power-loom weaving the temples are made to revolve so as to require no refixing as the cloth is woven.

Plain Weaving.—Each throw of the shuttle is called a "pick;" consequently the loom is counted in speed by the number of "picks" per minute. The number of weft-threads also is named in the same way, and is counted as so many picks to the inch. In Fig. 2896 a piece of plain woven cloth is represented, as before stated. Fig. 2904 represents the same thing as it would be drawn by the designer, and it is generally called "tabby" or plain weaving. In arranging the loom, the weaver employs another method of drawing the pattern, and in this case he would represent it as shown at Fig. 2905, in which *A* and *B* represent the two heddles, and 1 and 2 the treadles. The marks placed at the intersection of the lines show which of the treadles and heddles are connected together. This method becomes a matter of great importance when a number of heddles are used, as will be shown hereafter.

In plain weaving, the first step toward figured or pattern weaving is made by varying the thickness of the threads both in the warp and the weft, as may be observed in the borders of some cambric handkerchiefs. Different-colored warp- and weft-threads may also be used so as to form stripes, checks, or plaids; or material of different kinds, such as silk and wool, may also be used with more or less effect. Whatever the difference of the threads may be, the actual mode of weaving them is simply plain or tabby weaving. If various kinds of threads are required for the warp, they are arranged in the process of warping, and they are afterward entered or placed in the loom accordingly. But the various kinds of weft-threads are inserted by shuttles, each description of thread having a separate shuttle.

When the fly-shuttle was first introduced, it was intended for the use of one shuttle only; but it was afterward found that if two or more shuttles could be used on the same principle, it would be of great advantage. This was effected about the year 1760 by Robert Kay, the son of the inventor of the fly-shuttle, who invented the "drop-box" for that purpose.

The drop-box is usually made for two shuttles only, although by an ingenious contrivance three shuttles can be used, or several more, by an extension of the same principle. It will be advisable

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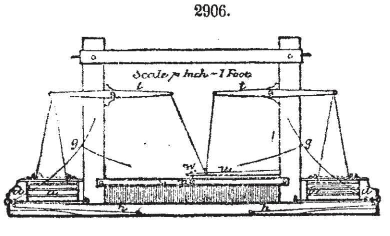

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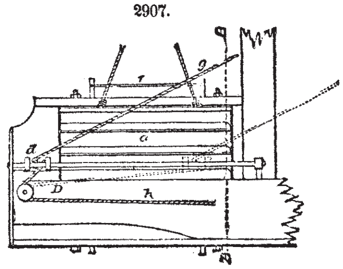

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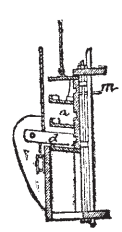
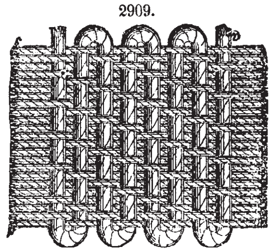


to describe a three-shuttle drop-box, for it comprises the principles of both the others. Fig. 2906 shows a front view of a batten fitted with boxes *a a*. Fig. 2907 is an elevation of one box on a large scale, and Fig. 2908 is a section of it at the line *B B*. The drop-box consists simply of a small board upon which are fixed three or more shelves, according to the number of shuttles; and as these shelves are lowered to the level of the shuttle-race, or board upon which the shuttle slides, so is the shuttle upon that shelf brought in line with the picker, and may be driven to the corresponding box on the opposite side of the batten. *a*, *a*, *a* represent the drop-box. In Fig. 2908 it will be seen that the bottom shuttle is on a line with the picker *d*. There are but two pickers, which slide horizontally upon spindles, and are driven by means of a stick and cords *q q*. An additional cord *h h* is provided in order to draw the picker out of the drop-box after the shuttle has been driven; otherwise it would prevent the box from being raised or lowered when required. In Fig. 2907 the dotted lines *D D* show the position of the picker after it has thrown the shuttle out of the box, when the elastic cord *h* withdraws it clear of the drop-box. It is by this simple and effective means that two or more shuttles can be used without difficulty. Each shuttle can be thrown either once or any number of times, and they may be thrown in any order which may be desired.

In applying the use of several shuttles to the power-loom, the difficulty to be overcome is far greater than would appear at first sight. So long as the speed of the loom is but slow, the task can be accomplished in many ways and with success; but to drive such looms at the speed exacted from the modern power-loom would destroy them in a very short time. As the speed of the loom has been increased, the more simply its parts are contrived, the more capable it becomes of working at that speed; but to apply several shuttles to a power-loom, so that each shuttle can be used any desired number of picks, and be immediately changed for another shuttle, necessarily gives rise to a considerable amount of complicated motions. To simplify these as much as possible, the box containing the shuttles is applied only to one side of the loom; consequently, when a shuttle is thrown through the shed, it is received into a stationary box on the other side, and it must be returned before another shuttle can be thrown. To throw the shuttles one pick only cannot be accomplished on these looms.

