left in one row at every point to keep the courses even

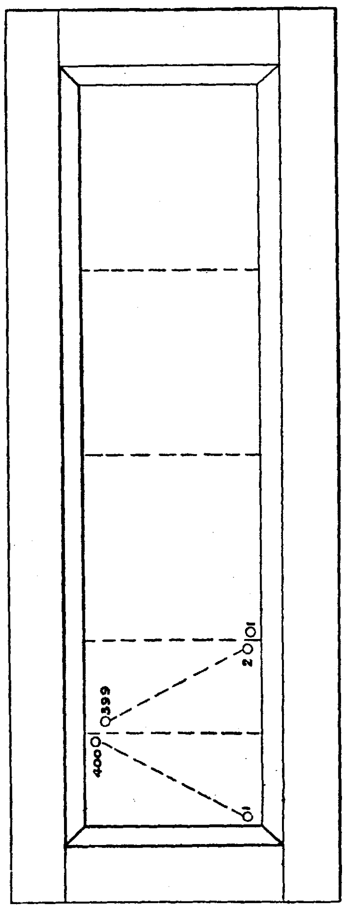

Fig. 121.

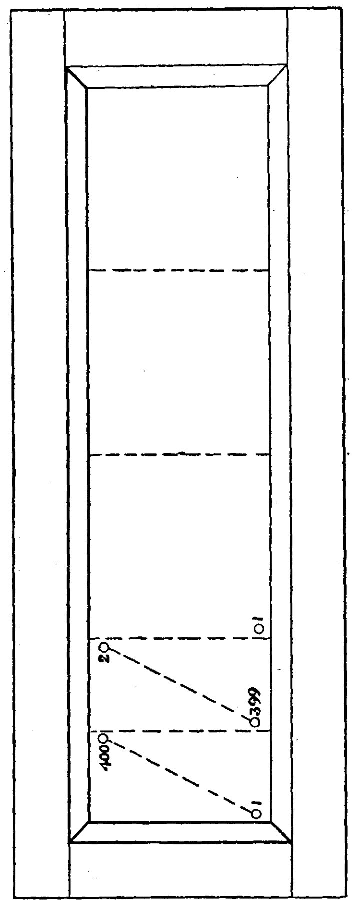

Fig. 122.

in the board and prevent two threads working as one at such places.

Mixed Ties

Some ties are partly straight-through and partly centred—straight-through in the body portion, centred in one or both borders; others are centred at the middle only; others again have centred borders and body, with straight-through portions between, of which it need only be said that care should be taken to prevent two odd or even threads from joining at any part—for instance, where the last body repeat joins a centred border,—otherwise defects in a fabric will be produced. By omitting the last body mail, or the first border one, this trouble may be avoided. Mixed ties are in general use where woven devices are worked in the centre of a fabric, such as a towel, a bath sheet, and a bed-cover.

Compound Ties

Compound ties are found in great variety, and may be straight, centred, or mixed. The essential feature of a compound tie consists in dividing a harness into two or more distinct sections, each to control warp of a different colour or count, or to produce a different texture. For this purpose a comber board may be divided longitudinally as well as transversely into equal or unequal parts, so that the mails in each longitudinal division may govern all the warp belonging to one section.

Fig. 123 is a plan of an equal compound tie in two sections. The Jacquard is divided equally, and consecutive needles from 1 to 200 control the couplings in section A; and needles 201 to 400 control the couplings in section B.

If, as frequently happens, the sections are in the proportion of two couplings in A to one in B, the board must be divided to correspond, as in Fig. 124, in which the board has twelve holes to a row, and 8 of them form section A, while the remaining 4 form section B. With a

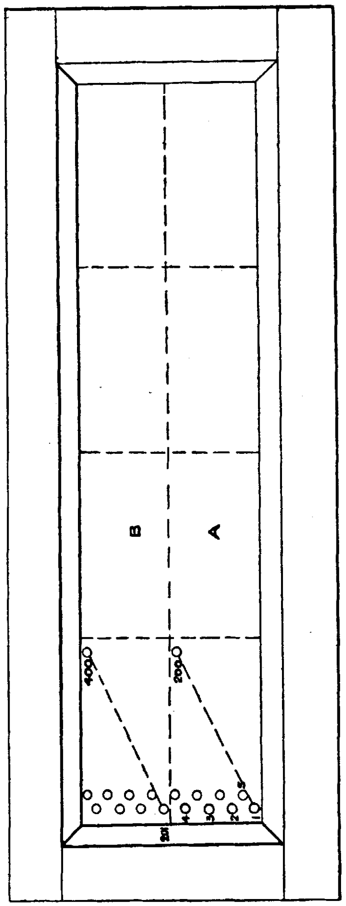

FIG. 123.

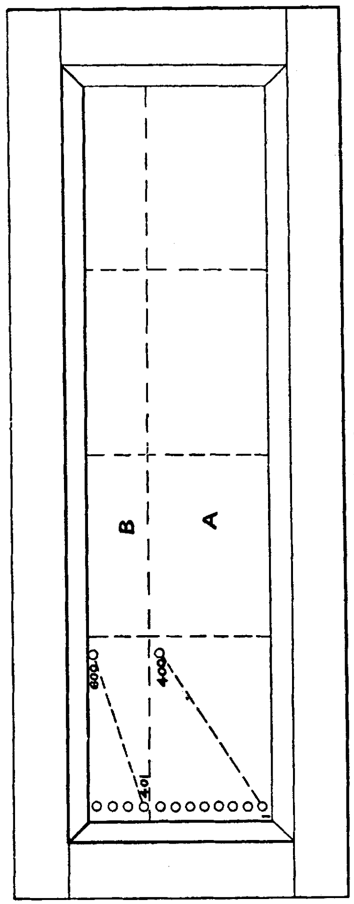

FIG. 124.

600 Jacquard, 400 needles may be used for one repeat of A, and 200 for B. Three or four sections can be formed

in a similar manner. In every case the leasing must bring the mails into their proper sequence; thus in Fig. 123 the first mail of section A must be followed by the first of B, and alternately throughout; but in Fig. 124 the first of A is followed by the first of B, then the second and third of A are taken before the second of B, the fourth and fifth of A are followed by the third of B, and so on to the end.

Compound ties of the foregoing description are adopted

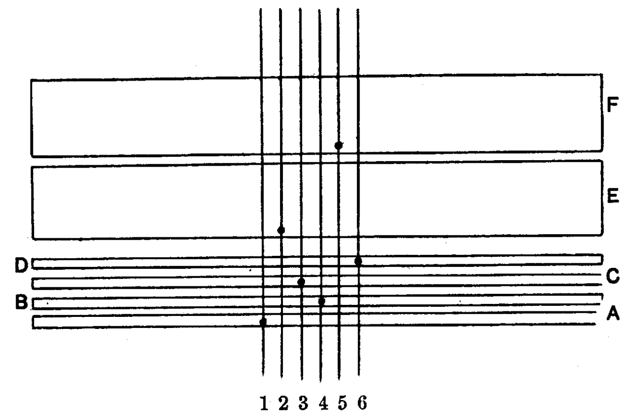

FIG. 125.

for convenience, and for reducing the cost of designing for many classes of fabrics, rather than for effecting economies in cards. Other compound ties, as compared with straight-through ties, save cards to the extent of from $\frac{1}{2}$ to $\frac{79}{80}$; they are usually built for weaving compound fabrics, which are stitched together in the loom. Fig. 125 is a plan of a mounting, commonly used in the manufacture of quilting fabrics, consisting of 4 shafts of healds, A, B, C, D, which control all the threads of one warp, and two comber boards, E, F, each containing half the remaining warp. Vertical lines 1 to 6 are warp threads, of these 2 and 5 only belong to the back fabric. A dot denotes the position of the heald or mail eye that each thread is drawn through. Fig. 126 is a plan of the Jacquard portion of this tie; it is arranged for a 400 machine, and the numbers 1 to 8 show where the couplings governed by the first row of needles are placed. The building differs from any of the systems described in having a knot tied upon every coupling immediately above a board. Each knot is too large to pass through a hole, but does not limit the power of a Jacquard to lift the

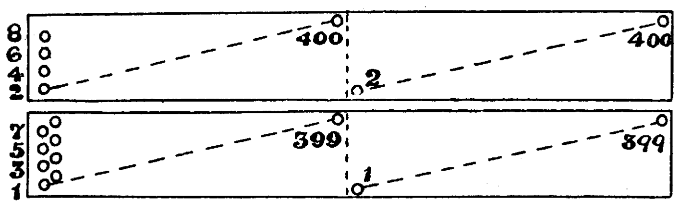

Fig. 126.

couplings. The shafts and boards are all actuated by tappets independently of the Jacquard. Thus, if the shafts A, B, Fig. 125, lift with the first upward movement of the griffe, all odd threads of the face warp will be raised, together with certain threads of the back, to form a shed for the first pick of face weft; A, B then sink, and C, D rise without movement in the Jacquard for number 2 pick of face. Thick padding weft is used for picks 3, 4, to give bulk and weight to the fabric, for both of which the shafts A, B, C, D are lifted, and the griffe remains up, but it must drop before the back pick 5 is inserted, and before it rises again the comber board E is lifted together with A, B, C, D.

It will be noticed that only one card has been employed

to place 5 picks of weft in the fabric, and 5 following picks will be driven home before number 2 card is replaced by number 3 as follows:—

For pick 6, A, B, and the Jacquard griffe lift.
" 7, A, B, C, D, " "
" 8, A, B, C, D, " "
" 9, C, D, " "
" 10, the griffe descends, and A, B, C, D, and the board F lift.

By operating the boards E, F, on picks 5, 10, plain cloth will be produced with the back warp and weft, because all even back threads are on F, all odd threads on E, and the knots being unable to pass through the holes, the couplings are lifted with the boards. Of the remaining eight picks, 1, 2, 6, and 9 are used for face, and 3, 4, 7, and 8 for padding. The Jacquard stitches both fabrics together by carrying back warp over face picks, and produces a figure upon the upper fabric by pulling that fabric down in places and allowing it to bulge in others; the actual weaving being done by the healds and boards.

As compared with an ordinary harness, this plan saves $\frac{14}{15}$ of the cards, because the Jacquard only governs $\frac{1}{3}$ of the entire warp instead of every thread. To govern every thread three Jacquards of equal size would be needed, and each machine would require a card for each pick, or $3 \times 5 = 15$ cards instead of one. But assuming an ordinary harness to govern the back warp, and healds to govern the face warp, the reduction in cards is $\frac{4}{5}$. A further reduction of half the cards may be made by using two Jacquards independently, and causing one of them to govern all odd threads of the harness, and the other all even threads. The moving boards, the knotted harness, and the healds are retained and used in the manner already described.

Thus, if both machines have 400 needles, the first will control all odd threads from 1 to 799, and the second all even threads from 2 to 800, in each repeat of the pattern. This is equal to doubling the capacity of each Jacquard and causing one card to do the work of two, as compared with the previously described special harness, or of ten as used with an ordinary harness to which healds have been added. For further particulars of this method, see "Scale Harness," p. 249.

A double-lift single-cylinder Jacquard may be used to weave fabrics of the foregoing type without the aid of lifting comber boards, but with four shafts of healds. The tail cords are disconnected and each hook operates a separate warp thread. For a fabric with four picks to a card, two face picks are of fine weft, and one filling and one back pick of coarse weft. One griffe actuates all odd hooks, the other all even hooks, and they work as follows:— One griffe ascends with either odd or even stitching threads, heald shafts one and two are lifted by tappets, and the first face pick is driven through the warps. The griffe remains stationary, but shafts one and two sink and shafts three and four rise for the second face pick. For the filling pick the griffe remains lifted and all the shafts are up. The griffe then sinks, and while the cylinder is away from the needles it immediately rises with all the hooks it is capable of controlling, namely, odd or even rows, the four shafts remain lifted, and the first back pick is driven into position. Number two card replaces number one, and a similar sequence of movements is made, but with the other griffe and hooks. This machine is used with the scale harness described on p. 249, and the cards are perforated for it in a similar manner.

Compound fabrics known as "Patent Satins" may also

be manufactured by the aid of a double-lift single-cylinder Jacquard, and without lifting comber boards, in which event each tail cord actuates a separate warp thread. The Jacquard is used in conjunction with two heald shafts. Thus, if picks 1, 2 are of coarse weft, and 3, 4 of fine weft:— For pick 1 both griffes will lift with shaft 1. For pick 2 both griffes remain up, but shaft 2 replaces shaft 1. For pick 3 both griffes sink and one immediately rises with all the hooks it controls, while shaft 2 remains lifted. For pick 4 the first griffe sinks, the second rises, and the healds change places.

The cards are cut as for ordinary Jacquards, each equals 4 picks, and the cylinder after presenting a card moves out and remains stationary until again required for the next card.

Double Equal Plain Cloth Tie

Four moving comber boards may be employed to weave compound plain textures that differ from each other in colour and are figured by passing one through the other. This system permits of any style of figure, and binds both pieces together wherever the fabrics change places. If four holes form a row, each board, Fig. 127, is about 1″ wide and from 1″ to $1\frac{1}{2}$″ deep. The top loops of all the couplings are knotted, and the knots when resting upon the boards hold the mails in a straight line.

The compound Jacquard described on pp. 195-196 is fixed over the loom, and the mounting threads from all hooks that face the cylinder are connected to couplings in one pair of boards; those from hooks that face the spring box govern all couplings in the other pair. A 400 needle machine contains 16 rows of hooks; rows 1 to 8 face the cylinder, and 9 to 16 the heel rack. Fig. 128 shows how these hooks are attached to the couplings for a straight-through tie; the numbers 1 to 16 represent warp threads. If white warp is drawn through the mails on boards 1, 2, by lifting 1, only odd threads of white will rise, and board 2 will lift only even threads; boards 3, 4 respectively move

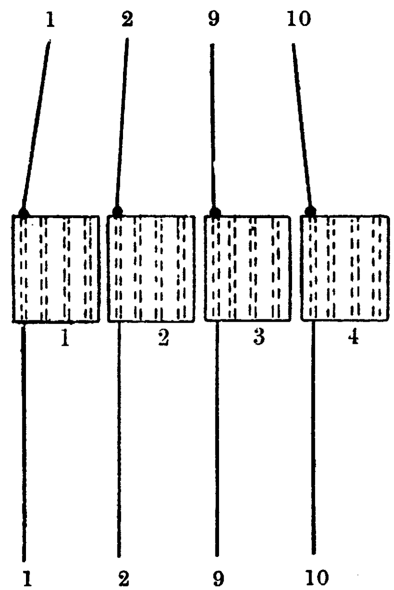

FIG. 127.

odd and even threads of the other colour, say blue. Hence without using a Jacquard two perfect plain fabrics can be woven—one blue, the other white. A Jacquard merely lifts blue warp above white weft where blue is to show on the upper surface, and white warp over blue weft where white is required on the upper surface.

As compared with two separate Jacquards and an

ordinary harness, each to weave one colour, the foregoing method saves $\frac{3}{4}$ of the cards; for in one case two cards are needed for one pick, in the other one card answers for two picks. Thus, while the first card faces the needles, the blue griffe and board 1 lift to provide for a pick of white weft. The same card presses the needles back while the white griffe and board 3 form a shed for blue weft. Card 2 is turned into position, and first the blue griffe and board 2, then the white griffe and board 4 rise for white and blue

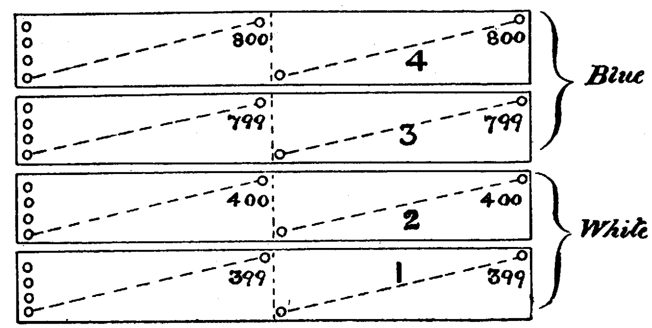

FIG. 128.

wefts respectively. With the mounting threads 1, 2, Fig. 127, connected to number 1 hook, and 9, 10 to number 9 hook, one card may be made to do the work of 16, as compared with two Jacquards operating ordinary harnesses. Thus, if the cylinder is stationary for four picks, and the blue griffe rises, the boards 1, 2 may rise and fall in rotation for two white picks, the blue griffe then descends, the white one ascends, and the boards, 3, 4 are operated for two blue picks. Card 2 replaces card 1, and the same order of lifting is followed. Therefore, since each needle governs 4 adjacent warp threads, and each card equals 4 picks, this plan has $4 \times 4 = 16$ times the capacity of an ordinary Jacquard and harness.

Split or Scale Harness

Harnesses known as "Split," as "Shaft Monture," and "Bannister" are used to weave wide patterns in fine reeds, and with small Jacquards. Some are capable of doubling, others of trebling, and others again of quadrupling the width of a design. A double scale harness may have a comber board, C, Fig. 129, fixed about 12″ above the warp, and couplings with top loops 16″ long drawn into it, if all are previously knotted 8″ above the mails at A. A strip of wood or metal, B, $\frac{1}{8}$″ thick by $1\frac{1}{2}$″ deep, is then rounded along both edges, and pushed between the loops of all couplings in one row of the board, immediately below the knots, consequently the number of shafts employed equals the number of holes in one full row of the board. Two consecutive couplings in each repeat of the tie are united to one mounting thread at D, but they can be lifted separately by the shafts in any desired order. Let it be assumed that 16 holes form one short row, then the couplings 1, 2 are tied, or warped, upon the neck cord of number 1 hook; the couplings 3, 4 to number 2 hook, etc., or the couplings 1, 3, 2, 4 may be respectively tied to hooks 1, 2; this is done to enable a Jacquard to lift plain cloth sheds without the aid of shafts; but since the couplings 1, 2, 3, 4 form parts of different longitudinal rows in the harness, they are threaded upon four separate shafts B, which may each be moved as required by extra hooks in the machine, and by cords E. Three or four adjacent couplings may be connected to one hook and treated in a similar manner.

If the cards are suspended over the warp, extra hooks

should be provided near both ends of the cylinder, so that the cords E may pass from them in straight lines through

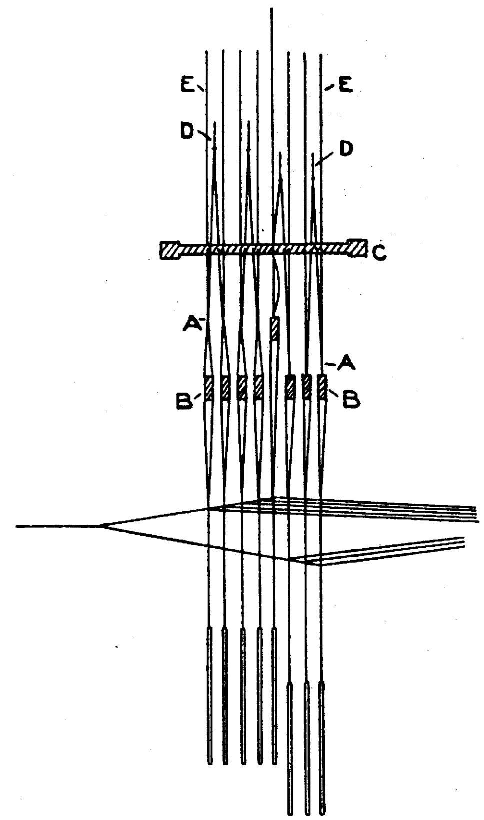

FIG. 129.

the comber board C to opposite ends of the shafts B, for this arrangement throws equal weight upon each end of the griffe. The cards are only perforated to weave the

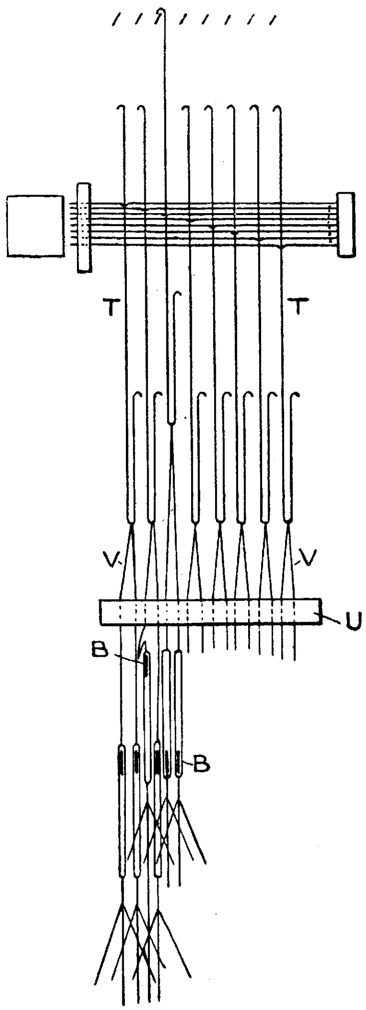

FIG. 130.

figure, therefore the shafts must lift some of the warp left down by the Jacquard in order to bind the ground portions of the fabric. One card is required for each pick.

The advantages of this harness are, that in addition to increasing the size of a pattern, different ground weaves can be obtained with the same figure, provided the hooks and needles used to actuate the shafts B are so placed that short cards may work outside the figuring cards. Less cost is incurred in designing, because the figure only requires attention. But since the warp threads are moved in pairs, in sets of three, or sets of four, a figure is slightly defective in outline.

From 8 to 24 shafts may be manipulated by attaching two neck cords V, Fig. 130, to each figuring hook T, and passing them separately through

contiguous rows of holes in a bottom board U, which is fixed 2″ to 3″ below the hooks. This board has two rows of holes for one row of hooks in the Jacquard. Each neck cord is knotted about 5″ below U, and a short shaft B is passed through each line of loops thus formed. The shafts work in the least crowded parts of the harness, and do not interfere with the weaver's freedom of action.

Another double scale harness, which has been used in the manufacture of certain kinds of cotton brocades for many years, also effects a saving of half the cards. If two separate machines are used, one governs all the odd couplings, the other all the even ones; but a double lift, single cylinder, or a double lift, double cylinder machine, with the neck cords disconnected, answers the purpose admirably. Couplings are operated by each separate neck cord in the usual manner; then, if a loom be run without cards, each griffe will cause alternate couplings to be moved, and weave plain cloth. One griffe of a 400 machine will therefore control all the odd warp threads from 1 to 799 in every repeat, and the other all even threads from 2 to 800. Any type of figure in which two adjoining threads are not required to lift simultaneously can be woven. But a warp float must be woven face down, a weft float face up.

In preparing a design for this harness the pattern will cover 800 vertical spaces on the ruled paper, and after outlining the figure in pencil, the lead lines are painted over with single dots arranged in plain order, or "on the tab." In perforating the cards two spaces on the design paper are treated as one, for one of the two will invariably be blank, hence a plain weave on the design paper requires consecutive holes cutting in any row of a card.

The Pressure Harness

A pressure harness is one in which a Jacquard is combined with healds to move the same warp threads. The figuring harness is of the usual type, but must be placed farther from the cloth fell than for ordinary work. As a rule, a space is left between the back shaft and the comber board of 7″ for cotton, and 10″ for linen warps. From two to twelve adjacent threads are governed by each hook, but they must be drawn through separate mails, or through separate eyes in a decked mail, in order to prevent them from twisting.

A set of heald shafts, equal in number to the threads in one repeat of the binding weave, are suspended as near the cloth fell as possible, and may be furnished with eyes from $2\frac{1}{4}''$ to 3″ deep, or healds in which the clasps fall in two lines may be substituted. In that event every thread is drawn above one clasp and under another, as at No. 2, Fig. 3. Or, again, single clasps, as at No. 1, Fig. 3, may be employed with double the number of shafts. For the latter, one loop of each heald is longer than the other by the depth of a shed. One set of the short loops are placed at the top, the other set below, and a warp thread passes over one and under the other. These shafts occupy more space in the loom, but in shedding they have only two positions, whereas other pressure healds have three positions. The warp, which has passed in groups of from 2 to 12 threads through the mails, is drawn singly and straight through the healds.