Figured Weaving.—There are various methods of arranging the loom for producing figured or ornamental fabrics, the principal ones of which may be classified as follows: 1. The use of healds in any practicable number, in regular or irregular order, as in weaving satins, twills, spots, or small figures. 2. By forming the healds into groups of two or more divisions, in such a manner that any of the divisions may be brought into action, each division having a distinct and separate control over the whole of the warp, at the same time each warp-thread to pass through one eye or leash only of the healds, as in diaper-weaving. 3. By passing the warp through two separate harnesses, so that each thread of the warp passes through two eyes, both harnesses having a compound control of the warp, as in damask-weaving. There are other kinds of weaving, such as gauze, velvet, etc.; but they are produced by entirely different processes from the above.

2909.



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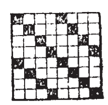
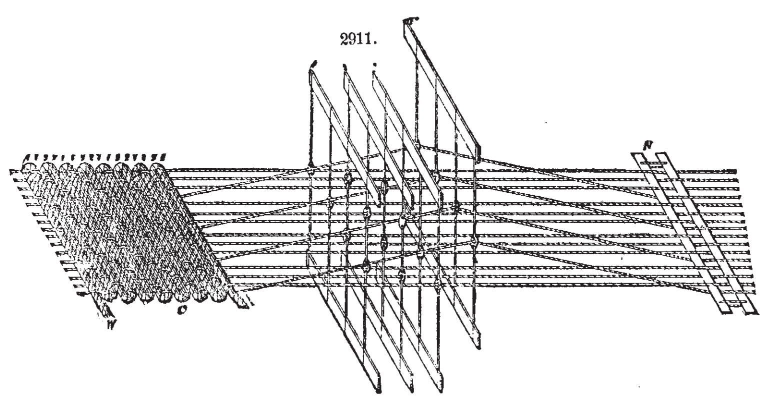


Twills.—In describing plain weaving it has been shown that half the warp-threads are passed through the eyes of one of the heddles and the other half through the eyes of the other heddle. The result of such weaving is threads interlacing each other alternately. In twilled or tweeled cloth the threads, instead of being thus disposed, intersect at certain regular intervals. Thus, in Fig. 2909, the weft-thread *a* passes under every fourth thread of the warp, in such a manner that after it has passed from side to side of the cloth four times it has intersected all the threads of the warp. These intersections, being made in regular and consecutive order, give rise to the diagonal appearance which is known as a "twill." Fig. 2910 shows how this twill is represented on design paper. It will readily be seen that if four heddles are employed, each carrying a separate series of threads, as represented in Fig. 2911, a great variety of patterns may be woven.

In actual work the number of warp-threads in each inch in width of the cloth may range from 40 to 400 or 500, or several hundred times more than it would be possible to show in a drawing. There-

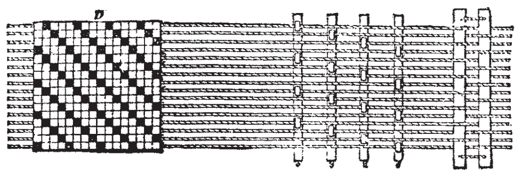
2911.



fore, instead of attempting to show several thousands of warp-threads, 16 will be a sufficient number to illustrate the subject. In the hand-loom the heddles are suspended from four levers called *tumblers* or *coupers*, which work on the *top castle* of the loom, as its top framing is named. To the lower laths or shafts of the heddles weights are attached. To the four treadles four long levers or *marches* are attached, and from the ends of these marches cords connect them with the tumblers. Now, as each of the heddles is attached to or connected indirectly with one of the treadles, it follows that on pressing upon any of the treadles the corresponding heddle will be raised, and consequently the four threads of the warp will be raised also, and thus a shed will be formed for the passage of the shuttle.

This is clearly shown in Fig. 2911, in which one of the heddles, H^1, is shown raised in the manner mentioned. In the same figure the course of the weft-thread *W* may be traced, and the various warp-threads under which it passes may be followed to see in which of the heddles each intersection of the weft-thread has been made. Thus the numbers 1, 2, 3, 4 on the weft-threads correspond to the number of the heddle which has been used when the weft was inserted. The lease or cross is shown at *N*, but the reed has been omitted in the diagram, in order to avoid unnecessary complexity. Fig. 2912 is a plan of Fig. 2911, in which the threads may be more distinctly seen. It will be noticed that *D*, Fig. 2911, represents, as it would be shown on design paper, the cloth as shown at *C*, Fig. 2911. A section of Fig. 2911 is shown in Fig. 2913.

2912.



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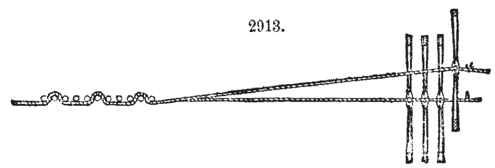
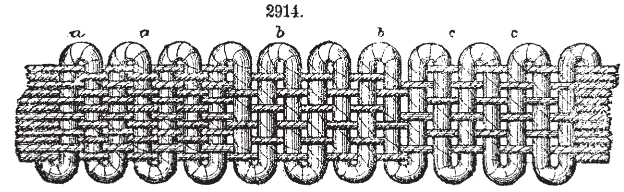


It will be seen that it is by raising the heddles singly and in consecutive order that a twill, such as shown in Figs. 2909 and 2911, may be woven.

Double-Cloth Weaving.—There is still another system, perhaps the most important in weaving, to be noticed, viz., the method of weaving double cloths. As before stated, it is by this means that the manufacturer can not only make thicker and heavier cloths, but he is enabled to use the materials to the best advantage. Although the illustrations are confined to the use of four heddles only, the principle upon which it depends can be fairly represented.

Fig. 2914 represents a piece of cloth composed of black and white warp-threads placed alternately. At *a a* the weft-thread is shown to pass under the white and then the black threads alternately. At *b b* all the white threads have disappeared, and the black alone are represented; and if these were sufficiently numerous to cover the weft-thread well, the surface of the cloth would appear black. At *c c* all the black threads have disappeared, and the white threads are thrown upon the surface instead. Thus a black or white surface can be woven at pleasure. Fig. 2915 shows a section of the cloth, and

2914.



2915.

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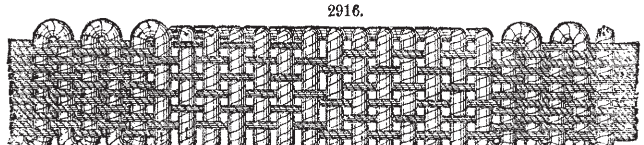

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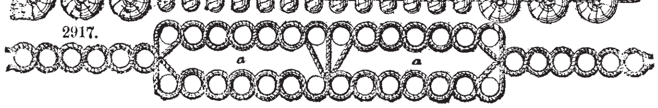


it will be seen that when the white threads disappeared at *b b*, Fig. 2914, they lay unconnected with the cloth or floated on the surface; and in the same manner the black threads float at *e* when the white threads are being used. In some kinds of figured weaving these floating threads are cut off, as may be noticed in figured shawls; but in such cases the loss cannot be avoided.

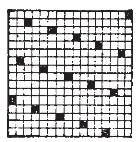
Now on comparing Fig. 2916 with Fig. 2914, the surfaces of both are alike; but on comparing their sections, Figs. 2915 and 2917, a great difference appears. When either the white or black threads disappear on one side of the cloth, they are not found floating underneath, but are being woven into another cloth; in fact, two separate pieces of cloth connected at the edges, or selvages, are being woven, forming a tube. If a few of the threads were at intervals interwoven from one surface to the other, the two cloths would then be bound together, and form one compact piece, and the spaces *a a*, Fig. 2917, would not exist. Again, an entirely different set of weft-threads may be inserted so as to fill the spaces *a a*, to which the upper and lower surfaces of the cloth could be attached without the threads passing entirely through the cloth to the other side. Three varieties of weft may in this manner be used. The central weft-thread is called the wadding, and cannot be observed on either surface of the cloth.

On referring to Fig. 2909, it will be seen that there are two threads at each edge of the cloth which are intersected alternately, as in plain weaving, by the weft-thread. Only two threads are shown, although in practice various numbers are used. If these selvage threads were not inserted, the edges of the cloth would be very irregular, if the weft followed the course of the ordinary warp-threads. This may be understood by referring to Fig. 2911.

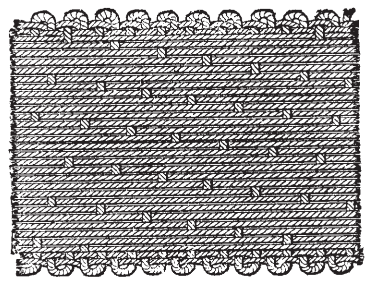
Satin-Weaving.—As far as the use of four healds only is concerned, the principle upon which satins, twills, zigzags, and double cloths are woven has been shown. But as four healds are the smallest number that could be used for the purpose, it is necessary to exhibit the use of a greater number of healds, and indicate how they may be employed in the weaving of ordinary satins, etc.

In silk-weaving, as many as 16 leaves and upward are used in making very rich satins. Fig. 2918 represents the order in which the intersections are made, and Fig. 2919 shows the appearance of the face of a 16-leaved satin when magnified. The intersections only occurring once in 16 times, the weft-threads, although they may be of different colors, are scarcely discernible in the face of the cloth. The warp-threads, when very numerous and crowded together, naturally tend to cover over the few intersections, and the threads thereby give that smooth and unintersected appearance by which rich satins are distinguished.

2918.



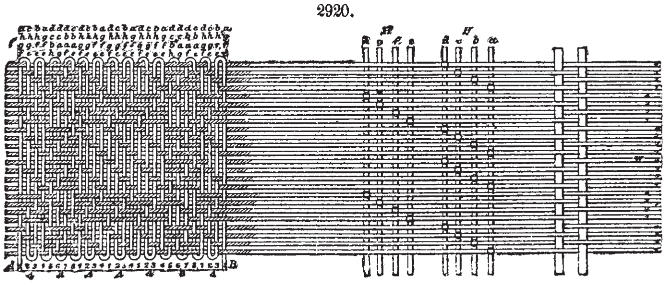
2919.



Diaper-Weaving.—In this class of weaving two or more divisions or sets of harness may be used. These are so arranged that any of the sets or divisions when used govern and alter the action of the remaining sets. By this means, very extensive designs may be woven for table-cloths, shawls, etc. Fig. 2920 represents a plan of a diaper harness in two divisions only, with the warp and a simple diaper pattern woven.