The Jacquard must be capable of lifting the warp without obstruction from the healds, and of leaving it lifted for several picks, during which time one shaft must sink and one rise for every pick in order to bind

both ground and figure. A sinking shaft pulls down one lifted thread from each repeat of the figure binding weave, and a rising shaft lifts one thread from each repeat of those left down by the Jacquard. If the rising and falling of these shafts is suitably arranged, a weft face weave will be formed throughout for ground, and a warp face weave for figure.

The saving effected by this harness is very great; for example, a 600 machine with 4 threads to a mail and 4 picks to a card gives a pattern that repeats on $600 \times 4 = 2400$ threads. This number of threads if moved by a single harness would require four 600 machines, and therefore 4 cards to a pick, in place of 1 card to 4 picks, or altogether $4 \times 4 = 16$ times as many cards as a pressure harness.

The smallest possible sheds and shuttles are employed; nevertheless great strain is put upon the warp; but, on the other hand, this harness is firmer and better adapted for very fine fabrics than the twilling machines which have been introduced to replace it. All twilling machines cause the ground weave to be centred where the harness is centred; but a pressure harness gives a perfect texture with any style of Jacquard harness. Curved lines produced by these harnesses are necessarily more irregular than those which result from placing the warp threads under separate control; and in proportion to the coarseness of the reed used, the figures have a stepped outline.

Pressure healds may be moved by a Jacquard, by tappets, or by dobbies. When the former is employed, one neck cord is tied to two hooks and passed under a grooved pulley A, Fig. 131. From a hook attached to A, a heald shaft is suspended by cords that descend to an upper shaft. A shaft can be placed in three positions:

first, if both hooks that control it are down some of the warp lifted by the harness will be held down by the shaft; second, if only one hook is lifted, a shaft will be put out of action, for its eyes permit the warp to be lifted by the

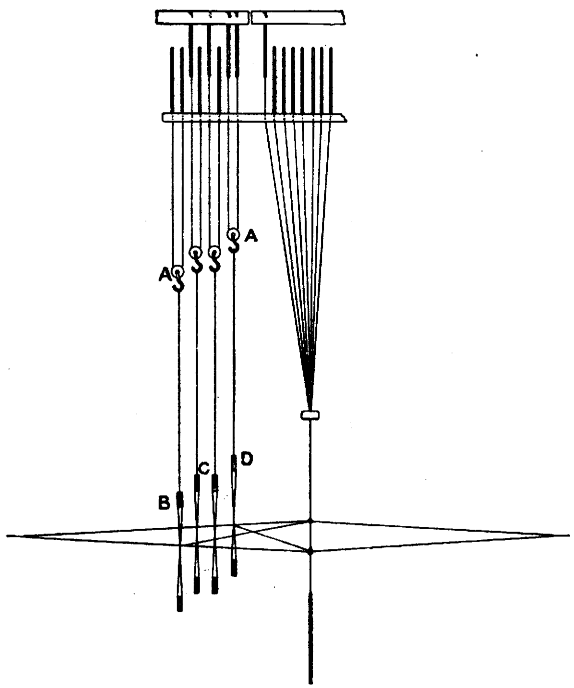

FIG. 131.

Jacquard; and third, if both hooks are lifted, some of the warp left down by the harness will be lifted by a shaft. But this system only lends itself to the production of unequal fabrics, in which the warp threads exceed those of the weft in the proportions of 2, 3, 4, 5, or more to 1. When both healds and mails are operated by the same

griffe there is an unequal strain upon the latter, and it cannot be left stationary for more than one pick, without leaving the healds stationary also. The warp is not lifted at the healds so high as at the mails, for if a mail is 20″ from the cloth fell, and a heald is only 10″ away, a lift of 5″ at the mails must be reduced to a lift of 20 : 10 : : 5 : 2·5″ at the heald. This actually occurs in the plan illustrated in Fig. 131. If the healds are suitably moved by tappets or dobbies, the Jacquard can remain lifted for any number of picks, and the shafts may move pick by pick to bind both ground and figure.

GAUZE WEAVING

Although designing and fabric structure are outside the limits of the present treatise, it will be necessary to describe how one portion of the warp threads may be twisted partly, or wholly, round other warp threads. Most tappets, dobbies, and Jacquards are employed for this purpose, but closed shedding requires fewer additions than open shedding. Special easers, and healds, reeds, or needles are needed to cross the warp. Healds are in most extensive use for general work, but the two last named possess advantages where the scheme of lifting and twisting is limited. Provision is made for lifting every twisting thread from two points, so that an open or a cross shed may be formed at pleasure, and if healds are employed, the ordinary type lift an open shed, but a heald and a half heald combined form a cross shed.

BOTTOM DOUPING WITH SHAFTS

The accompanying Figs. 132, 133, and 134 show how this effect is produced. Fig. 132 is a draft and lifting plan for a simple gauze; the thick, short lines at A indicate that two threads pass through one dent of the reed B. The horizontal lines 1, 2 are two heald shafts, the former containing even, the latter odd, threads of warp; S, D are respectively the standard and doup, both of which are better seen in Figs. 133 and 134. A standard S is an ordinary shaft of twine or wire healds into which half healds D, also of twine or wire, have been attached either by passing the doups over and through the eyes of S, or by

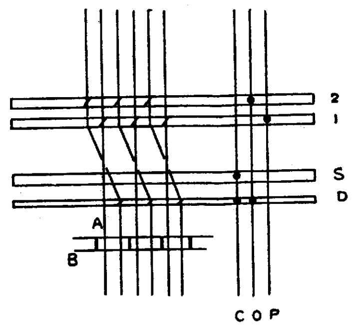

FIG. 132.

simply pushing them through those eyes. In the latter event, however, the doups are liable to fall out of position when the warp breaks. After the warp has been drawn alternately into shafts 1, 2, every odd thread is crossed under an adjacent even one, and passed through a loop of the half heald. It is the office of shaft 1 to prevent the straight threads from rising with those that cross, and for simple gauze this shaft may be dispensed with, if a rod is passed above the straight and beneath the crossing threads and then fixed securely in position.

Dots on the vertical lines O, C, P, Fig. 132, represent the order of lifting the shafts: O is an open shed obtained by

lifting D and 2, as seen in end elevation, in Fig. 133; C is a cross shed made by lifting D and S, as shown in Fig. 134,

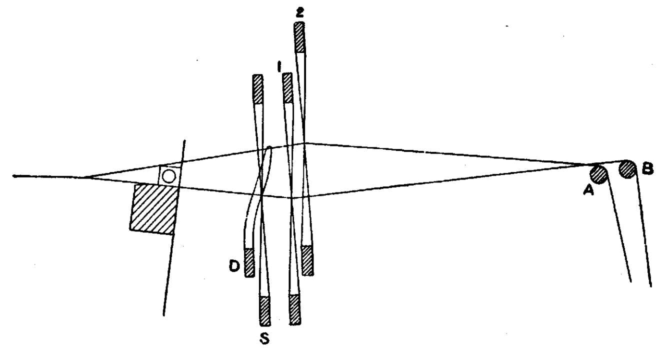

FIG. 133.

and when necessary a plain shed P can be formed by lifting 1.

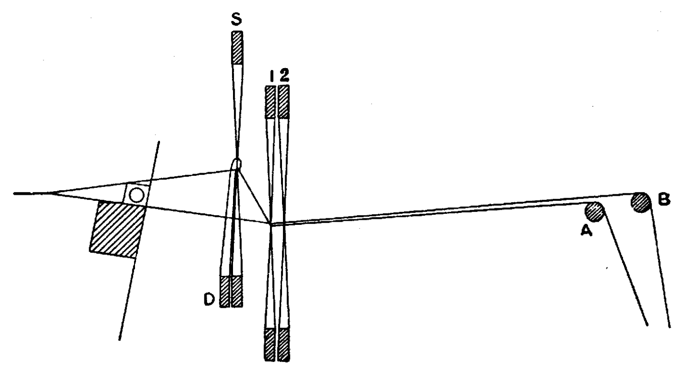

FIG. 134.

In the plan, Fig. 132, one thread crosses one, but any number of threads may cross any other number, provided all are in the same dent in a reed.

Twisting one set of threads round another set and lifting the same threads every pick are distinguishing features of gauze. For gauze weaving the threads on shaft 1 are never lifted above the weft, but as the crossing threads pass beneath them, to the right and left alternately, the

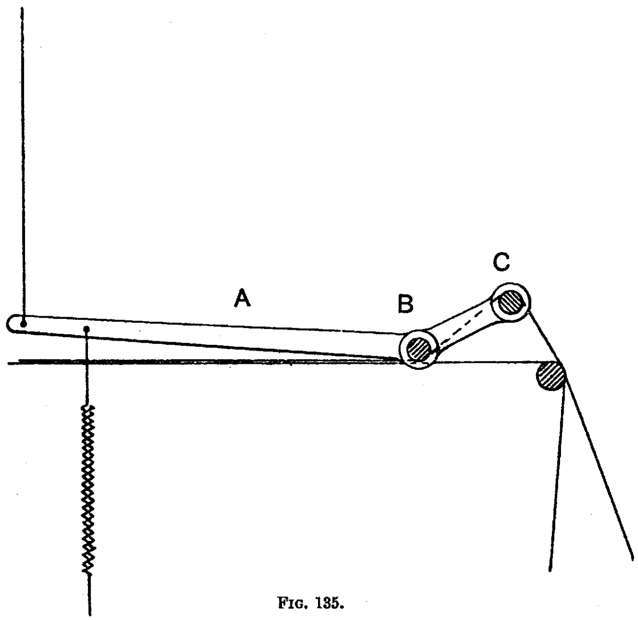

FIG. 135.

straight threads are securely bound into the fabric. Threads lifted for a cross shed would be subjected to greater strain than when lifted for an open one, unless something was added to regulate the tension. This is usually provided for by passing the stationary threads over a fixed bar B, Fig. 133, and the crossing threads over a bar A, that moves to ease those threads whenever a cross shed is opened.

Movement may be given to an easer by a dobby or a tappet, the latter being preferable on account of the timing, if the necessary mechanism is available. An illustration of each method is given in Figs. 135, 136. Fig. 135 shows a lever A, from which a cord is led to a dobby; A is fulcrumed at B, and at its extremity a rod C crosses the loom to support all the twisting threads. An upward movement of the cord lifts A, depresses C, and slackens the threads. In Fig. 136 the cord descends to a tappet treadle, and the

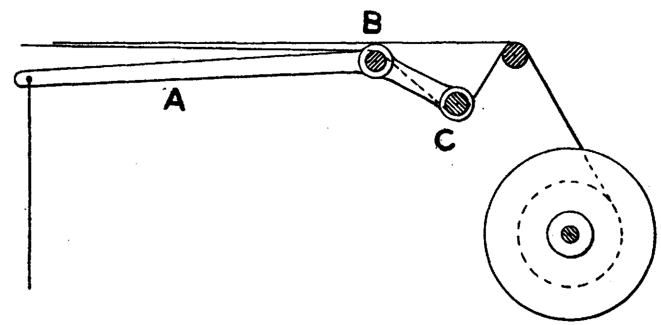

FIG. 136.

rod C is below the straight threads, hence easing is accomplished by depressing A to lift C. Instead of a bar C a shaft of ordinary healds may be employed to ease. In that case the healds occupy the position usually occupied by an easing bar, and the crossing threads are drawn through the eyes. If the easing mechanism lifts this shaft, the eyes must be placed in a lower plane than that which contains the straight threads, as at C, Fig. 136. But if the mechanism sinks the shaft, the eyes must be at a higher level than the straight threads, as at C, Fig. 135.

It is stated on p. 99 that open and semi-open sheds are not so well adapted for gauze weaving as closed sheds.

Still, any double lift shedding motion can be used provided suitable mechanism is added to lift the standing threads and sink the crossing threads to the centre of a shed, and thus permit one set of threads to cross those of the other set.

In weaving simple gauze one thread from each dent of the reed is lifted to the top shed level every pick, the others are lowered upon the race board, and between two movements of the shuttle, one set of threads must be twisted half round those of the other set. If an open shed dobby is employed to weave such a fabric, either some outside contrivance must be resorted to, or some modification be made in the construction of the dobby, for the latter is incapable of lifting and lowering a shaft on one and the same pick, without which the separated threads could never cross. The parts so added are known as shakers. Their function is to lift the standing threads from the bottom shed line to a point above that where the rising and falling threads pass each other, hold them in a state of comparative rest until the crossing has been effected, and return them in time for the following pick.

The half heald must simultaneously be lowered by the dobby to a point slightly beneath the mid position and return to the top. While the above is taking place, the standard S and the back shaft 2, Figs. 133, 134, make through movements and reverse the crossing. A shaker may consist of winged cams mounted upon the bottom shaft to lift and return the lower line of warp before the shuttle begins to move, or levers may be rocked from the connecting arms of the driving cranks, as in Fig. 137, where a bar A is held parallel with the heald shafts by brackets, and carries three arms, two of which are secured upon A at equal distances from the ends of the heald shafts, and one is seen at B. The arms B are connected by cords

to those shafts only that contain the standing threads. The third arm C is united by a link D to one of the connecting arms of the driving crank. As the latter rotates, a vibrating motion is conveyed through D to the bar A and through the arms B to the standing shafts. This movement must be sufficient to permit of crossing.

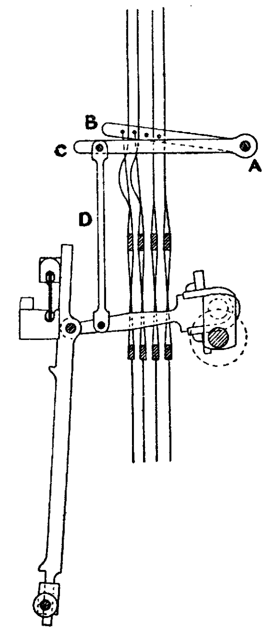

FIG. 137.

It is by far the best plan to compass the necessary movements by the addition of suitable attachments to the dobby, for, with cams and levers rocked by the loom cranks, the standing threads are lifted every pick whether or not the pattern requires such lifting. A dobby should act only when the crossing threads are to be moved to the opposite side of the standing threads.

A dobby shaker is shown in Fig. 71, but like the preceding it acts every pick whether the threads are to change places or remain unchanged. It consists in mounting a bowl 7 upon the swing lever B, and causing that bowl, both in its descent and ascent, to rock a lever 4. This lever is centred at 5 and carries a bowl 6, which impinges upon an arm 1. Two such arms are fulcrumed upon the framing at 2, and support a bar 3, having a series of holes drilled through it to permit of pegs being attached where required. As the bowl 7 passes and repasses the shoulder 8, the bowl 6 descends with the arms 1; the pegs in 3 thrust down those jack levers G that operate the standing threads, and shake the heald shafts. A helical spring 9 lifts the arm 1 and the bar 3, immediately 7 has passed off the shoulder 8.

The Stafford dobby is of the Hattersley type, but designed to permit of attachment to the loom end instead of the loom top, and to push instead of to pull the hooks. When used for leno weaving it has a draw knife A, in addition to the usual draw knives B, C, Fig. 138. A is mounted slightly above the upper line of hooks D. Four of these hooks are double-headed, and are actuated by a long peg when they are to be drawn by the middle draw knife B. But if no peg is used the hook D will be lifted into contact with A.

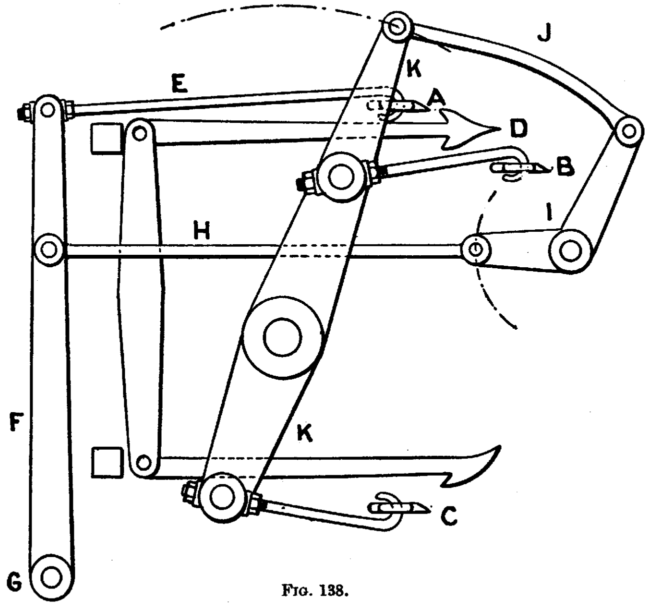

FIG. 138.

When a heald, governed by a double-headed hook, is to remain in the bottom shed line, a short peg in a lag will place that hook out of reach of both the knives A, B.

The knife A is moved through a little more than half the traverse of the knives B, C, and at twice the speed, in the following manner: A is attached by a link E to a lever F fulcrumed at G. A second link H connects F to one arm of a cranked lever I, and from the other arm of I, a link J passes to the three-armed lifting lever K, which is lengthened upwards for the purpose. The draw knife A makes an outward and an inward movement for every shed formed. Thus, as K is rocked to and fro by the usual vibrating rod, the lower arm of I is moved above and below its centre, and gives a half lift and return movement to those healds that govern the standing threads.

Two of the jacks are connected by straps, to a doup heald, both of which act in opposite directions, so that one will lower the doup to about the mid position of the shed, and the other will carry it back again to the top. By the combined movements of the standing thread shaft and the doup, both crossing and standing threads are brought into positions which permit the jacks that operate them to effect a crossing of the threads, on the completion of which the doup returns to the top and the standing shaft to the bottom shed.

Coarse textures, known as sponge cleaning-cloths, are manufactured by the aid of two needle bars A, B, Fig. 139; into each bar a series of needles C, D are fixed at the rate of 5 to 10 per inch, and they present two eyes to every dent in a reed. The shaft A is placed above the warp with the eyes of C at the bottom; but B is placed below with the eyes of D uppermost, and a warp thread is drawn through each eye. When the warp forms one line, the eyes of shaft A are midway between those of shaft B, hence, by sinking A and raising B, the warp will form two lines to receive a shuttle. A, B then recede until the eyes of C, D have separated the warp about $\frac{3}{8}''$. At this instant a lever actuated by a face cam gives a sufficient lateral movement to B, to cause the threads in B to cross those in A. The next vertical movement again forms a shed; therefore if the first was open, the second will be crossed.

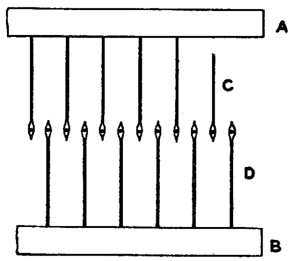

FIG. 139.

In addition to the vertical movement of A, and the combined lateral and vertical movements of B, these bars must be capable of weaving a plain texture for the heading. For this purpose they are operated by a lever and an anti-friction bowl; the latter runs in a double-grooved tappet. Both grooves are connected by a switch, and the opening or closing of this determines whether the bowl shall run in the plain or the leno groove. A change can be instantly made in the position of the switch, for it is governed by a chain composed of deep and shallow links, or by cards, or lags. The altered direction given to the bowl causes the needle bars A, B to form plain sheds alternately. One or other of the above-named selecting chains also actuates the taking-up motion, so that it may be equally adapted for plain and leno weaving, and for making fringes.

A second method of weaving heavy fabrics of the sponge cloth variety, and also applicable to a number of other fabrics, has been introduced under the name of the "heavy fabric loom."

In this loom the threads forming the warp are divided into two parts; one half is wound upon a beam A, Fig. 140, suitably placed near the floor, the other is contained in a series of carriages in a similar manner to the method employed in weaving lace. The ends from the beam are carried upward and are passed singly through eyes on a flat bar C, which performs the functions of a harness in that it is capable of moving the threads in a lateral direction. The carriage threads are wound on brass bobbins D, and may contain upwards of 200 yards, the length being controlled by the fineness of the yarn and the pitch of the combs E and E_1. The pitch of these combs also determines the closeness of the warp threads.

The shed for the weft is formed by the carriages moving forward from one comb, E, into another, E_1, which naturally carries this series of threads, say, to the right of the beam threads. Whilst in this position the harness bar is moved so that on the return journey the carriage threads pass on the left-hand side of the beam threads, after which the beam threads are moved back into the first position.

When this double movement has been made the carriage threads have passed completely round the beam threads, producing the equivalent of a full cross leno, as shown at J. After this the weft F is inserted by means of a vertical tube G, through which the weft passes from a large upright bobbin or spool H, resting on the floor. Movement is given to the tube by a face cam situated at the side of the loom. A number of pieces can be woven in the same loom, each piece having its own weft tube, and owing to the large supply of weft, the stoppages for weft replenishing are reduced very considerably. The weft is beaten up by an open-ended reed or comb having a vertical movement. The full cross leno structure produces a fabric of considerable firmness, considering the number of warp threads per inch.

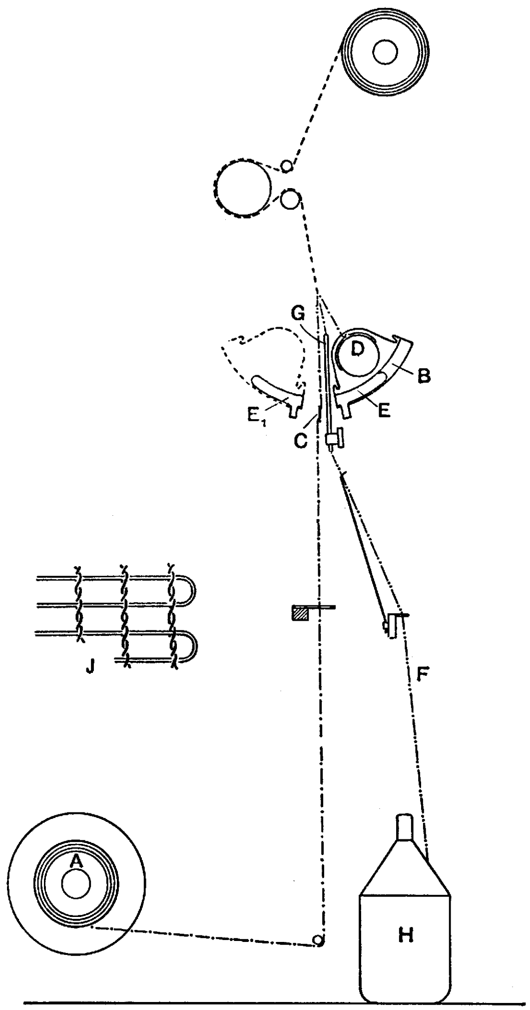

Fig. 140.

Another plan is to effect a crossing by the aid of a specially constructed reed, which is made to rise and fall by the action of a cam. This reed has a half dent A, Fig. 141, placed between the ordinary dents B, and provided with an eye near the top for a crossing thread 1 to pass through. The straight threads 2 are drawn through heald eyes, or through mails in a Jacquard harness, and are then taken between the full dents B of the gauze reed; finally, one straight and one crossing thread go into a dent of an ordinary reed.

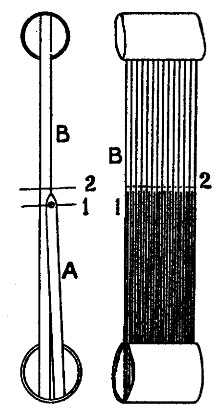

Fig. 141.

The warp threads 2 pass between the dents of a "tug" reed placed between the gauze reed and the harness; a slight lateral movement is given to this reed first to the right and then to the left; after each of such movements the gauze reed rises and thus its threads are raised alternately to the left and the right of the threads 2, forming a plain gauze texture. This device is commonly used in making Madras muslin textures.