Damask-Weaving.—In this class of weaving two separate systems of harness are used in the loom, in such a manner that after the warp has been passed through one set, it is passed through the second set, each set of harness having an especial duty to perform, although they both operate upon the same warp-threads. The first harness through which the warp passes is for the purpose of forming the pattern, as it were, on a large scale; and the purpose of the second harness is to break up this pattern into detail and complete the necessary minute intersections. In other words, in the first instance the outline of the pattern is formed, and in the next case that outline is woven in detail, so that each thread is intersected or woven together, as in twill or satin of any desired description.

2920.

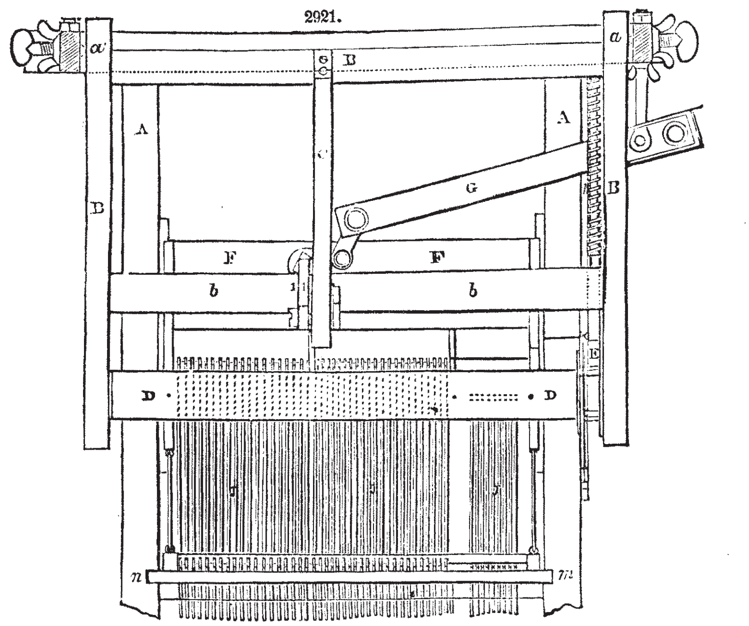


The Jacquard Apparatus.—Up to the invention of this device, the loom consisted of a complicated mass of cords, levers, and pulleys, which had to be compactly united or arranged together to produce the desired pattern or cloth to be woven. Every new design required a fresh arrangement, which often entailed a great amount of labor. In 1725 M. Bonchon made use of "perforated paper pressed by a hand-bar against a row of needles or horizontal wires, so as to push forward those that happened to be opposite the blank spaces, and thus bring loops at the lower extremity of vertical wires in connection with a cone-like rack below. This, being depressed by hand, pulled down the selected wires, and with them the tail-cords to which they were connected." (See "Report on Paris Exhibition," 1867, by Rev. R. Willis.) This contrivance was improved by Vaucanson in 1745. In 1790 it was reinvented by Jacquard of Lyons, who adapted it to practical uses.

The apparatus, which can be attached to almost any kind of loom, is made as follows: A hollow prismatic box extending the width of the fabric has each of its sides perforated in the direction of its length with a number of straight rows of holes, corresponding, as each face is presented to the fabric, accurately to the points of as many rows of metallic bars called needles or spindles. Each of these needles is pressed toward the box by a spiral spring, and each has passing through a loop in its length a lifting-hook, which takes up when lifted its proper thread of the warp. These rows of lifting-hooks terminate above also in hooks, and an arrangement of lifting-bars is let down after each throw of the shuttle, to engage these upper hooks, raise the lifting-hooks, and with them the warp-threads. The prismatic box has also a reciprocating movement by which at the same moments its sides are brought up to the ends of the needles; and it turns to present a new face at each movement. If all the needles enter the holes of the box, all the lifting-hooks are in position and are engaged by the lifting-bars as they descend, and all the warp-threads are raised. But the weaving of complicated figures, such as those of carpets, tapestries, or shawls, requires that, through a certain cycle of movements of the shuttle, new groups of the warp-threads continually shall be elevated. To determine, then, the groups of threads that shall be raised, a succession of stiff cards, looped together to form an endless chain of any required length, and all of size and form corresponding to those of a side of the perforated box, are made to move successively over the box, one lying flat upon it at each of its movements. Now, the order and groups of threads raised are simply determined by perforating these cards beforehand, and in succession, with groups of holes that shall precisely correspond only to the threads to be lifted for that part of the pattern. When the box now advances upon the needles, those meeting the unperforated portions of the card are forced back, their lifting-rods are moved out of position, and only the threads answering to the needles that enter the holes are raised. With the use of this apparatus, it is only necessary further to arrange properly the succession of colors to appear in the weft, or in both warp and weft.

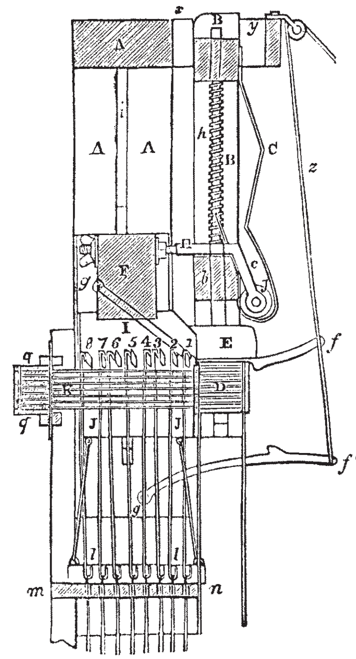
In Figs. 2921 to 2928 the details of construction are exhibited. Fig. 2921 is a front elevation of this mechanism, supposed to be let down. Fig. 2922 is a cross-section, shown in its highest position. Fig. 2923 is the same section, seen in its lower position. *A* is the fixed part of the frame, supposed

2921.

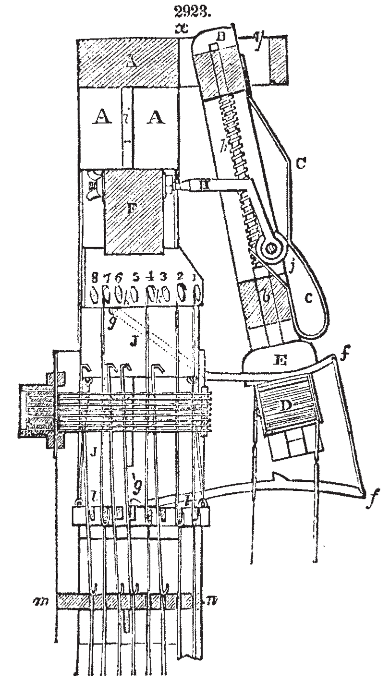


to form a part of the ordinary loom; there are two uprights of wood, with two cross-bars uniting them at their upper ends, and leaving an interval *x y* between them, to place and work the movable frame *B*, vibrating round two fixed points *a a*, placed laterally opposite each other, in the middle of the space *x y*, Fig. 2921. *C* is a piece of iron with a peculiar curvature, seen in front, Fig. 2921, and in profile, Figs. 2922 and 2923. It is fixed on one side upon the upper cross-bar of the frame *B*, and on the other to the intermediate cross-bar *b* of the same frame, where it shows an inclined curvilinear space *c*, terminated below by a semicircle. *D* is the box, a square wooden axis, movable upon itself round two iron pivots, fixed into its two ends, which axis occupies the bottom of the movable frame *B*. The four faces of this box are pierced with round, equal, truly-bored holes. The teeth *a*, Fig. 2925, are stuck into each face, and correspond to holes *a*, Fig. 2928, made in the cards which constitute the endless chain for the healds; so that in the successive application of the cards to each face of the box, the holes pierced in one card may always fall opposite to those pierced in the other. The right-hand end of the box, of which a section is shown enlarged in Fig. 2924, carries two square plates of sheet iron *d*, kept parallel to each other and a little apart by four spindles *e*, passed opposite to the corners. This is a kind of lantern, in whose spindles the hooks of the levers *f f'*, turning round fixed points *g g'*, beyond the right-hand upright *A*, catch hold, either above or below, at the pleasure of the weaver, according as he merely pulls or lets go the cord *z*, during the vibratory movement of the frame *B*. *E* is a piece of wood shaped like a T, the stem of which, prolonged upward, passes freely through the cross-bar *b*, and through the upper cross-bar of the frame *B*, which serve as guides to it. The head of the T-piece being applied successively against the two spindles *e*, placed above in a horizontal position, first by its weight, and then by the spiral spring *h*, acting from above downward, keeps the box in its position, while it permits it to turn upon itself in two directions. The name *press* is given to the assemblage of all the pieces which compose the movable frame *B B*. *F* is a cross-bar made to move in a vertical direction by means of the lever *G*, in the notches or grooves *i*, formed within the fixed uprights *A*. *H* is a piece of bent iron, fixed by one of its ends with a nut and screw upon the cross-bar *F*, out

2922.

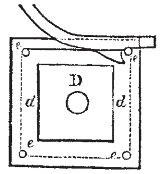


2923.

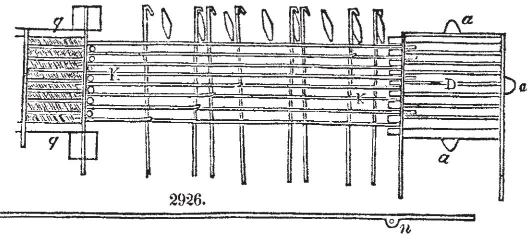


of the vertical plane of the piece *C*. Its other end carries a friction-roller *J*, which, working in the curvilinear space *c* of the piece *C*, forces this, and consequently the frame *B*, to recede from the perpendicular or to return to it, according as the cross-bar *F* is in the top or bottom of its course, as shown in Figs. 2922 and 2923. At *I* are cheeks of sheet iron attached on each side to the cross-bar *F*, which serves as a safe to a kind of claw *K*, composed here of eight small metallic bars, seen in section in Figs. 2922 and 2923, and on a larger scale in Fig. 2925. At *J* are upright skewers of iron wire, whose tops, bent down hookwise, naturally place themselves over the little bars *K*. The bottom of these spindles, likewise hooked in the same direction as the upper ones, embraces small wooden bars *l*, whose office is to keep them in their respective places, and to prevent them from twirling round, so that the uppermost hooks may be always directed toward the small metallic bars upon which they impend. To these hooks from below are attached strings, which after having crossed a fixed board *m n*, pierced with corresponding holes for this purpose, proceed next to be attached to the threads of the loops destined to lift the warp-threads. The horizontal spindles or needles *K K* are arranged here in eight several rows, so that each spindle corresponds both horizontally and vertically to each of the holes pierced in the four faces of the box *D*. There are therefore as many of these spindles as there are holes in one of the faces of the box. Fig. 2926 repre-

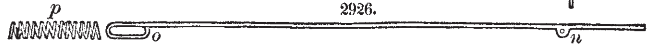
2924.