Top Douping with Shafts

A top doup differs from a bottom one in having the half heald shaft D, Fig. 142, turned to the top. Cords from D are also made fast to two pendent spiral springs, which enable the shaft to give to any unusual strain, and thus prevent breakages; otherwise, with closed shedding, D neither rises nor falls. The crossing threads 3 pass over instead of under the straight ones 4, and the healds are operated as follows:—for an open shed O, Fig. 143, the standard S and heald 1 are lifted. For a cross shed C, the healds 1, 2 are lifted, and the easer A, Fig. 142, is moved to slacken the crossing threads. For a plain shed P standard and doup and heald 2 are lifted. It will be observed that

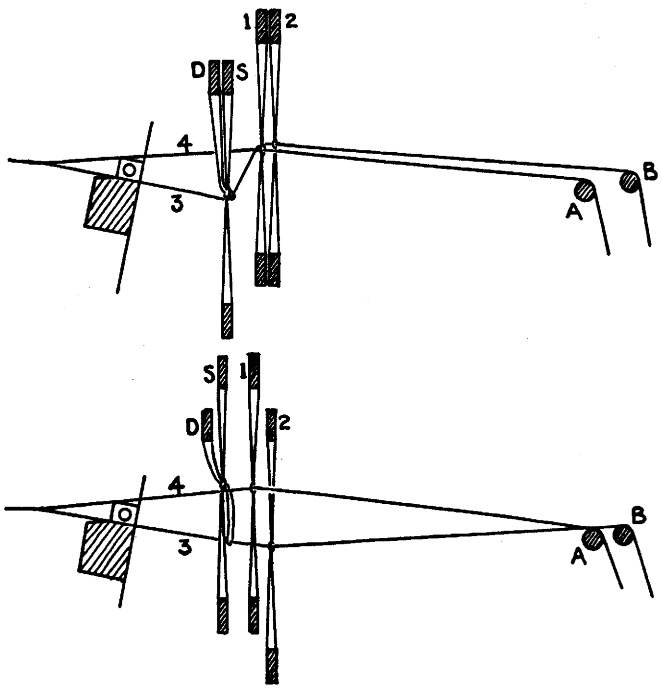

Fig. 142.

the crossing threads lifted by shaft 1 are always down where the shuttle traverses the warp, and the straight threads are up every pick. If an open shedding motion is used to actuate the healds, a shaker, Figs. 71, 137, 138, must be employed to lift the standard and doup. Shaft 2 must also be actuated by two hooks, each of which will

lift it for one pick and lower it for the next. By this means shaft 2 will sink to the middle and rise to the top every pick.

Gauze Harnesses

Special Jacquard harnesses are built to weave gauze fabrics with both bottom and top doups; still gauze can be woven with an ordinary harness if a doup and standard

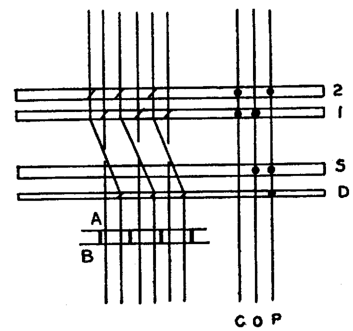

Fig. 143.

are placed in front of it, and if the crossing threads pass over an easing bar, Fig. 135, which moves to slacken them whenever the doup and standard rise together. This bar may be operated by spare hooks in the Jacquard.

For a bottom doup, with two ends in a dent, every crossing thread, after passing through a figuring mail, is taken under its fellow and drawn through a separate loop in the doup; then, for alternate picks, the standard and doup rise together and lift half the warp, say all odd threads. At the same time some even threads are lifted by the Jacquard griffe to form figure, for wherever both odd and even threads are lifted in any dent, no douping can take place, because there is nothing to cross round; but where even threads are down, the odd ones are crossed round them. On intervening picks the half heald is lifted to put the doup out of action, and where gauze is wanted the crossing threads are lifted by the figuring harness; but to form figure odd and even threads rise together. For plain cloth only even threads rise.

A harness of this kind can be used to weave many gauze fabrics; but it is limited in the sense that only one pick can be inserted into the gauze portion of a shed if in other places plain cloth is made.

If two or more picks are put into one gauze shed and combined in any way with plain cloth, a special gauze harness is required. These are built in various ways; generally there are three distinct sections, and three separate comber boards. Thus:—

If an ordinary 600 single-lift Jacquard is fixed for the cards to be suspended over one end of a loom, and if the reed has four threads through each dent, two crossing two, the hooks must be divided into six parts, and one-sixth used for easers, four-sixths for figuring, and one-sixth for douping. For example, let 576 hooks equal one repeat of the pattern, then 8 short rows from the back of the Jacquard must be set apart for easers, 32 following rows for figure, and the next 8 rows for doups $= 96 + 384 + 96 = 576$. In the event of cards being suspended over the warp, the first two long rows of hooks will be taken for easers, the eight middle rows for figure, and the last two rows for doups. With 576 hooks to one repeat, 48 rows will be required, for $48 \times 2 = 96$, and $48 \times 8 = 384$, and $48 \times 2 = 96$. Or, $96 + 384 + 96 = 576$ hooks.

Jacquards are specially constructed for gauze weaving; of these W. and H. A. Fielding, in 1890, patented one containing 12 griffe bars, 10 of which are fastened together, the remaining pair being detached. Both sets are connected

to one lifting lever, but one is fixed nearer to the lever

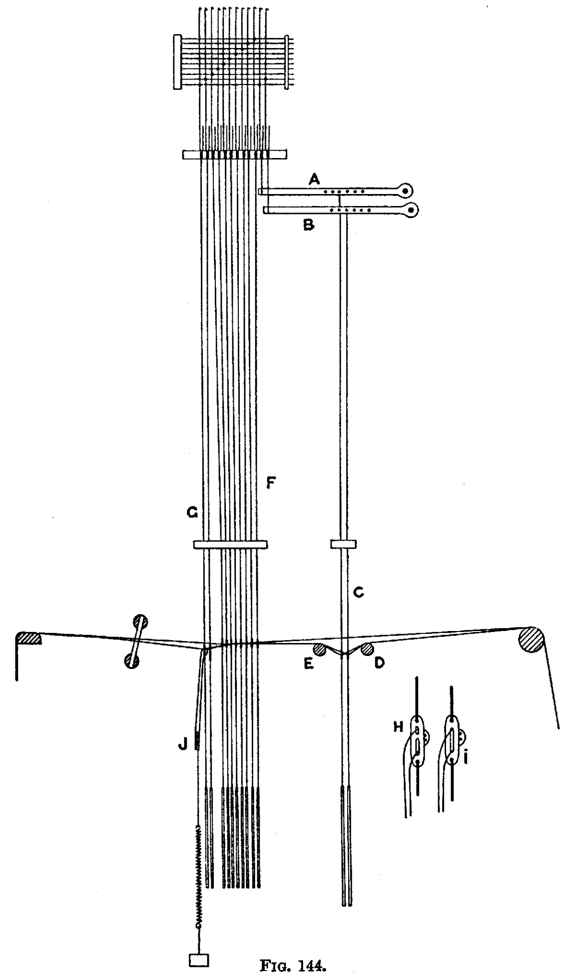

FIG. 144.

fulcrum than the other, so that the easer griffe may have a shorter traverse than the main one, and be capable of adjustment. These makers move the doup and easing hooks by one set of needles, as in Fig. 144. This plan has the advantage of making it difficult to lift a doup hook without lifting its corresponding easing hook, and reduces the cost of cards to the extent of rendering a 500 card capable of actuating 600 hooks. In building an easing harness the neck cords may be attached alternately to levers in two lines as at A, B, Fig. 144, one approximately $4\frac{1}{2}''$ above the other. Mounting threads from the levers are then connected to the couplings C, and the mails of C are set in a lower plane than those of the figuring harness, by from $1''$ to $2\frac{1}{2}''$, but on an average $1\frac{1}{2}''$. Steel, brass, or copper mails are often used, but glass ones are preferable, as, owing to their smoothness, they do not cut the warp. These mails control all the crossing threads, and their lingoes vary from 4 to 10 per lb., for lingoes provide the only means by which crossing threads are put under tension. Any one, or any group of the 96 easers in each repeat, can be lifted separately to slacken the threads. Two parallel rods D, E, called the bridge, are bolted upon slotted brackets which permit of lateral adjustment. As a rule, they are from $3''$ to $4''$ apart, and are fixed horizontally beneath the warp.

The figuring harness F is about $12''$ in advance of the easing harness, and is built on the ordinary plan. It contains a sufficient number of mails to control every warp thread separately. Between the figuring harness F and the doup harness G a space of from $\frac{1}{2}''$ to $1\frac{1}{2}''$ is left to minimise the strain upon the crossing threads. The mail eyes of section G are about $\frac{1}{4}''$ lower than those of F, and sometimes contain two eyes for the doup twine to be drawn through, as shown at H, but when the doups wear out new ones must be built at the loom. At other times

mails are made with a single eye, and the doup twine is pushed through it as at I. The doups are then apt to fall out of the mails when the warp breaks. On the other hand, they can be readily replaced when worn out. Doup slips are made fast to a heald shaft J, which is raised every pick by cording it to the machine griffe, and J is pulled down by springs placed beneath the shaft. A doup requires careful adjustment, or it will rapidly wear out. By fastening regulating cords upon opposite ends of the shaft J, and tying them to the comber board, much strain may be taken from the slips, for the cords prevent the springs from pulling the leashes tight upon the mails. Doup lingoes vary from 16 to 24 to the lb.

Doup couplings have been attached to separate levers placed near the floor, and easing couplings have been connected to the rear ends of these levers. Each easing mounting thread, in one repeat of the pattern, was made fast upon a weighted lever situated above the easing comber board. Each lever normally acted to deflect the crossing threads upward, but by lifting a doup the corresponding easing coupling was pulled down to slacken the crossing threads. By adopting this plan a Jacquard is only divided into two sections, one for doups and easers, the other for figuring.

Two crossing threads are drawn through each easing mail C, Figs. 144, 145, after which both crossing and straight threads, 1 to 8, are drawn singly through mails of the figuring harness F. The first pair of crossing threads, 1, 2, are passed under the first pair of straight threads 3, 4 to the right, and then drawn through number 1 doup loop; finally, two straight and two crossed threads go through one dent in the reed. The crossing threads are thus drawn into the easing, the figuring, and the doup mountings, while each straight thread only goes through an eye in the figuring harness.

To weave figure, the half heald J must be lifted, together with an assortment of threads in the middle harness F, as at 9. To form a cross shed, lift the half heald J, the doup

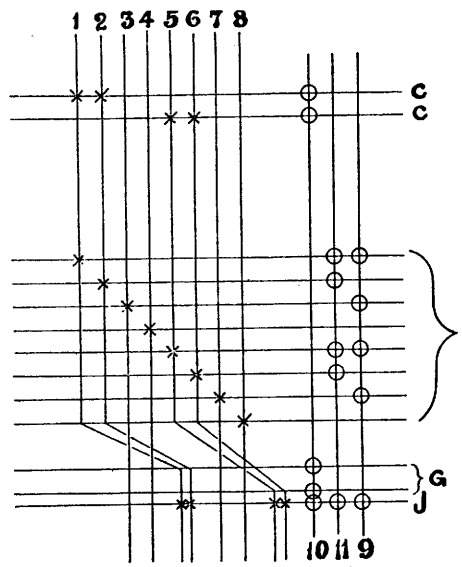

FIG. 145.

mails G that govern the threads required to cross, the easing mails C that slacken those threads, as at 10, also any assortment of threads in F for figure. To form an open shed lift the half heald J, the required crossing threads in the harness F, as at 11, and any assortment from F for figure.

With such a harness, variety of texture is almost limitless. The crossings may be of a most irregular description, including one crossing one, and one crossing eleven. The

picks in one gauze shed may differ from those in another at pleasure. Any doup can be brought into use at any time.

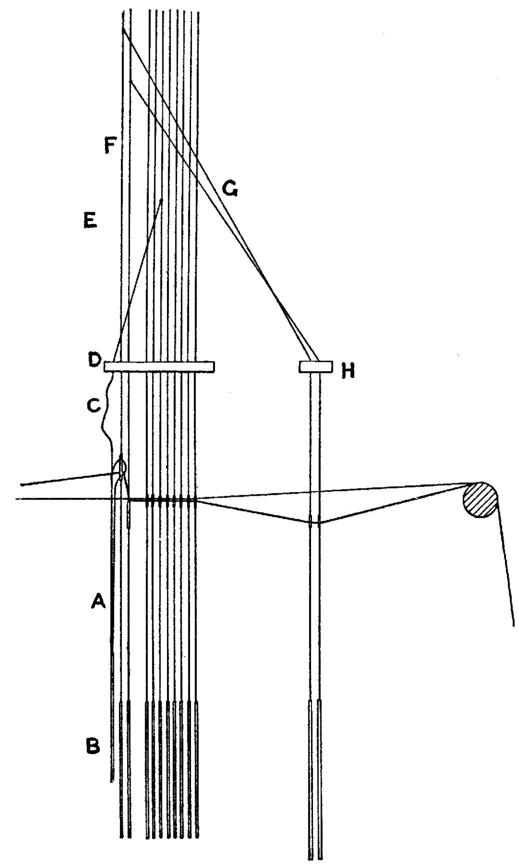

FIG. 146.

Warp and weft floats in the figure may be combined with the most varied ground weaves, provided plain cloth surrounds the gauze, for it is essential that the warp shall be thoroughly opened out before figuring is attempted. If the warp is allowed to become slack, there is a tendency for the harnesses to twist at the mails, and cause entanglements in the warp threads. This is specially noticeable in the doup harness G, Fig. 144, where slack warp may permit the doup slips to twist round the doup mails to such an extent as to necessitate redrawing the warp into them before weaving can proceed. If, when manufacturing coupling twine, the twist in the united strands is not correctly proportioned to that in the single strands, the couplings will not remain stationary. Attempts have been made to produce stationary, or "dead," couplings by twisting the twine for the upper loops in an opposite direction to that for the lower loops, but the plan has only partially succeeded.

Another form of bottom doup harness is occasionally met with, which requires two sections in the Jacquard—one for doups and easers, the other for figure. Every doup slip A, Fig. 146, has a separate lingoe B, and a second thread C from the lingoe is led through a comber board at D, and tied upon those mounting threads in the figuring harness E, that control the same warp threads as the doup slip.

By this means a slip rises whenever its warp is lifted in the figuring harness. The doup mounting F is of the usual type, but slightly below the neck cords a mounting thread G is led from every thread F to the easing comber board H. Although this plan augments the figuring capacity of an ordinary Jacquard, it crosses the harness and increases friction. Fig. 147 shows two threads crossing two; the threads 1 to 8 fill the first row of the comber board D; 3, 4, 7, 8 are crossing threads

that pass through two easers in H, and two doups in F, while O shows the lifting for an open shed, C that for a cross shed, and P that for a figuring shed.

Top Doup Harnesses

Top doups are as extensively used with Jacquards as

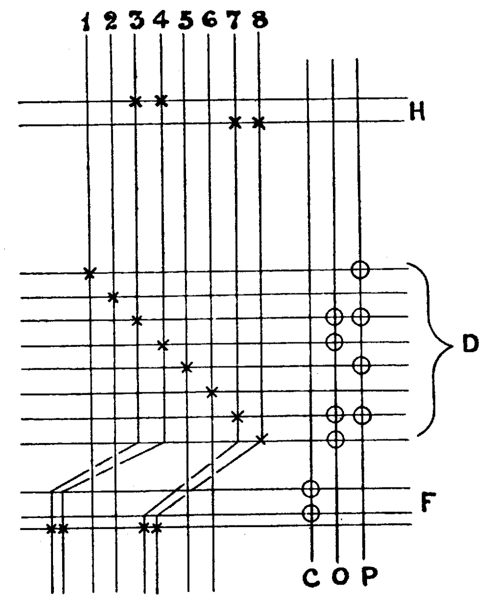

Fig. 147.

with heald shafts. A top doup harness differs from one for bottom doups—*a*, in having the half heald shaft fixed above the warp; *b*, in the doup lingoes being somewhat heavier; *c*, in the mails being approximately $\frac{3}{8}''$ higher than those of the figuring harness; and *d*, in the crossing threads passing above, instead of below, the straight threads. The half heald shaft may be screwed to the doup comber board, or suspended from the Jacquard. In Fig. 148 the lines 1 to 8 represent warp threads that pass through mails in the comber board B. The crossing threads 3, 4, 7, 8 are drawn through four mails in the

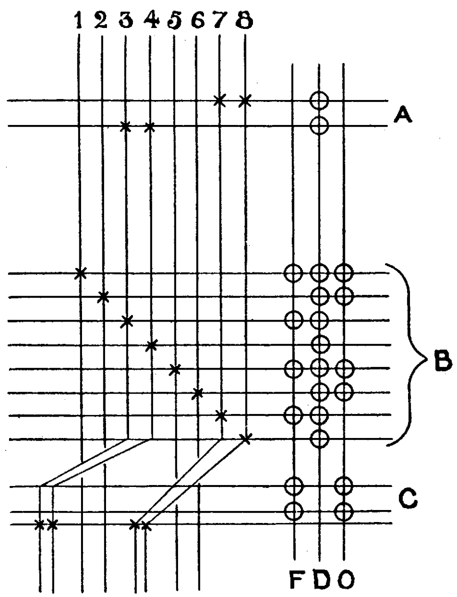

FIG. 148.

easing mounting A; through four mails in the figuring harness B, and through two loops of a half heald in the doup mounting C.

In the gauze portions of a texture an open shed O is formed by lifting the doup mails C, and the corresponding straight threads in harness B. A cross shed D is formed by lifting the easers A, together with straight and crossing threads in B. In the figured portions of a texture F, the

threads in harness B, that are required for figure, are lifted with the doup mails in C that govern those threads.

The chief differences between operating a bottom and a top doup harness consist in lifting the crossing threads for every pick of gauze with a bottom doup, and the straight threads for every pick of gauze with a top doup; also with the former, the doup and easer invariably move together; in a top doup this never occurs, for a lifted doup mail allows the crossing threads to become parallel, while the weight of a lowered doup lingoe is sufficient to hold them in the cross, but by lifting an easer the strain is reduced, and the straight threads are free to rise at the opposite side.

With a Jacquard of the type described on p. 268, the heads of either the easing or the douping hooks must be inverted, to permit a needle to press one hook clear of a griffe blade and to press the other over a blade.

The advantage of a top doup over a bottom one is that it is impossible, even with single-eyed doup mails, for the doup slips to fall out of reach of the weaver, and the doups are in the most convenient position to repair in case of breakage or disarrangement.

Top doups may be used when the crossing threads go under the straight ones, provided the crossing threads are lifted every pick; but the doup twine and the stationary warp rub as the sheds are formed; the doups also have a tendency to lift the straight threads off the race board and form irregular sheds.

If double lift Jacquards are used to operate gauze harnesses, shakers are essential. For bottom douping a shaker may consist in threading Bannister shafts (see Fig. 129) through those rows of couplings that actuate standing threads, and in causing those shafts to lift the standing threads slightly above the middle of the shed for every pick. A tappet may be employed for the purpose. In Fig. 145 a shaft would be required for the couplings in each of the rows containing threads 3, 4, 7, 8 in the harness F. But since the threads in rows 1, 2, 5, 6 are crossing threads, it is unnecessary to add shafts to them.

For top douping the doup couplings may be knotted immediately above the doup comber board, and that board, and the doup heald, be lifted half a shed every pick. A tappet may also be employed for this purpose.

PART VIII

CARD-CUTTING

DESIGNS are painted on paper which is ruled vertically and horizontally so that every space between two vertical lines shall represent a warp thread, and every space between two horizontal lines a weft thread. At regular intervals thicker up and cross lines, called bars, are ruled; the up lines enclose as many threads as there are needles in one short row of the Jacquard to be used. The cross lines mainly serve as guides to the designer and card-cutter. See Figs. 161 and 166. Paint laid upon the small squares, formed by vertical lines intersecting horizontal ones, denotes, as a rule, warp lifted above weft, and therefore holes in the cards.

Each card is cut from the painting found between two horizontal lines upon the design paper, but as holes are punched in the cards, they have the effect of turning up the design, bar by bar, into short vertical lines to correspond with the Jacquard needles.

Card-cutting machines are of two classes — *a*, those

used to transfer a pattern from design paper to cards; *b*, those used to duplicate sets of cards. Generally they are distinct, but occasionally they are combined.

The most familiar machines of both classes appear to be of French origin. The oldest method of cutting cards is used in districts where small Jacquards are the rule. It requires a pair of perforated plates which are hinged together, so that a blank card may be placed upon the lower plate, and the top one closed over it and locked by a sliding catch. Both plates are secured to a frame provided with rollers that run upon rails. A third plate is perforated like the others, but furnished with a handle at each end. It is placed on a bench, and the design to be copied is fixed behind it. Adjacent to the plate is a box containing several hundreds of cylindrical punches, all $1\frac{1}{2}''$ long by $\frac{7}{32}''$ in diameter. Each punch has an enlarged head for the purpose of preventing it from falling through the plate. The punches are dropped one by one into the holes in the carrying plate to correspond with the painted design; afterwards both plate and punches are fitted upon the other plates, and pressure is exerted to force the punches through the card. For this purpose a roller press is used, the roller being turned by one hand, while the plates are pushed beneath it with the other, or a power-driven press is used.

The process is more expeditious than might be supposed, especially where the groundwork of a pattern is regular, as in a plain or a twill weave. In the case of a plain ground all the punches are set for the first card, but after that odd picks only are cut during the first reading, because few punches require changing. On the second reading even picks are cut. A twill ground is read by repeats of the twill; thus for a four-end twill every fourth

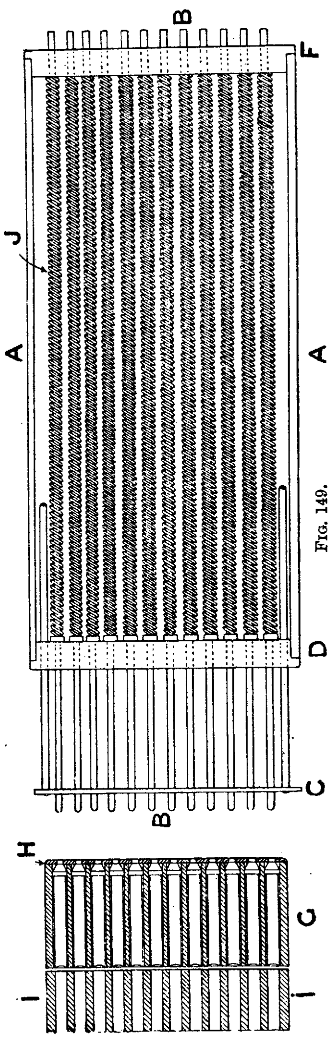

Fig. 149.

pick is taken at each reading. After all the cards are cut they are placed in sequence and laced together.

The above has been converted into a useful repeater by mounting a carriage on a frame so that it may slide to and fro. The carriage A, Fig. 149, generally contains 612 horizontal needles B, which are arranged in 12 rows of 51 each. Every needle is supported in front by two perforated plates C, D; the former is held away from the latter by riveting four spindles upon C, passing the spindles freely through holes in D, F, and threading spiral springs upon them. A similar perforated plate F is fixed in the rear of the carriage A to support the opposite ends of B. A shoulder, consisting of a piece of coiled wire, is fitted upon each needle to limit its forward movement, and also to permit one end of a coiled spring J to rest against the

collar, while the other end of J abuts upon the plate F. By this means the points of B are made to protrude through the plate C. A perforated box G is filled with punches that enter it head first. They are prevented from passing out at the back by a thin brass plate H, whose perforations are only large enough to permit the needles B to enter. Two studs are fitted in G to hold the carrying plate I, with its holes opposite those in G. The card to be repeated is held upon conical pegs in H, and the carriage A is drawn forward by depressing a treadle. Where holes are cut in the model card the springs J are strong enough to cause the needles B to push punches from the box G into the plate I, but solid parts of the card cause J to contract and the needles to recede. The carrying plate I, with the punches pressed into it, is removed to book plates containing the card to be cut, and all are led under a press either turned by manual or by mechanical power. After cutting that card, the carrying plate I is replaced upon the studs of G, and a comb, consisting of 612 pieces of wire fixed into a wooden back, drives the punches into the punch box G. A second card is fixed upon the pegs of H and the operations are repeated. This machine is reliable and simple, but compared with automatic repeaters, the process is slow and costly.

Reading-in and Repeating Machine

A "reading-in" card-cutting machine was patented in England by S. Wilson in 1821 from a foreign communication. It was for many years a great commercial success, but is now obsolete.

Shortly after its introduction the reading-in machine was converted into a reader-in and repeater, and from this model some of our best automatic repeaters have been developed. It consisted of a series of 612 vertical cords A, Fig. 150, each formed with a loop at the bottom. A rod was passed through all the loops and forced into

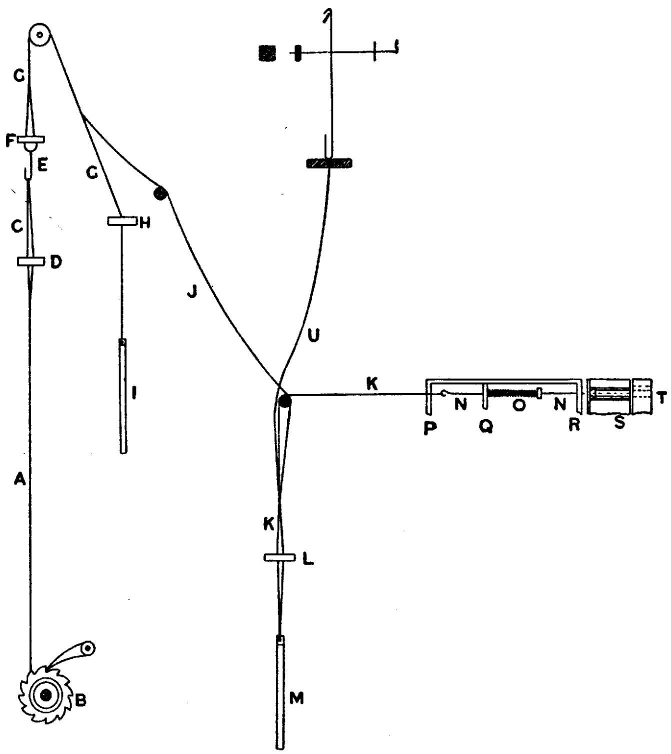

Fig. 150.

a slot in the roller B. At the top of A a second series of loops C were made by threading each cord through a separate hole in a guide board D, returning it through another hole in D and splicing it a few inches lower

down. After which the loops were severally dropped into wire hooks E that formed the terminals of another set of 612 cords G. These cords were held in one line by threading each through two holes in a fixed frame F. Each then passed over a guide pulley, through a comber board H, and was tied to a lingoe I. A third set of 612 cords J were spliced upon G, led over two guide rods, through a comber board L, and attached to lingoes M. From every lingoe M another cord K was drawn through a hole in a board L, then bent at right angles over a glass rod, and made fast to a needle N. Three perforated plates P, Q, R served respectively as front and back guides for the needles and the cords K. A collar twisted round N acted as a stop-hoop for a spiral spring O, and the rear of O abutted against a plate Q. A punch box S and a carrying plate T were fixed immediately in front of the needles N, as in the repeating machine. The lingoes M contracted the springs O, and pulled back the needles N. When any of the cords A were deflected, certain cords G, J, K were lifted to remove the weight of M from the needles N and thus permit some of the springs O to expand, and drive corresponding punches into the carrying plate T. The cords A were separated by a comb into sets of threads corresponding with the number of vertical spaces enclosed by bar lines on the design paper, and further divided by two rods to form an end and end lease. A straight-edge was placed across the design to assist the operator to read along a horizontal line. He proceeded to weave the pattern by interlacing cross cords, as picks, amongst the threads A in such a manner that every cord A representing lifted or unlifted warp would respectively pass in front of, or behind, a cross cord. When the cords A had been filled with picks, a roller was placed in the position occupied by the top cord and fixed in a sliding frame. By pressing down a treadle the cords A in front of the roller were deflected and corresponding punches pushed into the carrying plate, after which it was ready for the press. The operation was repeated until all the cross cords had been removed from the vertical ones, and all the cards were cut. This completes the reading-in section of the machine.

For the repeating section a 600 Jacquard was placed over the comber board L, and a thread U from each hook was connected to its proper lingoe M. By suspending the cards to be copied from a cradle and leading them round the cylinder, the machine, when set in motion, lifted those lingoes M that corresponded with the holes in the card, and in each case a spring O forced its punch into the carrying plate T.

Vertical Punch Reading-in and Repeating Machine

By altering the form and position of the punches, a superior machine was obtained. All parts of the reading-in section remain precisely as in the former machine, and in Fig. 151 they are lettered from A to J. The Jacquard and its connections U also remain unchanged; but each cord K, after passing the glass rod, is led over a guide pulley L, thence down to a vertical punch N, which is approximately 11″ long by $\frac{7}{32}$″ diameter. Each punch is recessed on one side for $\frac{3}{4}$″ at two places P, Q, to leave a cylindrical piece $\frac{1}{4}$″ long between them. At O a recess of $1\frac{1}{2}$″ is formed on both sides of each punch, to receive a fixed comb R, having 53 teeth, of $\frac{1}{2}$″ deep. The teeth are thick enough to touch two punches without interfering with their freedom of vertical movement. The comb R

holds the slots P, Q in two adjoining rows of punches N facing each other, so that a vibrating comb S may be pushed through all the slots that fall in one line. Each

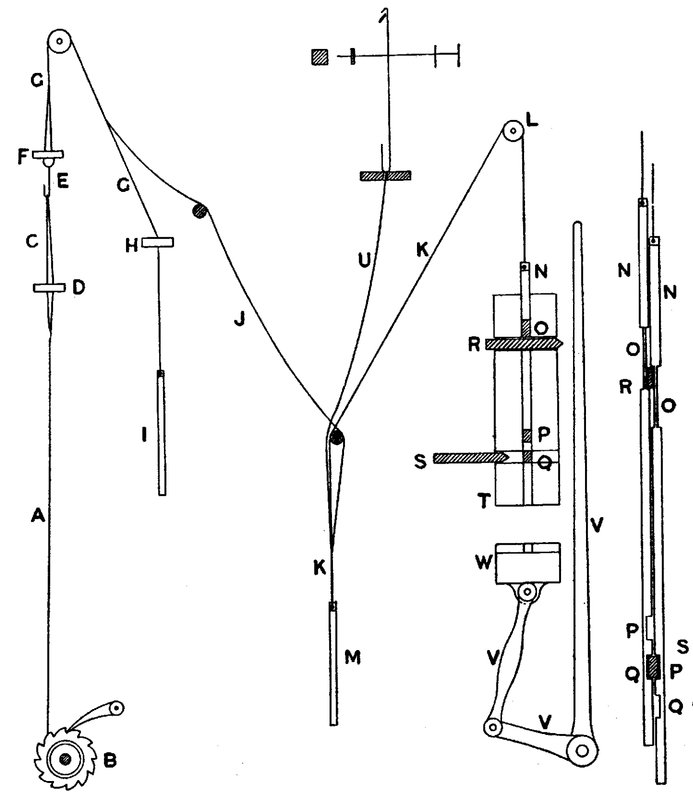

Fig. 151.

tooth of S will then lock two rows of 12 punches. This comb has 26 teeth, all $\frac{3}{4}$″ deep, and sufficiently wide to rest upon both lines of punches.

After withdrawing S, any of the cords, J or U, may lift the lingoes M, and the punches, normally supported by the weight of M, will fall until the slots P face the teeth of S, then as the latter advances some punches will be locked, with their ends protruding through the punch box T, while others will be retained in the box. See the enlarged, detached punches on the right of the Figure. A blank card is placed upon a perforated plate W, and by means of the compound lever V the plate W is carried up to T. On reaching the latter point every protruding punch will puncture the card, but those locked by S at a slot Q are inoperative. This machine is used on the continent of Europe, and embodies the essential features of the machine now made by Devoge and Co.

Devoge and Co.'s Repeater

Since Devoge's machine is merely a card repeater, the reading-in parts of the former are removed and only the Jacquard with its connections remain. A 600 Jacquard is fixed on an iron framing above a comber board V, Fig. 152, and cords U descend from the hooks to the lingoes M. Other cords K are attached to U, passed over rollers L, and made fast to the punches N. The latter only differ from the French punches in being recessed on both sides at P, Q, Fig. 151. By adopting this form of punch and furnishing the comb S with as many teeth as R, the makers claim that increased steadiness is given, because the punches are supported on both sides by S. The cards have peg and lace holes punched by a separate machine, after which they are laced into a continuous chain, passed over guide prisms and between the plates T, W. The Jacquard griffe rises, the comb S is withdrawn, and where lingoes M are lifted, the

punches N fall. In advancing, the comb S passes through the lower slots of lifted punches, and the upper slots of lowered punches, to lock them before the cutting plate W rises with the card to be perforated. The machine is rendered automatic by moving the plate W up and down with eccentrics, and the Jacquard griffe with a positive cam.

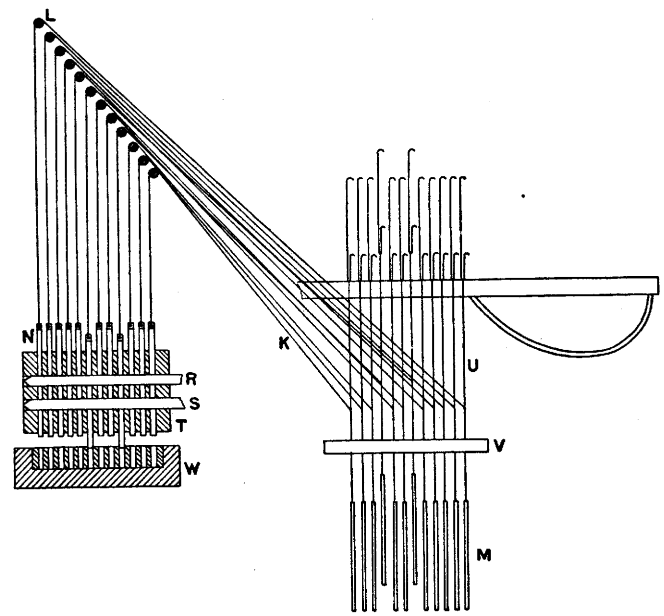

Fig. 152.

M'Murdo's Repeater

In 1887, J. M'Murdo patented a modification of the French machine, but since the punches receive a direct instead of an indirect action, compactness is combined with fewer parts.

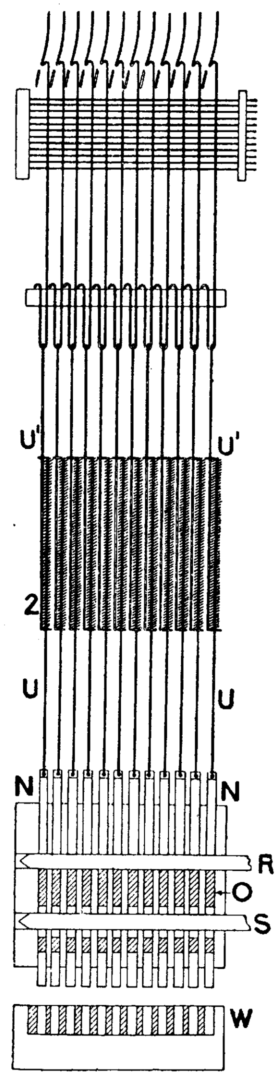

FIG. 153.

Above a punch box a 600 Jacquard is fixed, the heads of whose hooks face the spring box, and its griffe bars are set to miss vertical hooks and lift inclined ones. Two pieces of wire, U, U′, Fig. 153, are united to each other and to the hooks and punches. The piece U′ is flattened at the bottom, punched, and bent at right angles; U is similarly treated, then a steel spring 2 is threaded upon it; U′ is passed through the hole of U, and U through that of U′, with the spring 2 between the bends, thus forming a sliding joint.

The punches N are 11″ long, and recessed as usual at three places, but only on one side; the top recess O is $1\frac{3}{4}$″ long, the two lower ones are each $\frac{3}{4}$″, while the round portion between them is $\frac{1}{4}$″ long. All the recesses in two adjoining rows face each other. Both the combs R, S have 26 teeth; the former is stationary and prevents N from twisting, but S vibrates laterally.

Blanks in the cards to be copied cause the hooks to be pushed over the griffe bars. The comb S is then withdrawn to permit the punches, operated by ascending hooks, to be lifted into the punch box. After which the comb S moves in to lock them either up or down, and eccentrics lower the punch box upon the stationary plate W. The sliding joints 2 permit of the downward movement; they also allow the griffe to rise slightly before the punches are liberated, and thus accelerate the action of N. When 400[s] cards are to be cut, the needles in rows 1, 2, and 11, 12 are pressed back, and the surplus punches are lifted out of action.

NUTTALL'S REPEATER

In 1875, James and Thomas Nuttall introduced an automatic repeater, which was both original and ingenious in construction. The upper part of this machine contains 612 needles A, Fig. 154, and the cards to be copied are moved by a cylinder D successively into contact with the needles. Holes in a card leave A unmoved, but blanks push them back. A set of 612 vertical wires B have an eye coiled at the centre and are mounted upon 12 fulcrum pins E. These wires connect an upper set of needles A with a lower set of needles C, and give C an opposite movement to A. The top row of A are united to the bottom row of C, and the top row of C are governed by the bottom row of A. Each needle C is furnished with a cylindrical plug, that in its normal position covers the head of a punch F and prevents it rising. Every punch so covered will be forced through the card to be cut at the next upward movement of the cutting plate H, but a blank in a model card withdraws a plug and allows its punch F to rise. The liberated punch rests by gravitation upon the blank card, but its weight is insufficient to make a perforation.

Twelve horizontal rows of 51 plugs are placed in tiers along a stepped, perforated plate K. Beneath the plugs are 12 rows of punches with heads varying in length to suit the positions of the plugs which act on them. Each punch has a collar I, formed at a uniform distance from the cutting point, and as H moves down to permit the next

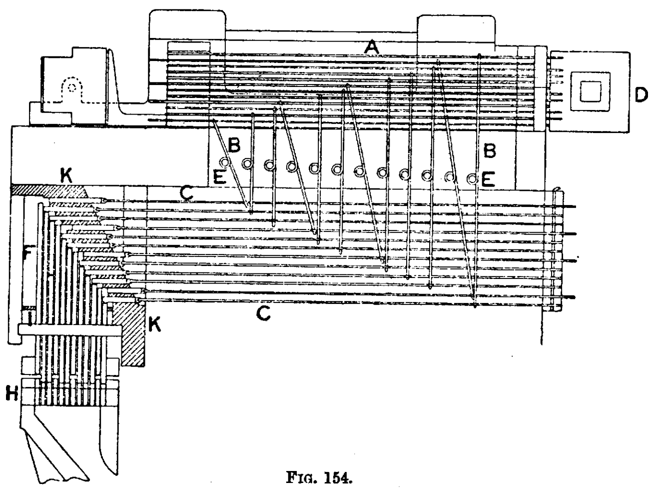

Fig. 154.

blank card to be brought into cutting position, the punches are suspended by their collars in a perforated plate.

As originally constructed, the vertical distance between plug and plug was insufficient, and in some cases vibration prevented a card from being perforated; in others, the cards were partially or wholly cut where they should be blank.

In order to reduce vibration, the punches F have been made so that one line acts slightly in advance of another line. Also, half the required number of punches have been

used, then two movements of the parts were needed to perforate a card. Thus the cylinder presented a card to be copied, and alternate rows of holes were cut; the cylinder then rose to bring the remaining holes of the same card opposite the needles, while the new card was moved laterally until blank places were under the punches, when a second series of perforations were made. Another machine of this type only cuts two or three rows of holes at one stroke. Messrs. Schaum and Uhlinger have simplified the machine by converting the wires C into hooks, and adding griffe bars at the extreme right of C, to withdraw the plugs from the punches. They also place the cylinder D beneath C, and cause it, in moving up and down, to operate vertical needles, and place the hooks in range of the griffe blades.

Hahlo, Liebreich, and Hanson's Repeater

In 1893 the above-named inventors patented a card repeater which has proved a commercial success. It is based on Nuttall's machine, but the modifications are material to its usefulness. Fig. 155 is an end, sectional, elevation. A is a shaft which is rotated from the first motion shaft by gearing. Upon A are six cams, four being employed to move the cutting plate B vertically up and down, and two grooved cams impart a swinging motion to a batten C and a cylinder D. The latter is accomplished as follows: Two runners are placed in the cam grooves; they are attached to two arms, and two links E unite the arms with the batten C. The cards to be repeated are passed round D in the usual manner, and are brought in rotation to face a set of needles F. Each needle operates a piece of metal G, whose basal end rests upon the head of

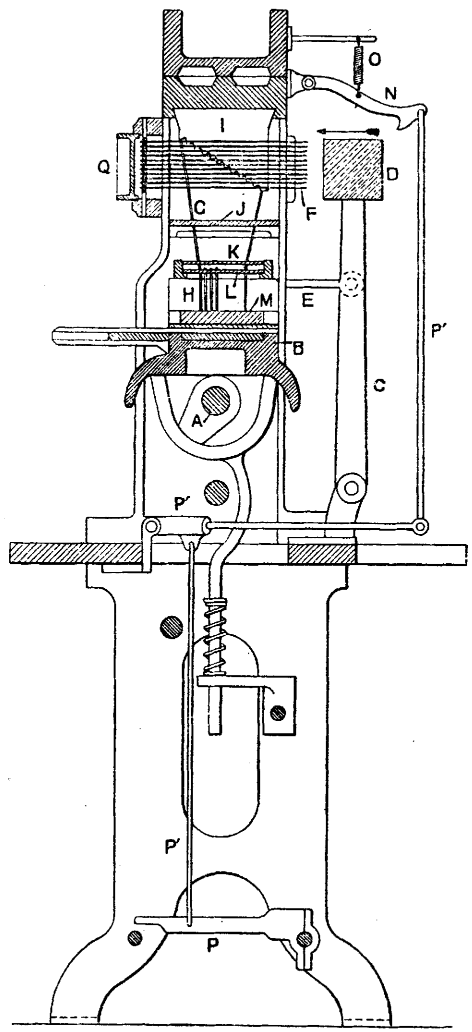

FIG. 155.

a punch H, while its upper end is normally held beneath a horizontal portion of a stepped plate I. The pieces G are kept in position by passing them through two plates J, K, and a stepped plate I is fixed between each vertical line of needles. In the event of a needle being pressed back by a blank portion of a card, the head of G is removed from its step. The punches H are suspended from a plate L, and their lower ends pass through a plate M. A blank card is laid in a sliding-frame which is pushed manually between the cutting plate B and the punch plate M. As the cams cause the plate B and the blank card to ascend, the punches H, and those pieces G that have been pushed from the steps in I, rest by gravitation upon the card and ascend with B. But where the pieces G are beneath their steps the punches are prevented from rising, and, as a sequence, are forced through the card. As the cams lower the cutting plate, the card frame is withdrawn from the punches, the perforated card is removed, a blank one is substituted, and the operation repeated. A card to be copied may be presented to the needles F any number of times in succession, for two catches N, employed to move the cylinder D through one-fourth of a revolution, are normally held above the lanterns of the cylinder by spiral springs O. When D is to partially rotate, a treadle P is depressed by the foot of the operative, and, acting through a lever and links P′, it lowers the catches upon the lanterns of D. Springs in the box Q thrust forward the needles F and the pieces G immediately the cylinder moves out. This machine punches a full card, including peg- and lace-holes, at one operation; the peg-holes are, therefore, always true with the pattern holes. By its aid single cards can be cut, and cards can be repaired more readily than by most machines.

THE PIANO CARD-CUTTING MACHINE

The "piano machine" is now in general use for cutting cards from designs. It consists of an iron table, from which two uprights rise to support a board, 52″ long by 20″ deep. A design is pinned upon this board, and two straight-edges traverse it from side to side; they guide the eye

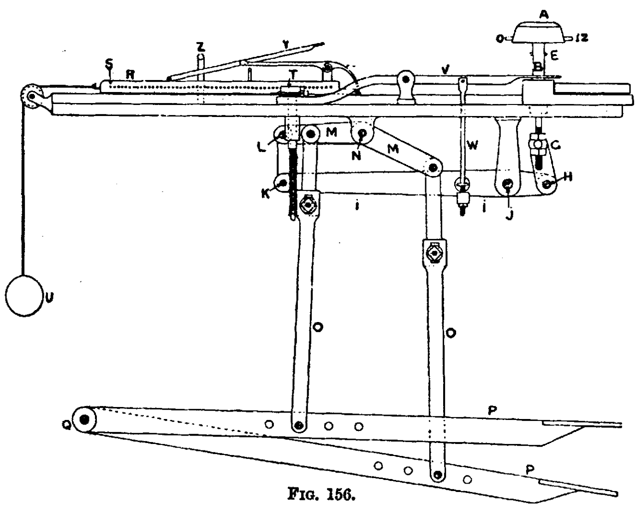

FIG. 156.

when reading along horizontal lines of a design, and may be moved up and down by screws that pass through nuts attached to each end of the straight-edges.

In the lower part of a head-stock A, Figs. 156 to 158, two perforated plates are bolted upon the table; the lower one cuts the card, the upper one guides the punches C, and a space is left between them sufficient to receive a card. Two holes are bored through the plates for the spindles B to work in. The spindles support a movable head-piece A,

in which a row of 12 vertical punches C are fitted to the gauge of the holes in a Jacquard cylinder. Each punch is $\frac{5}{8}''$ from top to shoulder, and $3\frac{1}{4}''$ from the shoulder to the bottom. In the centre, and immediately in front of the line of punches C, a peg-hole punch D is placed. The length of D is equal to C, but its diameter is $\frac{3}{8}''$. The shoulders of the punches C, D rest upon, and are lifted by, a guide plate E. Keys, numbered from 1 to 13, have square shanks and oblong heads; each shank is passed

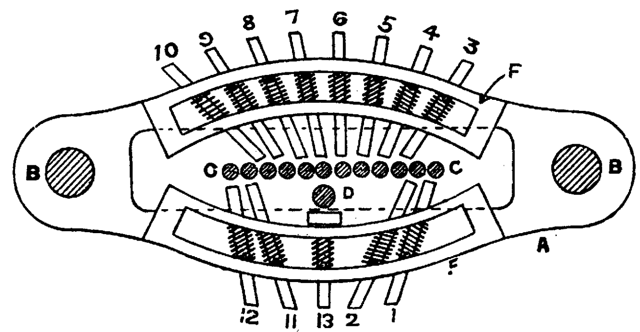

FIG. 157.

through one of two slotted plates F, and has a spiral spring threaded upon it so that one end of the spring may impinge upon a steel pin pushed through the shank, while the other end rests against the inner edge of F. When pressed in, a key covers a punch, and when the pressure is removed the spring carries the key clear of its punch. Keys 1, 2, and 13 are controlled by the right thumb, 3 by the little finger of the right hand, 4 to 10 by the remaining fingers of both hands, 11 and 12 by the left thumb.

The lower ends of the spindles B are secured by lock nuts to a cross head G, Fig. 156; the base of G is forked and united by a pin H to a lever I, whose fulcrum is at J. A link and pins K, L connect I with a three-armed lever M, that moves upon a centre N. From the two remaining arms of M connecting rods O pass to two treadles P, which vibrate on a pin Q.

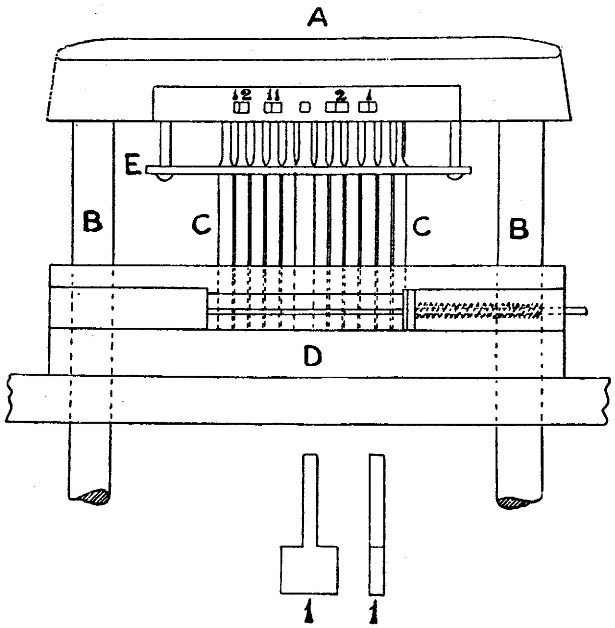

FIG. 158

By pressing down the left treadle the head-stock A rises with the plate E and lifts all the punches C out of the gap between the two fixed plates. If a card is pushed between the plates and some of the keys are pressed in, a downward movement of the right treadle will lower the punches and force those whose heads are covered through the

card, while uncovered punches will be supported by, but will not perforate, the card.