2925.



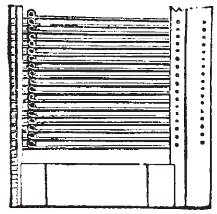
2926.



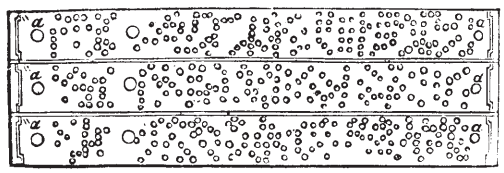
sents one of these horizontal spindles. *n* is an eyelet through which the corresponding vertical skewer passes; *o*, another elongated eyelet, through which a small fixed spindle passes to serve as a guide, but which does not hinder it from moving lengthwise, within the limits of the length of the eyelet. Small spiral springs *p* are placed in each hole of the case *q q*, Fig. 2925, serving to bring back to its primitive position every corresponding needle, as soon as it ceases to press upon it. Fig.

2927 represents the plan of the upper row of horizontal needles. Fig. 2928 is a fragment of the endless chain, formed with perforated cards, which are made to circulate or travel by the rotation of the shaft *D*. In this movement, each of the perforated cards, whose position, form, and number are

2927.



2928.



determined by the operation of tying up the warp, comes to be applied in succession against the four faces of the box, leaving open the corresponding holes, and covering those upon the face of the box which have no corresponding holes upon the card.

Now let us suppose that the press *B* is let down into the vertical position shown in Fig. 2923; then the card, applied against the left face of the box, leaves at rest or untouched the whole of the horizontal spindles (skewers) whose ends correspond to these holes, but pushes back those which are opposite to the unpierced part of the card; thereby the corresponding upright skewers, 3, 5, 6, and 8, for example, pushed out of the perpendicular, unhook themselves from above the bars of the claw, and remain in their place when this claw comes to be raised by means of the lever *G;* and the skewers 1, 2, 4, and 7, which have remained hooked on, are raised along with the warp-threads attached to them. Then, by the passage across of a shot of the color, as well as a shot of the common weft, and a stroke of the lay after shedding the warp and lowering the press *B*, an element or point in the pattern is completed. The following card, brought round by a quarter revolution of the box, finds all the needles in their first position, and lifts another series of warp-threads; and thus in succession for all the other cards, which compose a complete system of a figured pattern. If some warp-yarns should happen to break without the weaver observing them, or should he mistake his colored shuttle yarns, which would so far disfigure the pattern, he must undo his work. For this purpose he makes use of the lower hooked lever *f'*, the use of which is to make the chain of the card go backward while working the loom as usual, withdrawing at each stroke the shot both of the ground and of the figure. The weaver is more subject to make mistakes, as the figured side of the web is downward, and it is only with the aid of a bit of looking-glass that he takes a peep at his work from time to time. The upper surface exhibits merely loose threads in different points, according as the pattern requires them to lie upon the one side or the other.

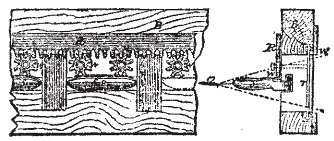
Thus it must be evident that such a number of pasteboards are to be provided and mounted as equal the number of throws of the shuttle between the beginning and end of any figure or design which is to be woven; the piercing of each pasteboard individually will depend upon the arrangement of the lifting-rods and their connection with the warp, which is according to the design and option of the workman. Great care must be taken that the holes come exactly opposite to the ends of the needles; for this purpose two large holes are made at the ends of the pasteboards, which fall upon conical points, by which means they are made to register correctly. It will be here seen that, according to the length of the figure, so must be the number of pasteboards, which may be readily displaced so as to remount and produce the figure in a few minutes, or remove it, or replace it, or preserve the figure for future use. The machine, of course, will be understood to consist of many sets of the lifting-rods and needles shown in the diagram, as will be perceived by observing the disposition of the holes in the pasteboard; these holes, in order that they may be accurately distributed, are to be pierced from a gauge, so that not the slightest variation shall take place. To form these card-slips, an ingenious apparatus is employed, by which the proper steel punches required for the piercing of each distinct card are placed in their relative situations preparatory to the operation of piercing, and also by its means a card may be punched with any number of holes, at one operation.

The expense of material and time in preparing the cards for the Jacquard apparatus, which for the heaviest work must be of sheet iron, and for all intricate patterns very numerous, has always constituted the most serious drawback upon the desirableness of that method. Thus an elaborate damask design has required 4,000 cards and 400 needles, at a cost of about $120 and five weeks' labor of a man in setting up; while a single design has been known to require 20,000 cards, at a cost of $600 and time equal to a year's labor of one man. With a view to reduce these expenditures, M. Bonelli constructed the electric loom, in which the cards of the Jacquard apparatus are superseded by an endless band of paper covered with tin foil, intended to serve as an electrical conductor. (See Electric Loom.)