Two smooth rails are laid down the middle of the table for the wheels of a carriage R, Figs. 156 and 159, to run upon; R is moved by a rack of pins S, a slip catch T, and a weight U. The rack has a pitch equal to that of the Jacquard needles; it is made by driving pins into a metal plate, and the plate is screwed along one side of the carriage.

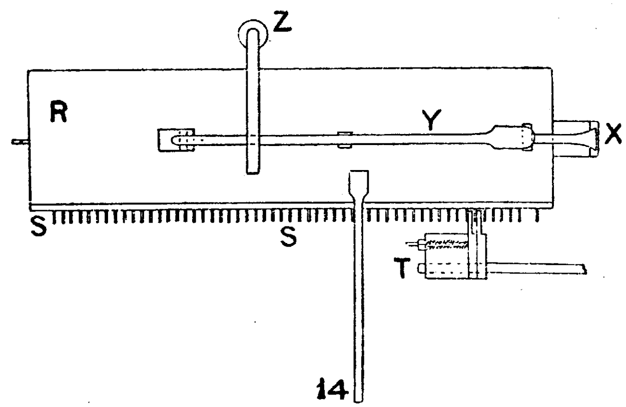

FIG. 159.

The shank of a slip catch T passes through the table top, and a helical spring is pinned upon it to hold it down. Two catches move amongst the pins, the upper one is fixed to the catch box, but the lower one is kept in advance of the upper one by a spring, shown in dotted lines. Each time the left treadle is depressed the box is moved vertically by a lever V and a rod W; the sliding catch is thus placed between the teeth of S, the weight U contracts the spring in the slip catch, and the carriage R recedes one tooth from the head-stock. In front of R two nipper jaws X are placed to grip each card fed into the machine. The operator sits in front of the head-stock with his feet upon the treadles. A card is pushed below the punches C and between two guide plates, situated in front of the head-stock A; the nipper jaws are then opened by depressing the lever Y with the left hand, and the card is forced close to a stop and level with the guide plates. The jaws close and draw the card forward as the carriage slides, tooth by tooth, through the catch T.

One bar from the design is read, and one short row of holes is cut at each downward movement of the right treadle, also one pin in the rack S is passed as the left treadle is depressed. An index cord carrying a small weight is tied upon an arm 14 of the carriage, and is led by guide pulleys across the pattern board. A strip of card is fully perforated, numbered progressively above the holes, and nailed upon the board. When the carriage R is close to the head-stock, a knot is tied upon the cord, to face the first hole in the index card, and as the cutter works, this knot should always cover a number corresponding with a bar number on the design from which he is reading.

In order to prevent mistakes, cards are numbered progressively on the 26 side with a pen, a stamp, or an automatic numbering machine, and the number on a card and that on the design, for picks, must always be the same. The numbered end is first pushed between the nipper jaws of the carriage R; the peg- and lace-holes are cut, then bars from 1 to 26 may be used for the design; a bar is left between 26 and 27 for the middle lace-holes, and bars from 27 to 51 are for the pattern; but with bar 51 the last peg-hole is cut, and beyond that again the end lace-holes.

Attempts have been made to operate the head-stock automatically, but they have not met with general favour.

For a considerable time attempts have been made to construct a machine that will read cards from the design automatically, but up to the time of writing no such machine has passed the experimental stage.

Card-lacing

Before cards are ready for use they must be laced into a chain; this may be done by hand or by machinery. For

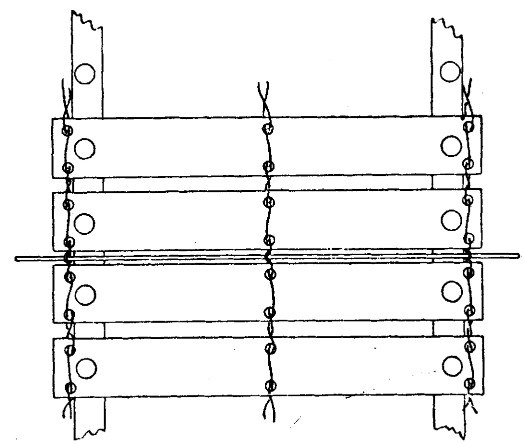

Fig. 160.

hand-lacing a frame is required which contains from 40 to 50 wood or metal pegs on each side. They are set to face each other, and to a pitch suitable for the width of card to be laced. The cards are placed in rotation upon the pegs, and the lacing is threaded through the lace-holes with a needle, but is crossed over from right to left between every pair of holes in one card, and also between two adjacent cards, then back again in the same order, as shown in

L

Fig. 160. The defects of this plan are due to inequality in the tension of the lacing, an excessive number of knots, and the time taken to do the work.

Lacing is of different kinds and used in different conditions. It may consist of single or folded cotton or linen twine, of plaited tubular banding, of narrow braid, or of woven tape, and these materials may be used without subsequent treatment, but most of them are soaped, or saturated with boiled linseed oil. In any case they should be strong, supple, and not readily influenced by atmospheric conditions.

Lacing-machines

Inventors have constructed automatic lacing-machines on the principle of a compound sewing-machine. In the earliest machines cards were sewn together in two or three lines simultaneously, by forcing needles through them and locking the needle threads on the under side with shuttle threads. The number of stitches in each card, the inequality of the tension on the twine, and the lack of flexibility rendered the inventors' efforts fruitless. W. Nuttall, Count Sparre, Stahlknecht, the Singer Company, Messrs. Reid and Fisher, Parkinson, and others, have laboured upon the problem with more or less success. Count Sparre was one of the first to pass needle threads through the lace-holes of a card, and to link shuttle threads into them.

One machine punches peg- and lace-holes, and laces simultaneously. Each thread of lacing is placed above one card and beneath the next; both are linked at the lace-holes, and crossed between card and card. Under these conditions machine-lacing does not differ greatly from hand-

lacing, except that in most of the former the threads are crossed in one direction continually.

Reid and Fisher, in 1888, and subsequently Parkinson, by improvements in details, have produced a lacing-machine that bids fair to supersede the hand process. By its aid 900 to 1000 cards can be laced per hour, from 400 to 700 without a knot, and the tension is also under control. This machine has been arranged for from 2 to 5 lines of lacing, and for cards from 8″ to 40″ long by 1″ to 4″ wide. When lacing 400^s or 600^s cards, three lock-stitch sewing-machines are employed, to pass lacing through the usual lace-holes. The cards are fed upon conical pegs inserted in endless chains, and the chains are drawn forward at a speed suited to the breadth of the card.

The Singer Company have introduced machines for various widths of cards in which an effect very similar in appearance to hand-lacing is produced. In a 600 card 4 holes are employed in each line of lacing, viz. 2, 4, 9, and 11, and the result appears to be quite satisfactory. Tapes have been secured to cards by metal staples, and by glue, but they were not sufficiently flexible at the joints. Cards have been notched at both edges, facing the lines of lacing, and the upper and lower twines twisted between the cards to form loops, each loop enclosing a card and holding it in position.

Card-wiring

Cards are suspended from cradles by wires which project about $1\frac{1}{4}$″ beyond both ends of the cards, as in Fig. 160. These wires are usually tied upon the lacing with waxed band to prevent slipping, but they are sometimes pushed between the two lines of lacing before being tied. If the wires are not laid upon the face of the cards they touch the cylinder and form an uneven bed for the cards to rest upon. The distance from wire to wire is determined by the vertical and horizontal spaces available at a loom. Some wires are only 12 cards apart, but 16 to 24 are more general.

Card Cradles

A card cradle consists of two pieces of curved metal which are secured beneath a Jacquard cylinder so that the cards will drop between them (see Fig. 152). But the space between the metal supports does not exceed the length of a card by more than $\frac{3}{8}''$ or $\frac{1}{2}''$, hence the wires are caught, and the cards prevented from falling to the floor. The bend of a cradle should be such as will prevent the cards from falling upon each other, and as fresh cards are taken up from the rear of a cradle, those remaining should automatically slide down into the vacated places, and thus leave a free fall for the descending cards. Provided sufficient firmness and holding room are given, the sectional shape of a cradle is unimportant.

PART IX

LAPPET SHEDDING

Lappet weaving is a species of embroidery by which various colours and patterns may be produced simultaneously upon any foundation fabric, but plain or gauze weaves are often employed, for with those weaves the

warp threads are not readily disturbed by a side pull from the "whip" threads. Lappet weaving consists in moving whip, or special warp, threads from longitudinal to transverse positions, and in lifting each over a pick of weft, to fasten it at both ends of every horizontal line, but the whip threads float loosely between the terminals. Although there are definite limits to lappet figuring, it is quite possible to produce extensive figure effects by skilful designing and the use of several lappet frames.

A lappet loom differs from a loom of the ordinary type in the following respects :—*a.* A groove is formed between the reed and the race board which is wide enough to receive pin and needle bars. *b.* A lappet wheel is needed, together with mechanism for operating it. *c.* Driving cranks have from 6″ to 7″ sweep; the larger sizes usually accompany three or four sets of needles, and they are sometimes placed outside the loom framing in order to leave the reed space clear and permit the sweep to be varied. *d.* A slightly longer stretch is also desirable. *e.* A separate whip roll is required for each needle frame, and these may be placed above the warp beam, below it, or in both positions, as may be found most convenient. Each roll is separately controlled by cords and small weights. *f.* A special tensioner is provided for each whip roll.

The Scotch type of lappet loom is in most general use. Its needle bars are moved vertically in, and horizontally by, shifter frames; a large wooden wheel has grooves cut in one face, each to receive a feeder or peck, and it is driven forward one tooth on alternate picks. Each shifter is moved in both directions by the dead weights of levers, and through spaces regulated by the breadth of a groove in the lappet wheel; an upward movement in both pin and needle bars is derived from the rocking shaft.

A lappet wheel is made of sycamore, or other close-grained hard wood, and is mounted upon the slay behind one of the shuttle boxes. Aluminium has also been used in place of wood. It has an irregular groove, or grooves, cut in one face to limit the lateral movements of the needle bars. The diameter of a wheel is not of great importance, provided it is large enough to prevent the grooves from becoming worn by frequent contact with the peck.

A wheel is made by turning a disc of wood to the diameter and thickness required, say, 13″ by 1″. A comb having a pitch that bears a definite relation to the reed, generally half as fine, is pressed against the revolving disc to describe a series of concentric circles on one face. The circumference is next equally divided by radial lines which are equal in number to the horizontal spaces on the design: see Figs. 161 and 162; of these Fig. 161 is the design and Fig. 162 the lappet wheel; C are the concentric circles, D, D are 32 radial lines which correspond with the 16 horizontal spaces of the design twice repeated. Each space between two radial lines equals one tooth, or two picks of weft in the fabric. A vertical space in the design represents two, and a circular space C in the wheel four warp threads. By comparing Figs. 161 and 162 it will be found that the breadth of each groove at number 1 and following numbers agrees with the design after a

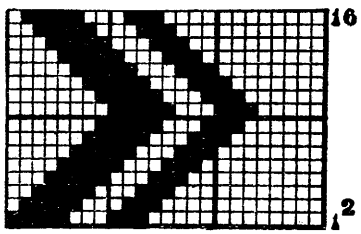

Fig. 161.

predetermined allowance has been made for the thickness of the peck, say two dents. A groove must be cut in B, to the exact dimensions of the marks made upon the radial lines. Two, three, or four patterns can be woven from one wheel by cutting additional grooves inside or outside

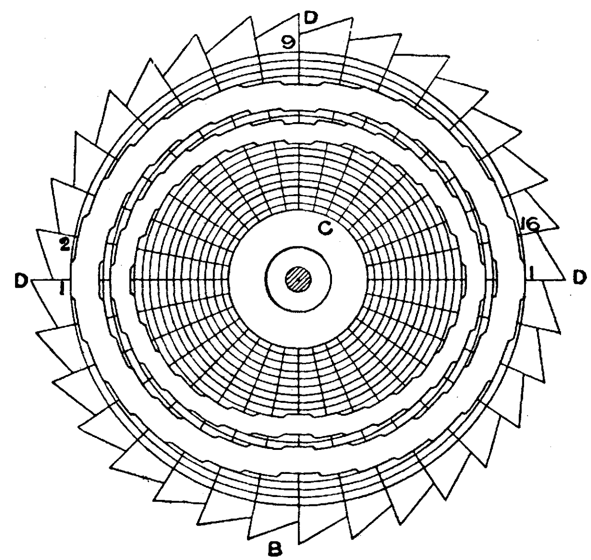

Fig. 162.

the first one as shown, but beyond this a new wheel is needed for a new pattern. A tooth is cut on each space between two radial lines D.

In case the lateral movement of a needle bar is positively controlled, a wheel is moved every pick, the pattern grooves then being only wide enough to receive a peck, but they meander over the wheel surface.

A hole is bored through the centre of a wheel to receive a hollow boss formed on a circular metal plate, and the plate is screwed upon the rear of the wheel. A portion of the rim is removed to the depth of the teeth to provide a brake surface about $\frac{3}{8}''$ wide. In this a ring groove is cut for a string which is first tied to a fixed bracket, then led into the upper part of the groove, and finally made fast to a spiral spring. See Figs. 163, 164. By regulating the pull of the spring a wheel can be prevented from overrunning when acted upon by a turning catch. A ring groove is also cut in the back of a wheel for each detached pattern, and two or more strips of metal are pressed into each groove. The strips vary in length to suit the stationary periods of the needle bars, for each space separating two strips equals an active period of a bar. The strips in the first groove stand out from the wheel about $\frac{1}{4}''$, but those in other grooves project a greater distance, because the hooks they act upon are further from the wheel than that for the first groove.

The accompanying figures show the mechanism of a lappet loom as made by the Anderston Foundry Company, Glasgow. A wheel A, Figs. 163 and 164, is mounted upon a stud which is bolted in a slotted rail attached to the swords. A is rotated intermittently by a bowl B fixed in an arm upon the bottom shaft. B depresses a wooden lever C once in two picks. A connecting rod is hooked into an eye bolt in C, also into a hole in a cranked lever D. The short arm of D passes through a slot in the catch-holder E. As C is depressed, the cranked lever D lifts a spring catch F over a tooth in the wheel A. So soon as the bowl B moves off the lever C, a spiral spring G pulls the catch F down, moves A one tooth inward, and lifts the lever C. A spring is employed because it can expand in case of obstruction, and prevent a smash. These movements

occur when a peck is passing from the outside to the inside

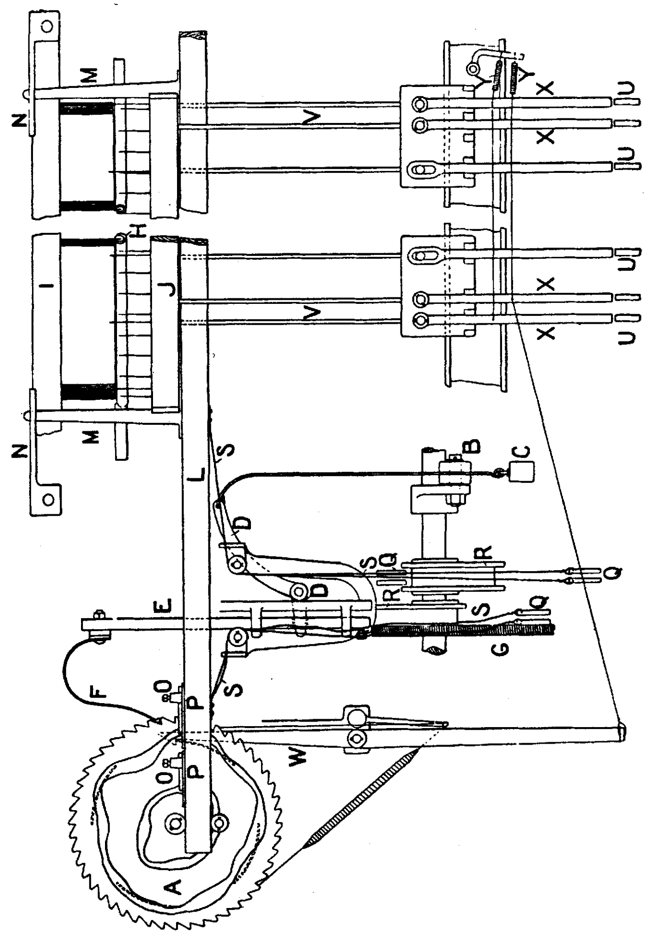

Fig. 163.

of a groove, and when the cams employed to slide the shifter frames are midway in their lift, for at that instant all strain is taken from the pecks. A peck P is adjustably attached to a shifter frame for the purpose of moving a needle bar laterally.

A pin bar and a series of needle bars are placed in a groove in the slay as follows: The lower rib of a reed

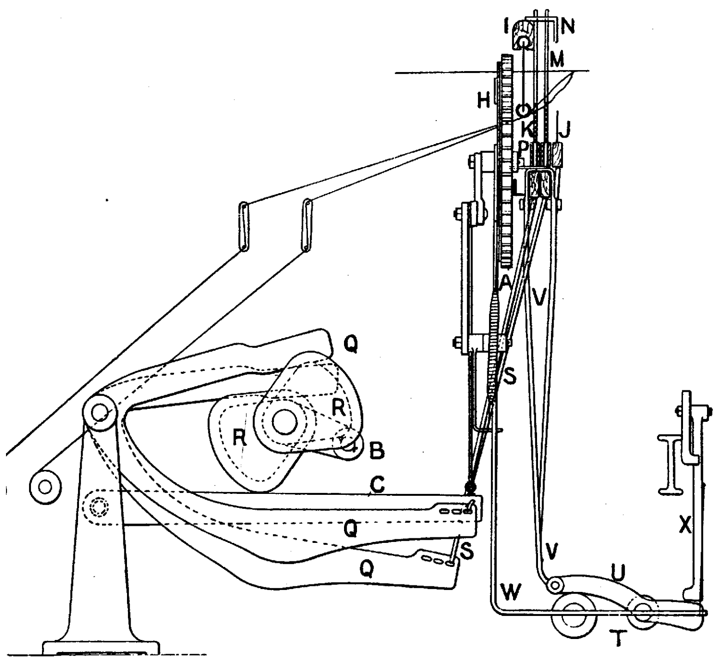

FIG. 164.

is fitted in a semicircular metal trough H, which is bolted upon the rear of the slay swords; the upper rib is secured in the slay cap I, but that cap is also bolted behind the swords. This leaves a space between the reed and race board of 3″ for the reception of one pin bar J, and four needle bars K, only two of which are shown.

For a 42″ reed space loom, a pin bar consists of a lath $1\frac{1}{2}$″ deep, $\frac{7}{16}$″ thick, and 44″ long. Into the upper edge of this lath a number of stout pins are driven $1\frac{3}{16}$″ apart. They stand out from the bar $2\frac{1}{8}$″ and are pointed at the top. The bar is tipped at each end with a vertically grooved piece of brass; these brasses fit upon iron slides mounted in the inner ends of the shuttle boxes. The bar is also lined with iron along the bottom edge at two places where the lifting rods act upon it. The pins are set to touch the race board, for they serve in lieu of a reed to guide a shuttle. As the slay recedes from and advances towards the cloth fell, the pins rise above and fall beneath the line of warp.

A needle bar K is made of wood $1\frac{1}{2}$″ deep by $\frac{7}{16}$″ thick, and 45″ long. Where the lifters act upon K, it is lined with metal along the under side; it is also tipped with grooved brasses which fit freely over the slides M in such a manner that a vertical lift can be imparted without side movement. Steel or brass needles, driven into the wood, stand out $2\frac{3}{4}$″. They are smooth, flattened at the top, pointed and punched to form eyes for the whip threads to pass through. The exact number and positions of the needles are determined by the size of the pattern and the number of times it is repeated on the width of a fabric. Thus pattern A, Fig. 166, has 32 dents to a repeat. If the reed has 20 dents per inch, and 37″ of cloth are to be covered with pattern, $37 \times 20 = 740$ dents occupied by warp. $740 \div 32$ dents per pattern = 23 patterns. Therefore 37″ of a bar is divided into twenty-two equal parts, and a needle is driven in at each mark. Every bar has two movements—namely, a lateral one to bend the whip threads into a transverse position, and thus form a pattern, and a vertical one to lift the threads above a moving shuttle. Lateral movement is derived from the wheel A, which permits the shifter frames to slide to and fro, but their maximum traverse is determined by slots in two steadying plates N.

Each needle bar is mounted in a separate shifter frame L, consisting of a lath 72″ long, $1\frac{1}{2}$″ deep, and $\frac{1}{2}$″ thick. Upon its top edge two metal slides M are screwed 45″ apart to work in the slots of N. A shoulder is formed upon a slide immediately beneath a plate N to prevent it from moving vertically. The plates are fitted in front of the slay cap; each is provided with four parallel slots, $4\frac{1}{2}$″ long by $\frac{7}{16}$″ apart. In order to facilitate lateral movement, the frames L are lined along their lower edges with metal in three places, and the metal rests upon three antifriction bowls. Near that end of each shifter which faces the lappet wheel A, a flanged brass plate O is screwed upon its upper edge, and between the flanges of O a peck P is fixed by a pinching screw. A peck is a piece of metal which is square in section, but bent at right angles to permit it to enter a groove in A, and there it is cylindrical.

Shifter frames are moved conditionally by cams, in the following manner: The upper and shorter arms of eight levers Q, only four of which are shown, rest by gravitation, in sets of four, upon the faces of two flanged cams R. Both cams are fixed upon the bottom loom-shaft, outside the framing, and adjacent to each other. They are set as for plain weaving, with the large face of one and the small face of the other uppermost at the same time. From the forward end of each long arm in the outer set of levers Q, a strap S is led to a guide pulley situated beneath a shifter frame L. The straps are deflected outward at the guide pulleys and are severally screwed upon the bottom edges of four shifters. From

the forward ends of the inner set of levers Q, four similar straps are led over corresponding guide pulleys, but they are deflected inward and screwed upon the shifters. As the cams rotate, all the shifters move simultaneously to the right or left; for as one set of levers fall they tighten one set of straps, and slide the shifters away from the wheel. When the other set of levers fall they tighten the remaining straps and slide the shifters towards the wheel. This movement is made in about $\frac{1}{8}$ of a pick, but the distance travelled is regulated by the breadth of the slot in the wheel; for once a peck reaches the edge of a groove, that lever remains suspended by its strap until again lifted. Lateral movement begins when the needle points are below the bottom line of warp, and the reed in moving forward is approximately $\frac{1}{2}$″ from the cloth fell; it must end before the vertical movement begins, and the needles should be fully lifted when a pick is delivered.

Both pin and needle bars are moved vertically by two brackets T upon the rocking shaft; in the forward end of each bracket a stud is held by a pinching screw. Each stud serves as a fulcrum for five levers U. To the rear end of each lever a rod V is attached. Of these rods the first pair, namely, the outer ones on each side of the loom, are led behind the fourth shifter L; they are flattened at the top, bent at right angles, and passed between the fourth shifter L and its needle bar K. The second pair of rods are led in front of number one needle bar, and are also bent and flattened, but pass between number one shifter and its needle bar. The third pair are cylindrical; they are straight at the top and placed beneath the pin bar. The fourth pair are led between number one and number two shifter bars, and are bent backward to go between number two shifter and its needle bar. The fifth pair of rods are passed between the second and third shifter and bent under the third needle bar. When the needle and pin bars are in their lowest positions, the rods V should be midway between the needle bars and shifters, without touching either.

As the rocking shaft vibrates, the levers U rise and fall with their fulcra, but they can either lift the rods every pick or leave them stationary. When lifted, the bent ends of the rods thrust up the needle bars until whip threads, in the needles, are level with the top line of ground warp.

In case detached figures are diapered over the foundation cloth, the needle bars must be put out of action. This is controlled from the lappet wheel, into the rear of which strips of metal have been inserted as previously explained. Four strips are shown by dotted lines on the wheel A, in Fig. 163. A strip holds back the head of a long catch W, and while so held a needle bar will be inoperative. A space between two strips of metal permits the head of W to move over the end of a strip, and the needle bar at once becomes active. Thus, a cord from the lower end of the catch W is made fast to a pair of pendents X. The pendents are centred at the top and, when W vibrates, they are drawn by the cord away from the surfaces of two levers U. On the next backward movement of the slay the levers' fulcra are lifted and the forward end of each uncovered lever rises, but their rear ends remain undisturbed. A spiral spring Y is hooked into a rod situated on the opposite end of the loom to the lappet wheel. In contracting, Y draws back the pendents until they assume a vertical position. Each then covers the forward end of a lever. As the slay again recedes the fulcra of U will be once more raised, but this time the forward ends of the levers are locked; consequently, their rear ends ascend, and the rods attached to them lift a needle bar.

Ten pendents X are arranged in two sets of five. The middle one in each set is securely bolted in a vertical position to operate the pin bar, which must rise and fall every pick. The remaining eight control eight levers U, eight rods V, and four needle bars K. Each pendent is bent inward at the base to ensure correct contact with a lever, and all are normally vertical. A long catch W is needed for each bar K that has to rise and fall intermittently; a rod limits the inward swing of W, and thus prevents breakages which would occur if the heads of W passed inside the metal rims.

The lappet wheel, the driving catch with its spiral spring, the cranked lifting lever, and the long catches are all mounted upon, and swing with, the slay.

Whip threads pass from whip rolls without being drawn into either healds or reed; they are led between the wires of a tensioner, between the leashes of the shedding harness, beneath the reed, and through the needle eyes. As a bar K rises and falls, these threads vary in length between a whip roll and a needle eye, and one of the most important points to be attended to in lappet weaving is the regulation of tension upon them. Delicately adjusted wires provided for the purpose are shown in Fig. 165. They consist of two wooden end pieces each $\frac{1}{2}''$ thick by $4''$ long and $1''$ wide. Two parallel pieces of wire B are securely fitted into the end pieces at a distance of $3''$ apart, and they are long enough to reach across the warp. Two holes are drilled in both end pieces at equal distances from their centres, and cords C, D are threaded through them, twisted, and tied upon two flat springs which are bolted to the loom framing. The whip threads pass in front of the upper and behind the lower wire B, and the degree to which the cords C, D are twisted determines the efficiency of B to give off and take back whip in unison with the rise and fall of the needles. If whip threads are to remain tight without fraying the foundation fabric at the edges of the figures, careful regulation of the twists in C, D is essential. A simpler and in some respects a more satisfactory tensioner is made by bolting two brackets to face each other upon the end framework, at a height of $2\frac{1}{2}''$ to $3''$ above the warp line. Each bracket has four holes to receive four parallel

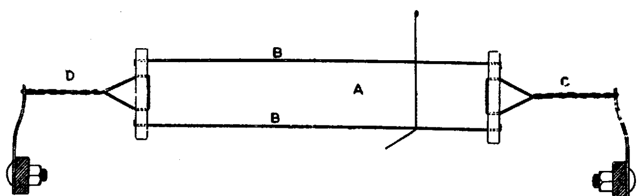

Fig. 165.

elastic bands which are stretched from bracket to bracket. The whip threads from each roll pass over a separate band, and as the tension varies the bands stretch or contract.

A lappet wheel may take the form of a hollow cylinder with a series of varying indentations cut in its front edge. Such a cylinder is rotated by a ratchet and pawl tooth by tooth. A feeler lever is then fulcrumed at the centre, and its lower edge is held by a spiral spring against the irregular face of the cylinder, but its higher end is made fast to a needle bar. Hence the feeler vibrates in unison with the ridges and hollows of the cylinder, and transfers the movement laterally to the needle frame and whip threads.

A cylinder is built up of close-grained wood, and filled

in at one end to enable it to be fixed upon a ratchet wheel. Its periphery and front edge are turned true and smooth, then as the cylinder rotates in a lathe the teeth of a steel comb are pressed against it. By this means a series of parallel lines are scratched along the surface. Its periphery is next divided into a number of equal parts to correspond

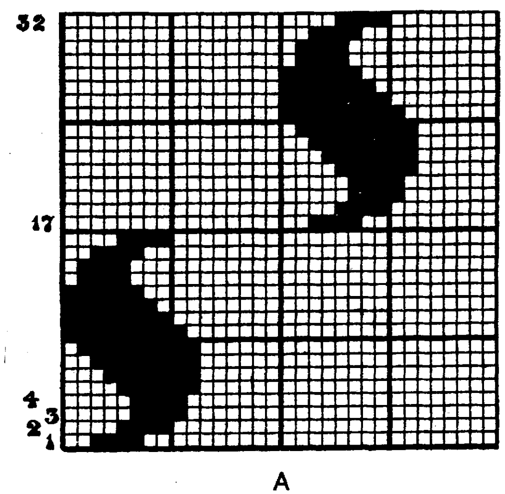

Fig. 166.

with the picks in one repeat of the pattern to be woven, and lines are drawn through each point, parallel with the cylinder axis.

For example, Fig. 166 is a design in which each vertical space represents a dent, and each horizontal space two picks; and Fig. 167 is the periphery of a lappet cylinder when opened out. The thin vertical lines C are those scratched by the comb teeth; they are indefinite in number, but equal in pitch the space occupied by two warp threads

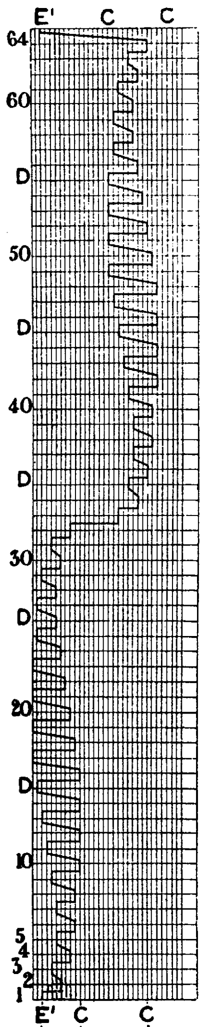

Fig. 167.

in a fabric. The horizontal lines D are parallel with the cylinder axis. Thirty-two horizontal spaces on the design paper A give one repeat of the pattern, but as each line of whip must be fastened at both ends of every float, 64 picks will equal one revolution of the lappet wheel; hence there are 64 spaces D, and 64 teeth in the ratchet wheel. The thick lines E′ show the form of cylinder end required to reproduce pattern A on a cloth.

In the first horizontal space of A, Fig. 166, and on the first line of D, Fig. 167, two dents, or spaces, are passed in each case to find the starting-point of the figure, which at 1, A, floats over four dents, and 2, D, is four dents lower than 1, D. Therefore a feeler will move a needle frame through a space of four dents.

On 2, A, four dents are passed, and four taken for the pattern. On 3, D, four dents are also passed over; then on 4, D, four more dents are taken, and so in like manner up to 16, A, and 32, D, where the first spot ends. At 17, A, eighteen dents are passed and four taken. At 33, 34, D, the same order is maintained.

In many detached spots, such as A, it is necessary to add binding to

each figure by moving the whip threads across a single dent immediately before a spot begins and ends, for this prevents the whip threads from being pulled out of the foundation weave. In such cases eight extra teeth must be provided in the ratchet wheel, and eight extra horizontal spaces on the cylinder, for each stitch equals two picks of weft in the piece. If a lappet pattern is to be free from defects, accurate marking and cutting of the wheel are essential.

For two patterns another cylinder is required, and it is usually fixed in a corresponding position on the opposite side of a loom. Where both patterns repeat on the same number of picks, or where one is a multiple of the other, mechanism may be economised by securing two cylinders upon a single ratchet wheel, one inside the other. Two feelers that move horizontally are then employed, each to be acted upon by one cylinder only, and connected to a separate needle bar.

A feeler that slides horizontally is superior to one that moves in the arc of a circle, because the latter will carry different parts of its surface into contact with the lappet wheel, and impart an inaccurate traverse to the needle bar. It is usual to employ a cranked lever and a cam to withdraw sliding feelers from the surfaces of lappet cylinders before rotation commences, for by this means friction and wear are reduced.

Instead of a cylindrical drum, a disc may be drilled at regular distances so that the holes form one circle, or two or more circles, and one pattern, or two or more patterns, may be formed by securing pins of various lengths in the holes. Provided the disc holes are a multiple of the design, such a wheel has the advantage of permitting many different designs to be woven by readjusting the pins.

Pegged lattices are used in various ways to actuate needle frames. If they are placed beneath the harness and parallel with the driving shafts, a number of feelers rest upon the lags, and the movements of the feelers vary with the lengths of the pegs. These movements are transmitted to the needle bars by links and cranked levers. One of the simplest lattice contrivances is of American origin. It consists in leading a set of metal lags above the shuttle box, and in causing metal pegs to press directly upon the needle bar shifters. As a rule the pegs do not vary in length to suit a particular count of reed, but are used with all reeds; the effect being that floats are of uniform length, but the number of dents passed over varies with the reed.

In the drawings here given the needles point upward, but in practice many point downward. In the former case the figure will be woven face down, in the latter face up: it is an easy matter to thread needles that point downward, but a difficult one to draw threads through the reed.

The consumption of whip largely exceeds the length of cloth woven; the difference depends upon the pattern. To determine the length required for a given length of fabric, the design must be counted to find how many dents the figure covers at each traverse of the needles; and when the sum of all the movements is obtained, the number of yards of whip, for one yard of cloth, can be found by the following rule :—

$$\frac{\text{The number of dents per pattern} \times \text{the number of needles in a frame} \times \text{the number of repeats of the pattern in one yard of a fabric}}{\text{The dents per inch in the reed} \times \text{the number of inches per yard.}}$$

Take as an example Fig. 166, in which there are 32

horizontal spaces, and assume 23 needles in a frame, 20 dents per inch in the reed, and 40 picks of weft per inch in the fabric.

The lines of whip vary as follows: The numbers in the second column are the dents passed over, as shown by the horizontal spaces; those in the third column are the dents crossed in moving the needles back to the starting-point on the next line.

Number	1 = 4 dents	+ 2 dents	= 6 dents
„	2 = 4 „	+ 3 „	= 7 „
„	3 = 4 „	+ 4 „	= 8 „
„	4 = 4 „	+ 5 „	= 9 „
„	5 = 6 „	+ 7 „	= 13 „
„	6 = 7 „	+ 8 „	= 15 „
„	7 = 8 „	+ 9 „	= 17 „
„	8 = 9 „	+ 10 „	= 19 „
„	9 = 9 „	+ 9 „	= 18 „
„	10 = 8 „	+ 8 „	= 16 „
„	11 = 7 „	+ 7 „	= 14 „
„	12 = 6 „	+ 5 „	= 11 „
„	13 = 4 „	+ 4 „	= 8 „
„	14 = 4 „	+ 3 „	= 7 „
„	15 = 4 „	+ 2 „	= 6 „
„	16 = 4 „	+ 0 „	= 4 „
			178

Total 178 dents in the first half of the pattern, and an equal number in the second half. To these must be added 10 dents passed over in moving from the first to the second spot, and 22 dents in moving from the end of number 2 spot to the beginning of the first spot in the next repeat. Altogether, $178+178+10+22=388$ dents. To find the number of repeats of the pattern per yard of cloth—

$$\frac{40 \text{ picks per inch} \times 36'' \text{ per yard}}{64 \text{ picks per pattern}} = 22\tfrac{1}{2} \text{ patterns.}$$

$$\frac{388 \text{ dents per pattern} \times 23 \text{ needles per frame} \times 22\tfrac{1}{2} \text{ repeats per yard}}{20 \text{ dents per inch} \times 36'' \text{ per yard}} = \begin{matrix}278 \cdot 875 \text{ yards of whip} \\ \text{for one yard of cloth.}\end{matrix}$$

PART X

PICKING

PICKING is next in sequence to shedding, and consists in passing weft between the upper and lower lines of a divided warp. With few exceptions, the method adopted, during many centuries, and by weavers of all countries, was to throw a shuttle from one hand through a shed, and catch it with the other hand at the opposite side. But in 1733 John Kay, of Bury, invented the "fly shuttle." He constructed a box at each end of a slay for the reception of a shuttle, and employed two propellers, or "pickers," to move it. A box consisted of a bottom, two sides, and one end. Over each box was a metal spindle, about $\frac{3}{8}''$ diameter, for the purpose of guiding a picker. Both pickers were connected by cords to a picking handle, which the weaver grasped with his right hand, and by making a rapid lateral movement with his arm, the shuttle was driven with sufficient force to carry it across the warp and into the opposite box. Kay's invention was slow to find favour with weavers of his own time, but, when once adopted, it displaced the older method in most countries. The system of hand-thrown shuttles is still in operation in some countries, and strange to say the plan has been adopted by a number of people who are endeavouring to foster hand weaving in this country.

More recent inventors have mainly endeavoured to

adapt Kay's invention to steam-driven machinery. The mechanism for propelling a shuttle is still simple in construction, but it is the least satisfactory part of a loom. For more than a century efforts have been made to perfect the pick: large sums of money have been spent in developing so-called improvements, in safeguarding work-people, and in preventing breakages of machinery and warp; yet the pick remains uncertain in action, costly to keep in order, and more serious accidents result from its defective action than from all the remaining parts of a loom taken together.

Picking inventions include a varied collection of picking devices, of shuttle guards, swells, check straps, fast and loose reed appliances, pickers, and an endless variety of details connected with the placing of weft between the warp, many of which are the result of a misconception of the problem, for they attempt to deal with the effect instead of the cause.

To appreciate the defects developed by a negative propelling motion, attention must be directed to the shuttle, which is made from wood, pointed at both ends, and tipped with steel. It is hollowed out in the centre and provided with a hinged metal tongue, whose length approximates to that of the hollow part. Weft, in the form of a cop, upon a wooden pirn or a paper tube, is pressed upon the tongue, and retained there during the operation of weaving. But it can be drawn through an eye in the front of the shuttle as a continuous thread.

Until box-wood was almost exhausted, shuttles were generally made from this material, and some are still made from Persian and African box, which has a dense, compact grain, and approaches more nearly to ivory than any wood known. Woods of less density than box are more difficult to drive across a loom, but Cornel, or dog-wood, is largely used; it is hard, heavy, and fine-grained. Persimmon, a dark-coloured wood with a hard and fairly close grain, is also in demand. Spanish oak, English apple, Moorland crab, Pear, Satin, Beech, Hawthorn, and Ash are also used, either compressed or uncompressed. In 1884 Messrs. T. Pickles and B. Blakey patented a process by which blocks of these and other woods are subjected to a pressure of from 450 tons to 2000 tons in order to render them suitable for shuttles. The routine of shuttle manufacture is: Cutting the wood into blocks that approximate to the size of a shuttle; seasoning, which, where artificial heat is not employed, requires from two to three years; squaring and bevelling the blocks to fit the race board and reed; grooving and drilling the sides, and ringing and tipping the ends; hollowing the inside, turning, pegging, eyeing, tonguing, and polishing. Shuttles vary greatly in size and shape, and numerous patents have been taken out for tongues and the methods of attaching them. At the present time a weaver usually sucks the weft through a shuttle eye. It is known that this practice is unhealthy and responsible for the spread of numerous diseases. In order to remove these dangers many patents have been, and are being, taken out for semi- and self-threading shuttles, but the shuttles in general use have not been greatly improved for many years.

The rapidity of motion in a shuttle, combined with an imperfect control, are the chief causes of serious defects in picking motions. But numerous forces tend to divert a shuttle from its proper course.

It is a law of mechanics that the energy possessed by a moving body varies in proportion to its weight and the square of its velocity. Since a shuttle leaves a line of weft behind each time it moves across a loom, a constant diminution of weight and energy occurs until a shuttle is empty, and any obstruction will be more liable to divert a light than a heavy one. Therefore, unless a spent shuttle is heavy enough to overcome every resistance and draw weft close to the selvage of a fabric, the risk of flying out will be great. When passing through a shuttle eye there is greater tension upon a coarse than upon a fine thread; for this reason the weight of a shuttle should bear a definite relation to the tension upon a thread. This means a heavier shuttle should be employed for a thick than for a thin weft.

The position of the centre of gravity in a shuttle, with relation to the direction of force employed to propel it, has an effect upon its motion. The centre of gravity has been defined as a point about which a body would balance when that body is turned in any direction; and further, if a body which is uncontrolled is subjected to a blow, it will move in a straight line and in the direction in which the blow is delivered, provided the line of force passes through the centre of gravity; but otherwise the body will not merely move as a whole, it will revolve.

Although a shuttle is not free to move in any direction, it moves at a high velocity without being positively controlled. It is therefore imperative that the force employed to move it, and the parts used as guides, shall minimise any tendency to rotate. Let it be assumed that a shuttle is a parallelogram, and that its centre of gravity is at the centre of the body, as in Fig. 168. If a force D passes through the centre of gravity C, and parallel to all sides of the rectangle A B, the movement will be straight without the aid of guides; but an obstruction, such as rough, knotty, or entangled warp, will be sufficient to set up a rotatory motion. If the line of force does not pass through the centre of gravity, then the distance between the centre of gravity and the line of force represents the leverage which will produce rotation; see Fig. 169, where A, B represent two sides of a rectangle, C its centre of gravity, D the line of force, and C, E leverage.

Rotation can be checked by placing the reed and race board against those sides of the rectangle farthest from the line of force; for this reason many shuttle tips are placed

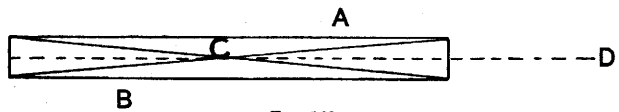

FIG. 168.

nearer the top and front than the back and base of a shuttle, for then the line of force will be above and before the centre of gravity. By so doing it is claimed that pressure will be exerted against the reed and the race board, and the tendency to fly up or outward will be checked; friction will thereby be slightly increased; but this is a small matter compared with the risks attending ejected shuttles. On the other hand, if the tips are too

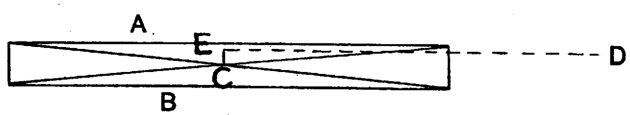

FIG. 169.

high, they will pass over entangled warp and the shuttle will tend to move upward.

The centre of gravity in a shuttle does not occupy a fixed position, but is constantly changing. If when a shuttle is loaded with weft its centre of gravity is at the centre of its mass, every time it moves across the warp that point recedes in proportion to the weight of weft drawn away, because the weft is pulled from the forward

end of a cop. Hence, until the weft is half exhausted the front of a shuttle becomes lighter, while the back remains unaltered. The change is small, yet it helps to make the movement of a shuttle uncertain.

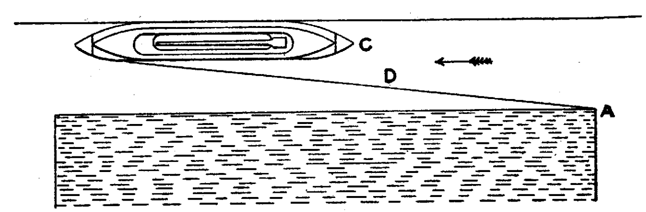

FIG. 170.

When weft is passing through a shuttle eye a side pull of varying intensity is exerted, which also tends to deflect a shuttle. A reference to Figs. 170 and 171 will illustrate this point. The arrows indicate the direction of motion: A is the cloth fell, B the reed against which the shuttle C moves, D is the weft running diagonally between C and A.

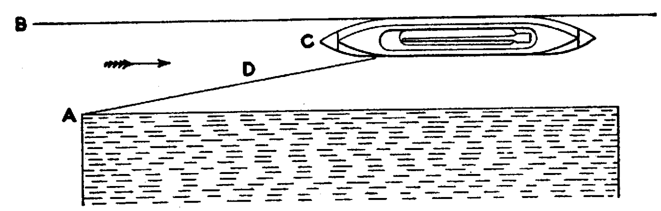

FIG. 171.

An obstruction to the free passage of weft through the shuttle eye will, in Fig. 170 draw the front of C from B, when C will be ejected from the loom. In Fig. 171 the forward end of C will be tilted against B, and this slightly reduces the risk of flying out, but the effect in either case will be in direct proportion to the intensity of the pull. If the eye was placed at the centre of a shuttle, and the weft revolved as in ribbon shuttles, the pull would be equal in both directions.

Weft is less free to pass from a shuttle eye when a cop has nearly given out than when full; this is due to the shuttle eye and tongue retaining their relative positions, while the position of the weft upon the tongue varies. A thread passes from the outer surface of a full cop to the tip of a tongue at a great angle, but as it is withdrawn from the shuttle the angle is reduced and a coarsely pitched coil of thread begins to form; this puts additional tension upon it. As a result, the movement of a shuttle is modified in a twofold degree: first, by a reduction in weight, which results in a reduction of force; and secondly, by an increased diagonal pull being exerted when the shuttle is least capable of resisting it.

It has been previously stated that a shuttle is guided by the race board, upon which it rests, and the reed, against which it presses; both are parts of the slay, and swing about a centre by the action of cranks and connecting arms. It follows, therefore, that a shuttle partakes of this swinging motion in addition to that of translation.

Fig. 172 is a diagrammatic representation of the above-named parts: A is the shuttle, B the slay, C the reed, D a sword, E the rocking-shaft centre about which D moves; F is a connecting arm, G a crank, and H a dotted line showing the circular path of G. When a shuttle begins to move, the several parts occupy positions corresponding with the solid lines; the slay is moving back and continues so to move until the crank G reaches point 2 in the periphery of the circle H, where a slight pause takes place for reasons that are fully dealt with in Part XVI. The

position of each part at this instant is indicated by the same letter with the addition of a dash against dotted lines.

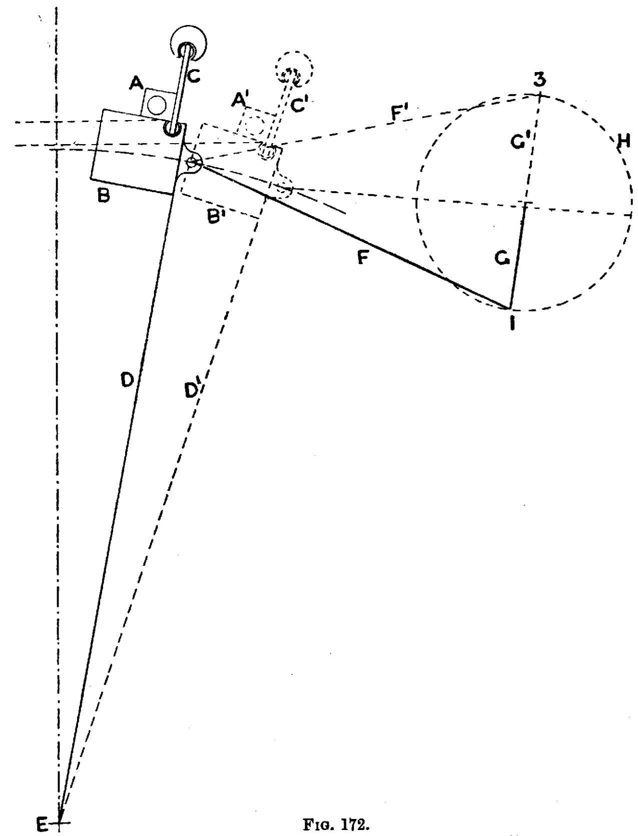

FIG. 172.

It will be noticed that when the sword is at D′, the shuttle A is in a lower plane than at D, the fall of the slay being indicated by the space between the lines 4, 5. In consequence of which, during the movement of the slay from D to D′, the shuttle has been travelling across the loom, moving back, and falling with the slay; but as the crank G moves round point 2, the shuttle simply continues to pass across the loom. Between points 2 3 the shuttle moves up and forward with the slay until it finally reaches the opposite shuttle box.

Fig. 173 will further elucidate the aggregate motion of

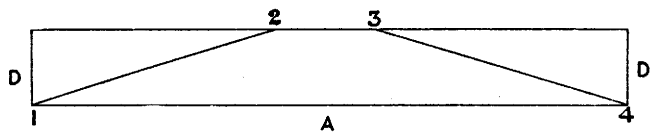

FIG. 173.

a shuttle. Let the line A represent the breadth of a loom, and D the backward movement of a slay; it will then be found that a shuttle, in passing from 1 to 4, moves in a curved path, from 1 to 2, straight from 2 to 3, and in the opposite curve from 3 to 4. This does not reveal all its motions, for the fall and rise are not taken into account. In Fig. 174 A equals the width of a loom, and 1 5 and 4

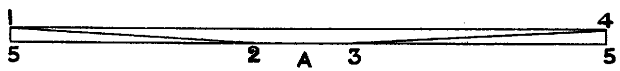

FIG. 174.