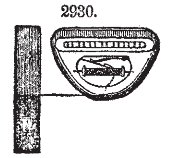
In another improvement of the Jacquard loom, a sheet of prepared paper punched with the proper apertures is substituted for the cards of the old machine, this paper being in form of a continuous band, only three-fourths of an inch wide, so that the weight of the new is to that of the old band as but 1 to 11. The arrangement is also such as permits the 400 spiral springs in connection with the needles in the old machine to be dispensed with. Thus the wear and tear due to the resistance of these is obviated, and fine and light wires are introduced in lieu of the heavy ones previously employed. Various additions have also been made to the Jacquard loom by Barlow, Taylor, Martin, and others; and an ingenious application of it to the positive-motion loom to adapt the latter for weaving corsets will be found described under Looms, Power.

Ribbon-Weaving.—The frames of the most improved ribbon-looms of the present day are still arranged upon the plan of the old Dutch engine or swivel loom. The shuttles are, however, driven by the wheel and rack. The chief improvements in the loom have been the application of the Jacquard machine, and the employment of several tiers of shuttles for using various colors of weft. Figs. 2929 and 2930 show the method of throwing the shuttles or swivels by means of the rack-and-wheel motion. The shuttles *s s* have a small rack inserted, and they are geared in the star-wheels *w w*. The wheels are worked by the rack *R*, and as this rack works all the wheels by its alternate motion, the shuttles are thrown from side to side of the openings through the warp.

2929.

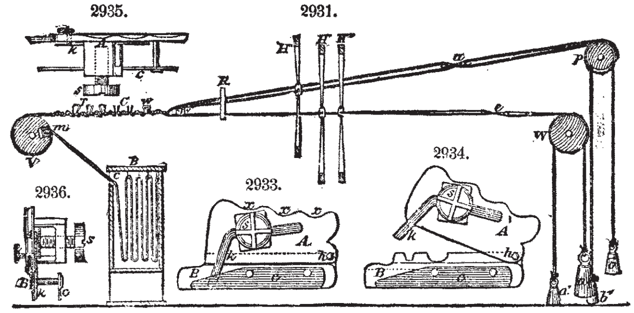


2930.

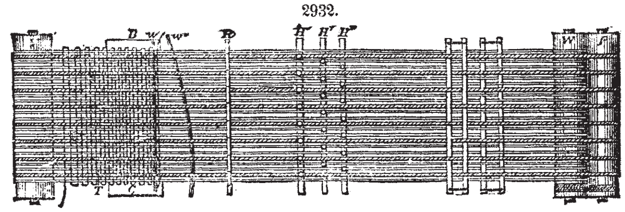


Pile-Weaving.—This class of weaving includes velvets, Brussels carpets, fustians, etc. It consists in the formation of loops on the surface of the cloth, and if the loops are cut through they form a brush-like surface to the cloth known as velvet. If the loops are left uncut, similar to the loops on Brussels carpets, then it is known as terry velvet. The loops may be formed either by means of the warp-threads or the weft-threads, and they are called the pile-threads. The richest description of velvet made (with the exception of Dutch, Genoese, and specially made velvets) is known as "collar velvet" for gentlemen's coats. The pile-threads are of silk, but the weft is often of cotton, and velvets so woven are said to have cotton backs. Cotton makes the body of the cloth firmer and more suitable for the purpose than silk, so that the inferior material is not used on the score of economy alone.

Fig. 2931 represents a section of a velvet-loom, showing all the working parts necessary, but omitting the framing. *W* is the ordinary warp-beam supplying the threads for the body of the cloth; *P* is the "pole" (corruption of pile) or the pile-beam which contains the pile-threads; *V* is the cloth-beam, showing that it has made three-quarters of a revolution; and *B* is a closed box to contain the velvet as it is unwound from the beam. At *T* will be seen loops rising from the surface of the cloth, and at *C* the loops are shown cut through at their upper surface. These loops are made by inserting thin wires into the shed, which are beaten up with the cloth similar to ordinary weft-threads. One of these wires is shown thus woven in the cloth at *w*, and at w^1 another wire is being inserted. Now between each insertion of the wires three shoots of weft are thrown into the cloth, and well beaten together; otherwise the pile-threads after they were cut would draw out. Fig. 2932 shows a plan of Fig. 2931, and the same letters and numbers refer to each. In the plan the wire w^1 is shown placed in the shed of the warp, and will be driven up by the reed *R* in the same manner as the wire *w* has been. When both wires have been firmly bound into the cloth by the weft-threads, the first one is cut out by means of a knife fixed into a frame and called a "trevet," and it is again inserted. Thus only two wires are used, and they are cut out alternately by means of the trevet. The instrument is well suited for the purpose, and when it is considered that the wires are inserted from 50 to 60 times, and upward, per inch in length of velvet woven, and three times that number of weft-threads, it will be evident that great exactness in the operation is necessary, as the slightest error or carelessness would cut the warp-threads out of the loom—a circumstance by no means unknown to most velvet-weavers. The wires, which are made with a fine groove for the point of the knife to enter, are very truly made, and the blade of the trevet must be "as right as a trevet"—hence the well-known simile—or such beautiful work as velvet could not be produced. Figs. 2933 to 2936 show the trevet. The knife *k* is fixed into a frame *A*. This frame is hinged to another frame *B* at the point *h*, so that the weaver can open and sharpen the knife easily. The knife is held firmly by the screw *s*, and at the back of the frame a small adjusting screw *e* is placed to regulate the distance of the knife from the steel frame *B* against which it is placed. The frame *A* is of brass, but all the rest is of steel. The indentations *x x x* are for the fingers to fit in, a requisite precaution to insure accurate hold of the instrument. The use of the trevet is shown in the enlarged sketch, Fig. 2937, in which the knife-edge is seen entering the wire *w*. *B* and *C* are the bottom portions of the trevet, and rest upon the warp and cloth as shown. The trevet is held in the right hand, and drawn from left to right. It is pressed



2932.