5 the fall of a slay. Hence the shuttle falls from 1 to 2, moves straight from 2 to 3, and rises from 3 to 4.

Add to these modifying influences that a shuttle begins its journey when a slay is moving back at nearly the same speed as a point in the periphery of the crank circle H, Fig. 172; but after the crank passes point 1 the velocity of the slay is rapidly reduced, until at 2 a pause is reached; then from 2 to 3 the increase in velocity is proportional to

the decrease from 1 to 2; and it will be observed that a shuttle partakes of many variations in velocity and direction, yet they do not all necessarily tend to eject it from the loom. On the contrary, some of them assist in reducing such a tendency. For example, when a shuttle begins to move across, it is also travelling back with the slay at its greatest velocity, and if at such times the reed and box back were removed, the shuttle would continue to travel backward; but with the reed in position, as the slay's speed is reduced a shuttle presses against the reed with a force in proportion to its weight and acquired momentum, and this minimises its liability to fly out.

Many forces, therefore, are acting simultaneously or successively which tend to make the movement of a shuttle a complex one. Still, the mechanism for controlling it is less efficient than is generally supposed. Before proceeding to describe the varied devices used to propel a shuttle, it will be advisable to determine what features may be considered essential to a good pick, for if this is done the relative values of picking motions can then be more readily appraised. The following points are suggested as essentials:—

(1) The power consumed. When a shuttle is negatively driven, much energy is wasted, partly on account of the difficulty of accurately gauging the force required, and partly because all motors are liable to variations in speed. On entering a box the momentum of a shuttle must be destroyed or the shuttle will rebound. Therefore the first proposition is: that since the weight of a shuttle and the time taken to move it are of greatest moment, only sufficient force to pass that shuttle across a warp in the time allotted should be employed.

(2) Altering the speed of a loom. If the speed of a

loom varies, the energy of the picking mechanism varies also; an acceleration causes a shuttle to rebound through excessive force; and a retardation prevents a shuttle from reaching the opposite box owing to insufficient force; in either event the loom stops. A similar effect follows if two shuttles of unequal weight are used in a loom, for, if the pick is correctly set to the light shuttle, the heavy one will be driven with violence into the opposite box; but if the pick is set to the heavy shuttle, the light one will not reach its destination. This has long been one of the most obvious defects of negative driving, for numerous parts have been devised to prevent an alteration in the speed of a loom from affecting the picking force. The second proposition is that energy in the picking mechanism should remain constant, irrespective of fluctuations in the speed of a loom.

(3) A desirable motion. The movement of a negatively driven shuttle is essentially jerky, and frequently produces the most disastrous results; its velocity is developed suddenly, and is greatest as it enters the shed which at this instant is small, for the driving cranks are little beyond their bottom centres. As the reed moves back considerably more room will be provided for a shuttle to pass, and granting that obstructions are less likely to eject a shuttle as it enters a shed than elsewhere, there is a risk of breaking the warp. Again, the power required to develop a high speed suddenly is in excess of that required to develop it gradually. The third proposition is, therefore, that a shuttle should begin to move slowly, develop speed until it reaches the slay centre, and from the centre to the opposite side a corresponding decrease should take place.

(4) A positive motion. Most of the serious accidents

that occur in weaving sheds are caused by flying shuttles, and these are due to negative picking. In order to compass the movements named in the preceding paragraph a shuttle would of necessity be positively controlled, and this would mean safety to the work-people, a considerable reduction in power and breakages, as well as a cheapening of production. The fourth proposition is, therefore, that a shuttle should be under complete control throughout its movement, and that the loom and shuttle should be capable of starting and stopping together, whether the shuttle is in or out of the warp.

(5) Connecting the principal motions. In many looms shedding, picking, box, and taking up, and other motions work independently of each other, and it is the object of the fifth proposition to prevent this by positive connections which will prevent one piece of mechanism from getting out of sequence with the others.

The picking motions now in use do not fulfil the conditions set forth on the preceding pages, but a weaving student must consider whether a piece of mechanism which gives a blow to a shuttle and leaves it without sufficient control is either true in principle or economical. Also to what extent the application of guards, swells, check straps, and other parts designed to prevent shuttles from flying out are attempts to deal with the effect instead of the cause.

The mere enumeration of the requirements of a picking motion is sufficient to show that a formidable problem must be solved before a truly satisfactory pick can be obtained; and an analysis of the defects arising from inattention to the points mentioned will reveal the pressing need for improvement.

Attention has been frequently directed to this subject, and various devices have from time to time been resorted to with a view to improvement. Fig. 175 illustrates an attempt made by Messrs. Butterworth and Dickinson to economise power by removing pressure from a shuttle as it leaves a box. A lever A is so secured upon the stop rod B that it may normally bear upon the swell C. A hook upon B holds the upper end of a spiral spring D, but its lower end is attached to the slay sword E. The spring, therefore, holds A in close contact with C, and a shuttle in entering a box must possess sufficient energy to overcome the resistance of D. The pressure of A C upon a shuttle as it leaves a box is relieved by a bent finger F attached to the rod B. As the slay moves back the free end of F passes beneath an antifriction bowl G mounted in a vertically adjustable bracket H, and G presses F down and A back at the moment of picking. At other times this device permits the spring D to act upon C with its full force. Another shuttle easing motion is illustrated in Fig. 238, where D is a stop rod shown bent backward at D′ to receive the swell lever E, which is set to bear upon the swell E′. A blade F is also secured upon D, and operated each time the slay recedes from the cloth by a rod I. The rear of I is held between the prongs of a supplementary, forked, connecting-rod K′ by a strip of metal P, but the forward end of I passes through a hole in a sword B. The rod I carries a spiral spring J′, one end of which impinges against the sword, the other against a stop hoop J. This spring normally thrusts the stop P′ upon the arm K′. As the crank H revolves, a projecting piece O′ on the connecting arm K makes contact with a bowl Q on the rear of I, contracts the spring J′, moves I against F with sufficient force to partially rotate D and remove E from the swell.

A cam has also been fixed upon each extremity of the driving shaft to cause two levers and links to release a shuttle before picking. In many American looms a swell is placed in front of a shuttle-box, and in some of them a flat spring is bolted to the breast beam, so that at the time

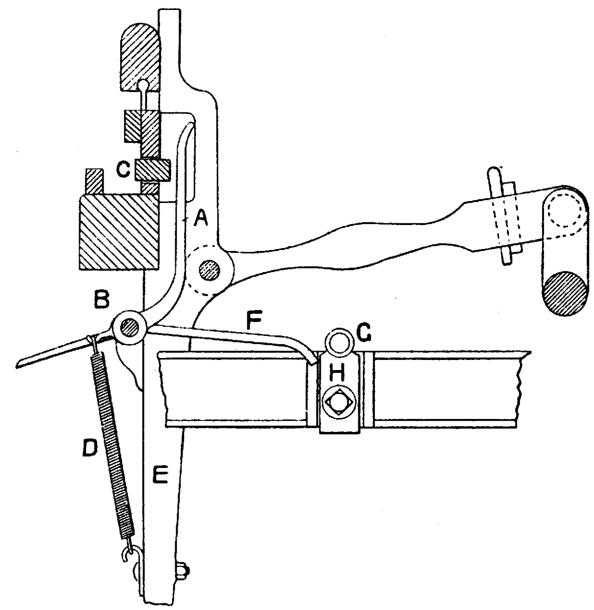

FIG. 175.

of picking a double cam surface formed beneath the spring may pull back the swell finger; at other times the spring bears upon the finger to check a shuttle as it enters a box. But such appliances as the foregoing cannot effect great economies in power. In most cases it is a question of reducing the power consumed by the pick and increasing that by the slay. They, however, materially reduce the wear of pickers, strapping, picking noses, and other parts of a loom.

Shuttles have been moved by the elastic force of compressed air, by gravitation, by electricity, by a carriage, by a worm, by springs, by cams, and by other means; some of which have a negative, others a positive action. Negative or conditional picks are over, and under, alternate, and pick-at-will. The difference between an over and an under pick relates to the position of the picking arm fulcrum, which if entirely below the shuttle boxes constitutes an under-pick, but if some portion of the fulcrum is above the boxes the motion becomes an over-pick. Of under-picks there are *a*, those that deliver a blow from the bottom shaft, and *b*, those that deliver it from the crank shaft. In most of the motions included in division *a* it is possible to cause the piece that receives the impact to push rather than strike a shuttle, and when this is accomplished the best results are obtained. It must, however, be admitted that less attention has been given to this matter than it deserves, and as a consequence, if under-picks are compared with over-picks, it will be found that the former usually consume more power, work less smoothly, and the number of shuttles ejected is greater than in the latter.

Pick-at-will motions are applied to looms that have multiple boxes at each end of a slay; they permit two or more shuttles to be driven from one end of a loom before a return movement is made from the opposite end. A single weft thread of any colour may thus be passed through a warp; this is rarely attempted with alternate picking. Most of the pick-at-will motions are modifications of alternate picks, and the mechanism can be converted from one system to the other without making important structural changes, but some alternate picks require considerable modifications and additions to adapt them for pick-at-will work.

OVER-PICKS

A few years ago several types of over-picks were commonly met with, which have now become obsolete, and it may be affirmed that, with the exception of one type, over-picking is not progressing. In England, however, the cone over-pick is attached to more looms than all other systems and varieties of picking taken together.

The cone pick is used for most fast-running looms weaving light and medium fabrics; and for many both narrow and wide looms weaving heavy fabrics. The mechanism has also been modified to suit pick-at-will looms. It consists of a vertical shaft A, Fig. 176, which is placed either inside or outside the loom framing, but when placed outside it gives the most satisfactory results, for in that position a picking tappet can be moved near its bearing, and greater steadiness obtained. Shaft A serves as the fulcrum of a lever; it is held against the loom framing by a cannon bearing near the top, and a footstep at the base. This footstep is bolted to the loom framing, and no provision was made for vertically adjusting the shaft A, until T. Pickles, in 1904, passed a set-screw, with a cone-shaped tip, through the base of the footstep, and formed an internal cone at the foot of A. When once adjusted a lock-nut on the set-screw made all secure. One arm of A consists of a short stud B that carries a loosely fitting, truncated cone. B is either passed through a slot in A and secured by screw and nut, or it occupies a fixed position upon A. The long arm C is of wood, and attached to a ring on the top of A having radiating teeth on its upper surface for a ring with similar teeth on the under side to fit into. These teeth form a rigid connection and facilitate adjustment. A grooved cap is bolted over the

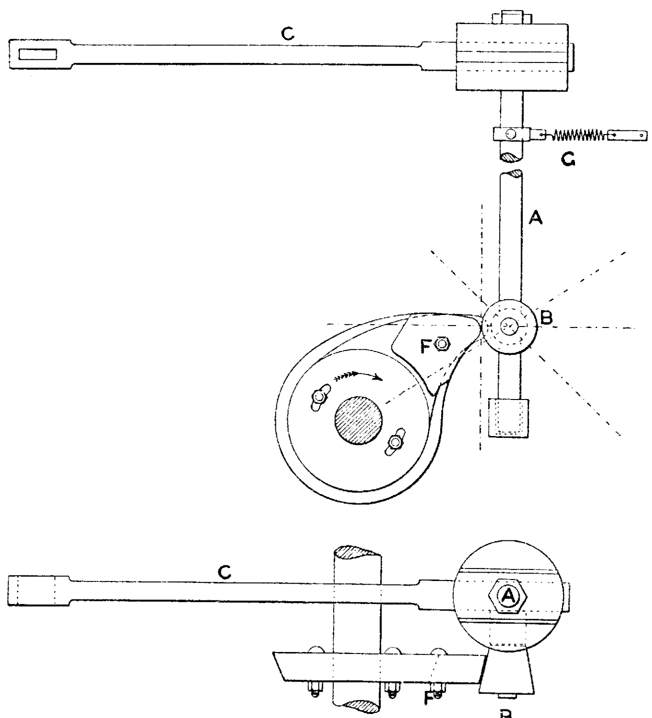

FIG. 176.

picking arm C to hold all secure. From the forward end of C a leather strap passes down to a buffalo-hide picker which is freely mounted upon a spindle placed over the shuttle-box centre.

A tappet is keyed upon the bottom shaft and inside the

framing, in revolving, its nose F strikes the cone-shaped antifriction roller on B; partly rotates the shaft A and the arm C, and causes the picker to move inward with sufficient velocity to drive a shuttle across a loom. The tappet F is made in three parts: one consists of a fixed disc, which is keyed upon the bottom shaft. Another part is provided with a smooth oblique surface, and with concentric slots for bolts to pass through; the slots permit of a slight adjustment to vary the time of picking. When a greater change is needed than the slots provide for, the driving wheels must be disconnected and the picking shaft turned forward or backward before again putting the wheels in gear. A groove is also formed to take the third piece—namely, the picking nose.

Similar mechanism is fitted at both sides of a loom, but the picking tappets F oppose each other; for when the noses of both pieces F are in a vertical plane, one is above, the other below, the shaft centre.

The conical roller on B is kept in contact with the tappet F by attaching one end of a spiral spring G to any convenient part of the framing, and the other end to a hoop upon A. This hoop is usually fixed immediately below a bead on the framing in order to prevent the shaft A from moving vertically. The spring G also causes the picking arm C and the picker to move back after the delivery of each pick. On narrow looms the straps from both shafts A are connected to opposite ends of a spiral G, situated below the warp; then, as a pick is delivered at one side, the power required to distend G is utilised in pulling back the free arm C. Since a picking strap is more or less slack when an arm C is in a state of rest, it follows that a picker can only be partially drawn back by C; but its backward traverse is completed by a shuttle impinging against it.

The high speeds attained by many looms using this pick have rendered careful construction of the tappet F essential, and easier working, a smaller consumption of power, and reduced wear and tear have resulted. Yet the cone pick will remain defective, so long as energy is developed from a slow-running shaft, in from $\frac{1}{9}$ to $\frac{1}{18}$ of its revolution. At $\frac{1}{12}$ of a revolution a picker in a loom making 200 picks a minute completes its journey in about $\frac{1}{1200}$ part of a minute; but its velocity is not uniform, for a tappet pushes a cone stud, in equal units of time, through evenly accelerating spaces in the proportion of 1, 3, 5, 7, 9.

It is difficult to obtain the exact amount of power required to drive a shuttle, for the conditions under which it performs its office vary. There are differences in friction, caused by large and small sheds, rough and smooth, close and open warps, strong and weak swells, also differences in the weight of a shuttle; but the energy can be approximately reached as follows :—

The work accumulated $= \frac{wv^2}{2g}$, where w equals the weight of a shuttle in pounds, v its velocity in feet per second, and g 32·2.

For example, assume a loom to make 200 picks per minute, and that a shuttle weighing 10 oz. is moved across a space of 5 feet in $\frac{3}{8}$ of a pick; then the average speed of such a shuttle is $\frac{200 \times 8 \times 5}{60 \times 3} = 44{\cdot}4$ feet per second, and the energy developed is $\frac{10 \times 44{\cdot}4 \times 44{\cdot}4}{16 \times 2 \times 32{\cdot}2} = 19{\cdot}13$ foot lbs. per pick, or $\frac{19{\cdot}13 \times 200}{33{,}000} = 0{\cdot}116$ of one horse-power.

The length of a picking arm C, Fig. 176, is to some extent determined by the reed space of a loom, as the latter should not exceed C by more than $2\frac{1}{4}$ times; on an average, a 20″ arm is used with a 45″ shuttle race. The length of a picking arm fixes the position of the upright shaft A, because, when the reed and fabric are in contact, the arm C, if moved half the length of the picking spindle, should place the centre of the picking strap, where it leaves the arm, in the same vertical plane as the spindle centre.

Energy is often wasted by giving the picking force an upward or a downward direction; but if, as far as circumstances will permit, this force is transmitted to the cone stud B, at an angle approximating to a right angle, much of the harshness of this pick disappears.

Since a cone moves horizontally in the arc of a circle, its surface will form different angles with the tappet shaft, and also with the picking tappet F; hence the latter must be bevelled to present a flat surface to the cone in every position. This bevel has rendered the correct construction of such tappets difficult of attainment. It has been customary to fix a roughly shaped wooden model in position upon the tappet shaft and, by rotating it slowly, to note if sharp edges were presented to the cone, and if so, to alter the shape where necessary; after which a casting was made from the model.

A picker may move 7″ to 14″ at each stroke of a picking arm, but it is only driven through 6″ to 11″ by a tappet F; the inertia completes its movement and is of no consequence to the shuttle, because the latter leaves the picker so soon as a decrease in speed takes place. A picking tappet may be said to have three functions, namely, to tighten the picking band, to drive a shuttle through the warp, and to reduce the momentum of both picking arm and picker. A tappet gradually tightens the picking strap to avoid giving a jerk to a shuttle; during this time the arm C, and the stud B, move through an angle approaching 10 degrees. This is followed by picking the shuttle across, and from 20 to 30 degrees of accelerating movement in C, B is usually allowed for the purpose. Lastly, a further movement is given to C, B, in order to bring them gradually to a state of rest and thus reduce the wear and tear—say $7\frac{1}{2}$ to 10 degrees in the decreasing ratio of 3, 2, 1.

It has been asserted that a shuttle is intended to be in the middle of a slay when the driving cranks are on their back centres, but in practice this is not adhered to. Much depends upon the time and force of picking. A pick is set to act between 15 degrees before the bottom centres are reached, and 10 degrees after they are passed. If, for example, a shuttle begins to move when the cranks are 10 degrees past their bottom centres, and makes its journey in $\frac{3}{8}$ of a pick: $\frac{3}{8}$ of $360° = 135°$, therefore, when the cranks are on their back centres the shuttle should be past the middle of the slay, for $135° - 80°$ leave only 55° of movement in the cranks in which to complete its course.

If a pick is set earlier a shuttle will, with an equal driving force, be considerably beyond the slay centre when the cranks are on their back centres.

Fig. 177 shows the construction of a picking tappet: A is the bottom shaft, B the picking tappet, C a sectional view of the upright shaft, which is assumed to be $6\frac{1}{2}''$ from the centre of A to the centre of C; D is the cone, and E the horizontal plane in which D moves when the tappet nose F is pressing upon it. Solid lines show the cone stud and bowl in contact with the shell of B, and dotted lines show them after they have been moved, by the nose F, 30 degrees. The tappet disc is employed to tighten the picking strap,

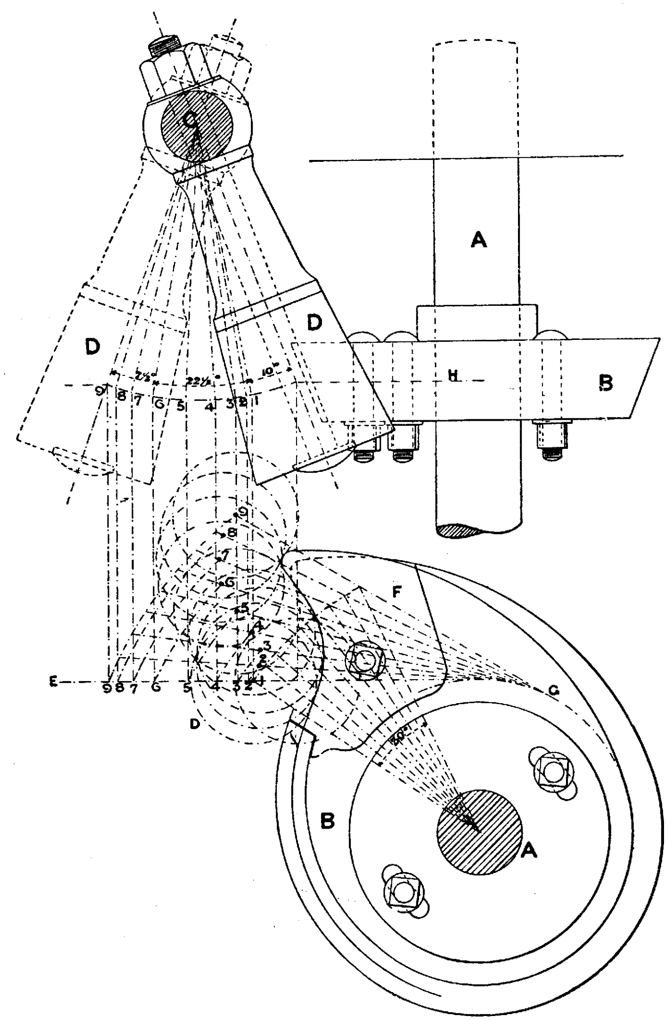

FIG. 177.

but in practice tightening begins between the top and front centres of the driving cranks. In some looms upwards of 100 degrees of movement are allowed; this shows that the time taken is unimportant. The actual delivery of the pick is therefore the starting-point. Divide $22\frac{1}{2}$ degrees of movement in the cone D into 25 parts, and, reading from right to left, drop perpendicular lines through intersecting points, 1, 2, 5, 10, 17, and 26, which will give the proportions of 1, 3, 5, 7, 9. Divide the remaining $7\frac{1}{2}$ degrees into six parts, and drop perpendicular lines through points 4, 6, 7, which will give the proportions of 3, 2, 1. Describe, from the centre of A, a circle G, equal in radius to the vertical distance between the centre of the cone stud and the centre of the tappet, say 3″, and draw a horizontal line E tangential to G. The perpendicular lines 1 to 9 cut E at right angles. Draw a line radiating from A to pass through point 1 on E. From A, 1, make an angle of 30 degrees, and divide it into eight equal parts. Through each point where a radial line intersects the arc line draw a line tangential to the circle G. Then with radia A, 1 to A, 9 describe arcs in rotation that cut the tangential lines. Let each point of intersection represent the centre of the cone D as it is pushed outward by the tappet. Describe a circle round each having a diameter equal to that of D, where it touches the line H on the tappet B. To find the centre line of the nose F, trace a line that touches the periphery of each circle. The inner and outer edges of F can be obtained in a similar manner, but the diameter of the cone D must be taken where contact is made with that portion of the tappet face to be drawn.

The line already traced is slightly inaccurate, owing to the circles that represent the cone being uniform in diameter, instead of having diameters that differ in accordance with the varying points of contact between the cone and the tappet; and, again, only one true circle could thus be obtained, namely, when the cone stud and tappet shaft were parallel; at all other places elliptical figures should have been described. But the plan followed has been adopted to avoid undue complication, also because the inaccuracy is so slight as to be of no practical account. Still, if it is thought desirable to construct a geometrically

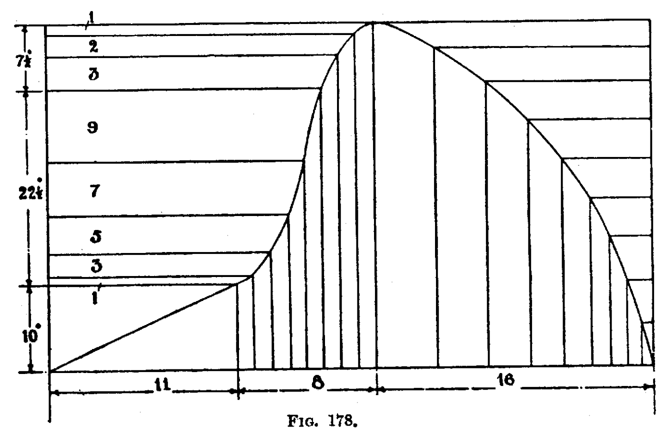

FIG. 178.

correct tappet, take the dimensions of the cone D at each of the eight defined points, and draw ellipses of the proper shapes instead of circles.

Fig. 178 represents the movement of a cone stud as traced from a picking cam fitted upon a 45″ reed space calico loom. The thick line shows how the stud is moved from the time of tightening a picking band until it again becomes motionless. The movement made to drive a shuttle equals 40°; for the first 10° of which the stud is pushed from the bottom shaft uniformly. For the following $22\frac{1}{2}°$ it moves in equal units of time through accelerating spaces, represented by 1, 3, 5, 7, 9. For the remaining $7\frac{1}{2}°$ it moves through decreasing spaces, represented by 3, 2, 1. At the end of the last-named position the cone is upon the extreme point of the cam, and from thence it is gradually restored to the disc.