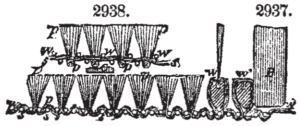


against the flat side of the outside wire w^1, which forms the guide or fence, and the knife is regulated to fall into the groove of the inside wire w. When upward of 60 insertions of the wires per inch are made, an idea of the perfection of workmanship required for the purpose may be realized. About six times in length of the pile-threads are used to what are required for the "back," which, of course, arises from the formation of the loops. Much less strain is also put upon the pile-threads by the use of smaller weights, as shown at b and b^1.

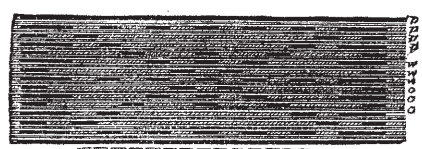
After leaving the beam the velvet is hung up by means of pin-hooks in the box B, Fig. 2931, which keeps it free from injury. The warp- and pile-threads may be traced in the figures as well as the weft. The heddles shown at H^1 and H^2 work the ground- or warp-threads by raising each half of the threads alternately as in plain weaving. The heddle H^3 raises the pile-threads at every fourth change. Singular as it may appear, when the work is taken from the loom the weaver places it upon a table, and by means of a sharp common razor literally shaves or mows the whole surface of the pile in order to remove any stray filaments of extra length and to improve the face of the cloth. Fig. 2938 shows a section of the velvet through the line of warp-threads, in which *s s* is the weft, *w w* the ground- or warp-threads, and *p p* the pile. Fig. 2937 is a section at the side of the cloth, and the letters refer to the same parts. In these figures the actual formation of the cloth is represented, excepting that the pile-threads are usually made thicker or doubled.

Brussels and other pile carpets are made upon the same principle as the velvet above described, but generally the pile is not cut; consequently round wires are used instead of grooved ones, and they are drawn out from the side of the cloth. There are two descriptions of carpets, one in which the pile-threads have had the pattern printed upon them previous to weaving, and the other in which the threads are used dyed in separate colors. The first kind is known as tapestry carpets, and form a comparatively simple and cheap manufacture, when compared to Brussels carpets. Let Fig. 2939 represent the warp- and pile-threads, with the pattern printed upon the pile-threads. The pile-threads are marked *p p* and the ground-threads *w w*, these lying between and under the pile-threads. About five of these warp- or ground-threads are used to each strand of the pile, which may be seen in section in Fig. 2940. Now when the threads are woven together the pile is contracted to nearly one-third of its length in consequence of the loops, and the distorted figure, as printed, becomes of the intended

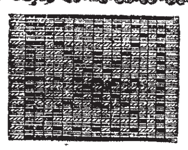
2938. 2937.



2939.

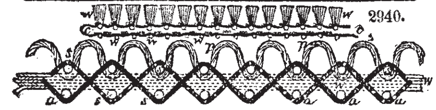


2941.



2940.

2943.



2942.

proportions. Thus Fig. 2939 becomes, when woven, Fig. 2941. A section of the cloth is shown in Fig. 2942, and in all the figures the same letters refer to the same parts. The threads *c c* do not intersect with the weft, but merely lie between the warp-threads *w w*, and form a bed or ground for the pile to rest upon. The wires used are generally six or more in number; for if only two were used the loops would scarcely resist the strain of drawing the wire, the greater number causing greater firmness to the cloth to resist the strain.

Brussels carpet is a very different affair. A great variety of threads of different colors are required, and they are selected by the action of the Jacquard machine to form the pattern. They are wound upon separate bobbins, for each color is used in various lengths. Fig. 2943 represents a section of a Brussels carpet. The threads *a a* are the warp-threads, and *s s* the weft. Where there was only one thread in the tapestry carpet there are five in the Brussels; thus the pile-threads are shown at *w w*, and as the various colors are required they are drawn to the surface to form the loops, while four-fifths remain in the body of the cloth. The great number of pile-threads, and their being of wool and not of hemp, as the warp and weft are, cause the Brussels carpet to be much thicker, the colors brighter, and altogether a superior carpet to the less costly tapestry, as the difference in price attests.

Many kinds of carpets and rugs are woven on the systems above described, but have the pile cut as in cut-velvet weaving, such as Axminster and Wilton carpets.

The foregoing article is abridged from a valuable series of practical papers on weaving in *Engineering*, vols. xvii., xviii., and xix. See also "The History and Principles of Weaving," Barlow, London and New York, 1879.