The time taken to make the entire outward and inward journey equals 260° of movement in the driving cranks, namely, 80° for tightening the picking band, 60° for delivering the blow, and 120° for moving the stud back, leaving 460° for the stationary period.

An idea prevails that a shuttle is less liable to fly out if a box spindle is slightly tilted upward and outward at the inner end, and if a fall is given to a race board, between the shuttle box and the centre of the reed space, of about $\frac{3}{32}''$ in a 45″ loom. Some loom-makers also give a reed an outward bow to the extent of $\frac{3}{32}''$ on the above-named width of loom. The reasons assigned are that a picker in travelling along an inclined spindle elevates the rear end of a shuttle and tilts its forward end nearer the race board and reed. By so doing any tendency to rise is minimised. Also that a sloping race board and a curved reed assist in further reducing the chances of flying out by permitting the shuttle to continue moving in a downward and backward direction to the centre of the reed space, by which time much of its energy will be expended.

Advocates of this plan point to under-picked looms as demonstrating its utility, for in those picks the curvilinear movement of the picking arm, when near the front of a box, has a tendency to press down the rear end of a shuttle, and impart an upward direction to the forward end. As most of these looms are more liable to eject shuttles than over-picks, the plea seems to be a reasonable one. Still, the difference is doubtless due in part to the

more rapidly developed force in many under-picks. Until exhaustive experiments have been made, the question must remain a more or less speculative one.

When a cone over-pick is converted into a pick-at-will motion, the picking tappets may be made to slide out of reach of the conical bowls, or each bowl stud may have a swivelling joint, by which a bowl can be lifted out of contact with a tappet. Or, again, a clutch on the upright shaft may be opened to avoid picking, and closed to pick.

Under-Picks

The cone pick has been converted into one of the best motions for alternate under-picking, and has been applied with great success by Continental makers of silk looms, producing a much smoother pick than is usually found on under-pick looms. It has also been adapted for under-picked, pick-at-will looms. For the latter purpose a novel feature has been introduced, namely, that of causing a shuttle to decide from which end of a loom the following pick shall be delivered. Further, if through faulty manipulation two shuttles face each other, neither will be ejected from its box. The last-named feature is a desideratum in all pick-at-will looms, for much breakage of warp, and many smashes of other kinds, result from one shuttle being driven out of a box when another is in the opposite box.

The parts are as follows:—The picking cams F, Fig. 179, are doubled-nosed; in other respects they are similar to those of an ordinary cone over-pick, but the shaft A, together with its short arm, and cone B, are fixed horizontally outside the framework, so that B is beneath F. The wooden picking stick has been replaced by a short metal arm C, which terminates in a catch. A second arm

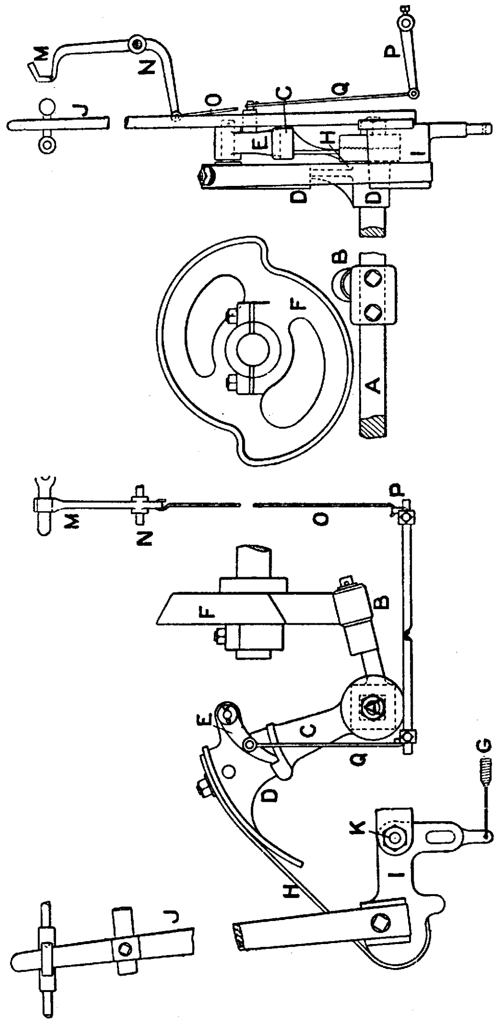

Fig. 179.

D is loosely mounted upon A, and carries an adjustable fulcrum pin for a latch E to vibrate upon. A strap H, bolted on the curved upper surface of D, is led round a curved portion of a shoe I. This shoe is a three-armed lever; its long arm J is furnished with a picker that is loose upon a spindle placed parallel with a shuttle box. The horizontal arm of I is drilled to receive a fulcrum stud K on the rocking shaft, and to it the strap H, and the picking arm J, are secured. The vertical arm of I sinks below K to take a spiral spring G, by which J is drawn back to the outer end of a shuttle box. Provided both latch and catch engage, as C is vibrated by the stroke of F, the strap H is tightened, tilts over the arm J, and drives a shuttle through the warp. As I moves about its fulcrum pin, J rises and falls in addition to moving to and fro. Although this does not produce a parallel motion at the picker level, yet the stroke more closely approximates to a parallel one than is usual in under-picked looms.

A latch E is lifted above the catch on C when its picking arm J is to remain in a state of rest. This is accomplished by mounting a cranked lever M freely upon the stop rod N, so that its vertical arm shall rest against a box swell. To the horizontal arm of M a wire connection O is made with a lever P, whose fulcrum is a light rod that crosses the loom in front of the rocking shaft. From the opposite end of this rod the second arm of P is united by a link Q to the latch E. Whenever a shuttle in a box faces a picker, the finger M is pressed back by a swell, it vibrates P, and moves E out of contact with C, thereby permitting J to remain stationary while C moves. Similar parts are fixed on both sides of the loom, hence, if a shuttle in a right-hand box faces its picker, the latch E on the left hand will be lifted and that picking arm will remain inoperative. Likewise, if a shuttle in the left-hand box faces its picker, a latch E on the right hand will be lifted and that picking arm be thrown out of action. Also, if

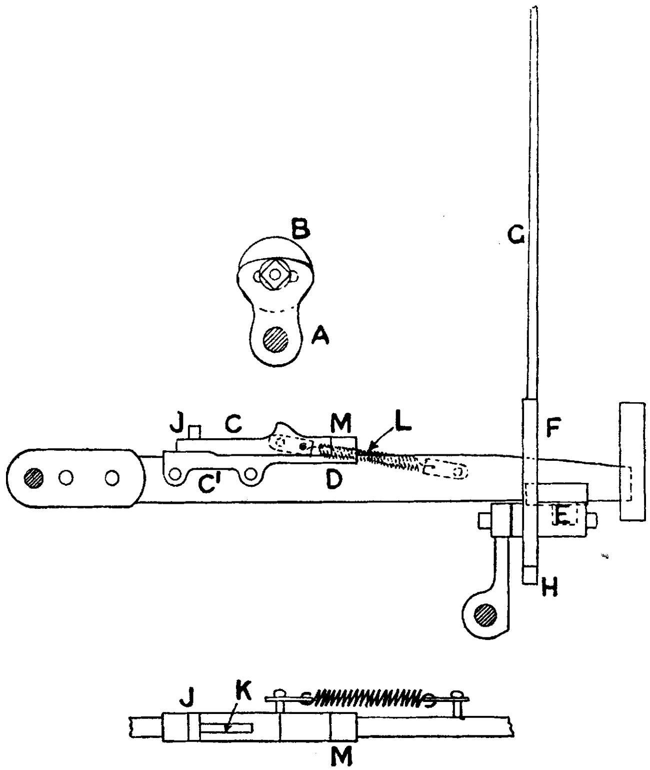

FIG. 180.

two shuttles face the pickers, both picking arms will remain stationary.

The lever pick is one of the best known under motions; it consists in fastening an arm A, Figs. 180, 181, upon the

bottom shaft to carry an adjustable stud and bowl B. As A revolves towards the left, the bowl B strikes a curved metal plate C, which is bolted to a wooden lever D, the latter being fulcrumed upon the rear of the end framing. The forward end of D rests upon a short arm E, of the picking lever F, G. The fulcrum pin of E, F, G is fixed in a bracket on the rocking shaft and swings with the slay. G is a wooden arm which passes through a slot in the base of the shuttle box; a leather picker is dropped over its upper end, and a wooden or iron rib at the back of the shuttle box holds the picker in position.

When a bowl B strikes the picking plate C, it depresses the lever D, tilts the picking arm and picker, and drives a shuttle across the loom. A spring and strap H draw the arm G back to its normal position.

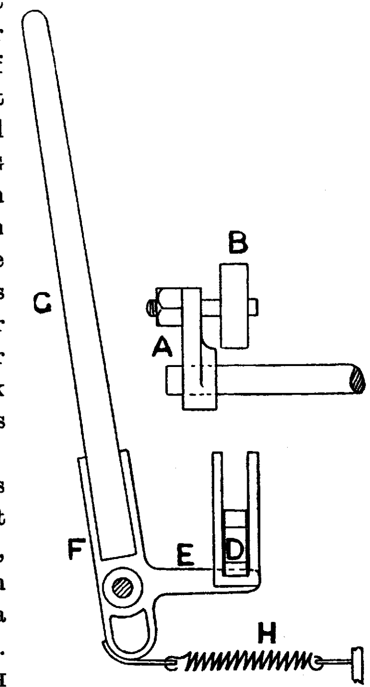

FIG. 181.

Duplicate parts are placed at the opposite end of the loom to return a shuttle, but when one pick is active the other is inoperative. Since a picking arm of the foregoing description vibrates about a centre, it rises and falls in the picker, and this causes the arm to abrade rapidly;

also, in moving to the vertical position, it tilts up the rear of a picker; but in moving from the vertical position to the inner end of its stroke, the front of a picker is tilted up. All these movements are undesirable, and can be prevented in various ways. A plan known as "Stearns parallel motion" has a stand A, Fig. 182, fixed upon the rocking shaft, and A has a uniformly flat surface, except for a vertical projection B and a slot. A wooden plug saturated with oil is driven into the inner end of a slot in A to serve as a fulcrum for a picking arm C. This arm C is bolted upon a shoe D whose under surface is cam-shaped, and the cam rests upon the stand. A hole in the shoe receives the projection B, and a curved tongue E is bolted upon the picking arm. E and the base of C pass through the slotted stand A. An arm C is pulled outward by a strap F and a spiral spring G. The strap F is hooked into the base of the tongue, and also attached to a pulley, which is loosely mounted upon a stud in the stand. One end of the spring G is rigidly fixed to a projection on A, the other end is passed through the periphery of the pulley and through the strap F.

As a picker C advances to eject a shuttle from a box, the curved face of D lowers C sufficiently to enable a picker, when screwed upon C, to move in a plane parallel with the box bottom. In making this movement the base of C tightens the strap F and partially rotates the pulley; this puts a twisting strain upon the spring G, and the energy so created draws back both arm and picker to their normal positions, when no longer under the influence of a picking cam.

If a slay has two or more shuttle boxes at one end or at both ends, the picking arm G, Figs. 180, 181, passes through a slot in front of the boxes, and also through a buffalo-hide

picker which slides upon a guide spindle. A further alteration has been made in one or both picking plates C, in order to avoid ejecting shuttles from the boxes when a slay is moved backward. It consists in fixing a casting

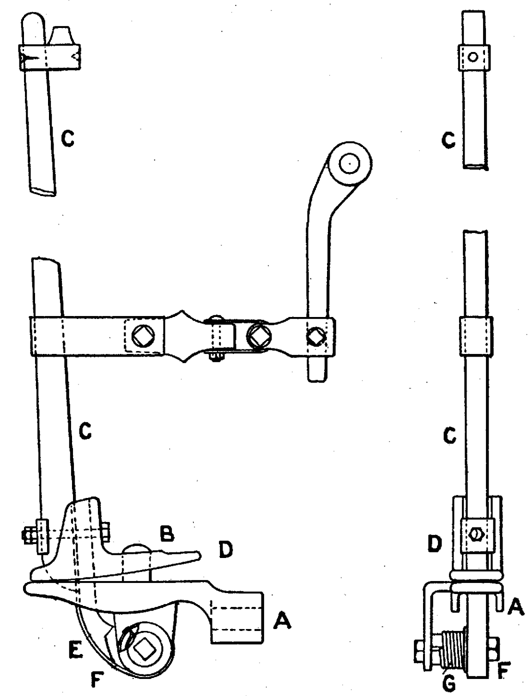

Fig. 182.

C′, Fig. 180, upon D, for the reception of a sliding picking plate C, and in securing C to C′ by passing a bolt J through a slot K in C. When a loom is running in its normal direction, the plate C is drawn by a helical spring L against a fixed shoulder M, and a pick is delivered in the usual manner; but when a loom is reversed, the bowl B strikes the back of C, distends the spring L, and causes the plate C to slide along the surface of C′ without depressing D, and consequently without moving either picking arm or shuttle. In case of obstruction to the movement of a shuttle, such as a box being lifted half-way, a picking arm is sometimes prevented from moving at all, at other times its fulcrum gives way and an arm moves at the lower instead of at the upper end.

In order to shape the plate C correctly, it is necessary to ascertain (*a*) the movement to be given to a picker; (*b*) the lengths of the two arms F, G, and E, Fig. 181, from the fulcrum to a picker centre, and from the fulcrum to the outer edge of D; (*c*) the dimensions of the lever D, between its fulcrum and the curved surface of C, and its fulcrum and the point of connection with E; (*d*) the radius of a circle described by the centre of a bowl B, and (*e*) the radius of a bowl B. Thus: assume a picker to move 9″; the mean length of F, G, from the fulcrum to the centre of a picker, to be 28·25″, and that of E, 4·75″; the length of D, from its fulcrum to its point of contact with E, to be 29″, and from its fulcrum to the point of contact with B, 16·25″. Then, 28·25 : 4·75 : : 9 : 1·513″ = the fall of E, where it touches D; and 29 : 16·25 : : 1·513 : 0·848″ = the fall of D, where it touches B. Further, let it be assumed that the centre of a bowl B, describes a circle 4″ in radius, and the bowl has a radius of 1·625″. The distance between the centre of the picking shaft A and the centre of the fulcrum pin of D, when measured horizontally, is 15″. The time for delivering a blow varies from $\frac{1}{13}$ to $\frac{1}{20}$ of a revolution of the picking shaft, but let $\frac{1}{16}$ be taken. The thickness and length of the picking plate C, is 1″ by 6″; and the depth of the lever D, $2\frac{3}{4}$″. The space through which

the lever D is depressed at its point of contact with a bowl is seen to be 0·848″. The ratio of depression is in arithmetical progression, or 1, 2, 3, 4 units of space in equal units of time, because a lever should begin to move slowly, and increase rapidly in velocity until a pick is developed.

In order to construct a picking plate, fix the position of the shaft centre A, Fig. 183, and describe a circle 1 with a radius of 4 inches; this will trace the path of the bowl centre. Drop a vertical line 2, 3, and from 3 divide the circle 1 into sixteen equal parts. Next divide the section 3, 4, which is $\frac{1}{16}$ of a revolution, into four equal parts. Round point 4 describe a bowl circle B, with a radius of $1\frac{5}{8}$ inches; draw the upper line 5 of the picking plate C at right angles to line 2, 3, and touching the periphery of the circle B. Show the thickness of the plate by drawing a second line 1 inch below and parallel with 5. Find the pin centre x by continuing the line 2, 3, downwards to 3′ and producing a line at right angles to it,

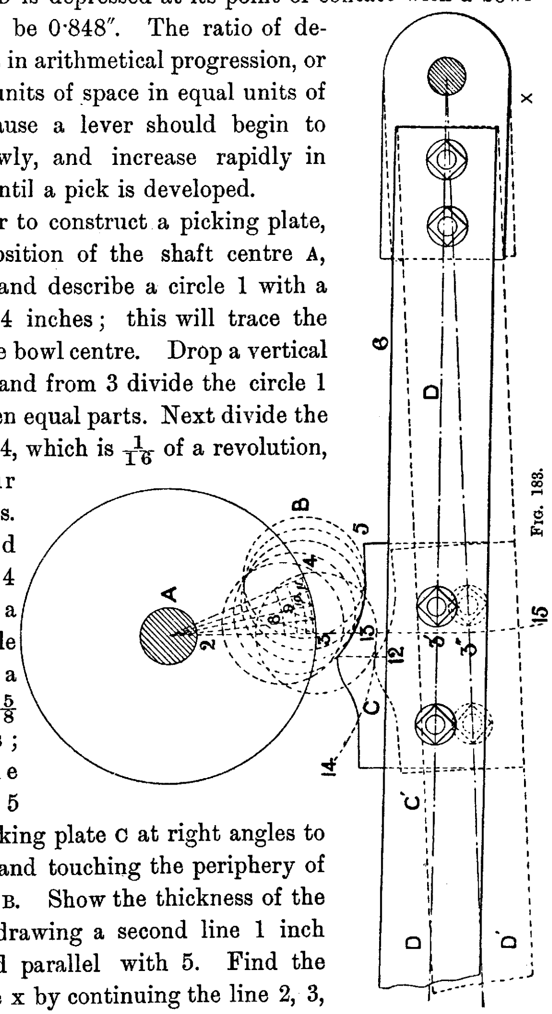

FIG. 183.

at half the depth of D below line 6, $=2\frac{3}{4} \div 2 = 1\frac{3}{8}$ inches, which gives the centre line of D when the lever is horizontal. On the centre line mark off 15 inches to the right, which equals X, and 14 inches to the left will give the point of contact of D with E (Fig. 181). Complete the lever D. With X, 3 as radius, describe arc 8, and from the same centre, through each point between 3, 4 formed by a radial line intersecting the circle 1, describe arcs 9, 10, 11. From point 3 on arc 8 cut 0·848 inch to equal the fall of the lever D, and divide it into ten equal parts; then, with A as centre, describe concentric arcs through divisions 1, 3, 6, 10 to give the requisite ratio of depression. Begin with 4 and take in succession, as the centre of the bowl B, each point where the arcs, concentric with A, cut the arcs 11, 10, 9, 8, and describe corresponding circles. Trace a line touching the periphery of each, and the correct curve for C will be obtained. To define the length of this curve, fix the position of D when fully depressed, namely, 0·848 of an inch below the centre line at 3′. With a radius X, 3′ describe an arc; from 3′ mark upon the arc 0·848 inch at 3″, and draw the lever D′ and the picking plate C′, as shown by dotted lines. Round point 3 in circle 1 describe a circle 13, and with a radius A, 13 describe an arc 14 which shall trace the periphery of the rotating bowl B. The nose of the picking plate C′ will be found where its curve is cut by arc 14. From 3″ measure the distance to the nose C′, and from point 3′, with the same measurement, cut the line 5; this will give the tip of the nose of C. Drop a perpendicular 12 through the nose of C, draw any curve on the opposite side, and make the plate C 6 inches long by taking 3 inches on each side of 12, and the picking plate is complete.

The lever pick is much used as a pick-at-will motion for

silk weaving, because it is clean, simple, easily altered, and capable of throwing shuttles in any desired sequence.

Figs. 184, 185, and 186 give respectively a plan, a front and a back elevation of this device. Two arms are keyed upon each end of the bottom shaft, and each is furnished with a bowl that can be made to strike or miss one of the picking plates C any number of times in succession. The

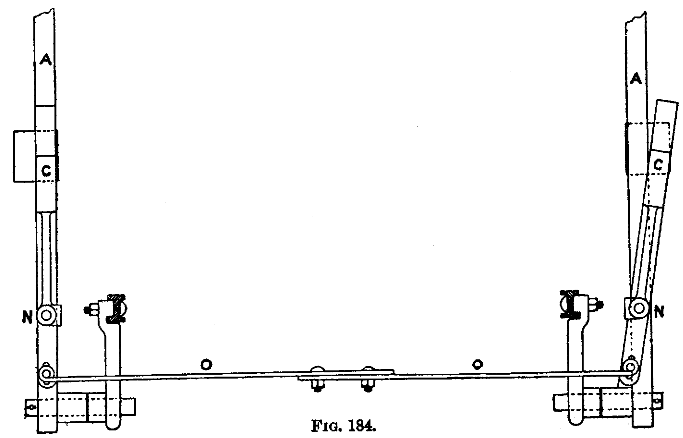

FIG. 184.

plates C are pivoted upon the picking levers A at N, and the rear end of each is so connected to a bar O that one is always parallel with A, while the other is moved out of contact with a bowl.

The mechanism for governing the picking plates C may consist in set-screwing a slide wheel P, Figs. 185, 186, upon the bottom shaft; on one side of P are two semicircular flanges, and midway between the ends of these flanges two studs are fixed to make contact with an eight-sided star wheel Q. The pins in P partially rotate the star wheel Q upon a stud placed inside the framing.

The star wheel is compounded with a barrel whose office is to rotate a chain R, one link for every pick. The chain

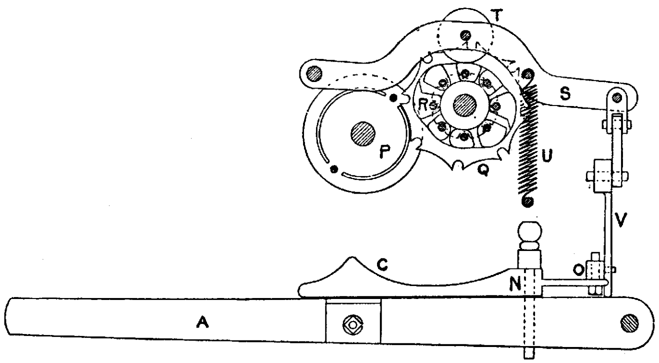

FIG. 185.

is built up of deep and shallow links to suit the required order of picking.

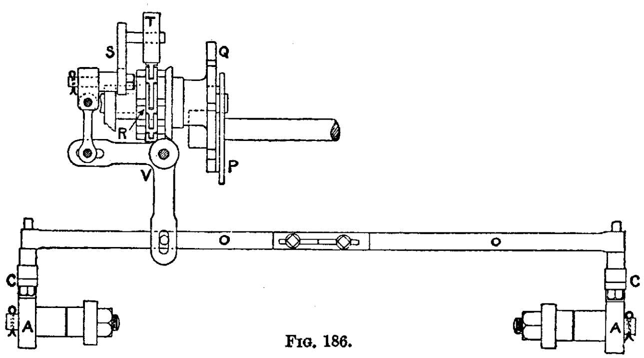

FIG. 186.

A lever S, also centred inside the framing, carries a bowl T, which is pulled upon the chain R by a spiral spring U, but rises or falls as the link beneath it is deep or shallow.

A cranked lever V is fulcrumed upon the back rail, and is connected by a link to the lever S. A stud in the bar O, Figs. 184, 185, 186, takes into a slot in the vertical arm of V and imparts a lateral movement to O whenever V is vibrated by the chain. Every movement of O pushes one picking plate C out of striking position, and pulls the other plate under a bowl.

Instead of controlling the picking plates C by a chain R, they may be actuated from a Jacquard machine as shown in Fig. 187, where the upper drawing is an elevation, and the lower one a plan of the parts:—A split, elliptical cam W is attached to the bottom shaft, and a bracket X is bolted inside the end framework. Upon X a brass slide Y is moved back horizontally every pick by the rotating cam W. Two spiral springs Z are fastened to Y and X, for the purpose of drawing the slide forward immediately it is liberated by the cam. A tongue 1 is hinged at 2 to the upper arm of a lever 3, whose fulcrum is at 4. The lower arm of 3 enters a slot in a cranked lever V, the latter being fixed upon the rear rail with both arms horizontal, and a finger 5, bolted upon the bar O, passes through a slot in the outer arm of V. A cord is passed through an eye formed in the tongue 1, at 6, and led to a spare hook in the Jacquard. A spiral spring 7, attached to the under side of 1 and also to the bracket X, draws the tongue into position for being operated by the slide.

When 1 is lifted the slide Y passes beneath it without producing any change, but when 1 is left down the slide thrusts it back, rocks the levers 3 and V, traverses the bar O laterally, places one picking plate C over a wooden arm A, and moves the other away from a second arm A, as seen in Fig. 179. This plan offers great scope for variety of wefting, because the picking scheme need only repeat with one repeat of the pattern cards. Whereas the former plan is limited by the length of a chain R.

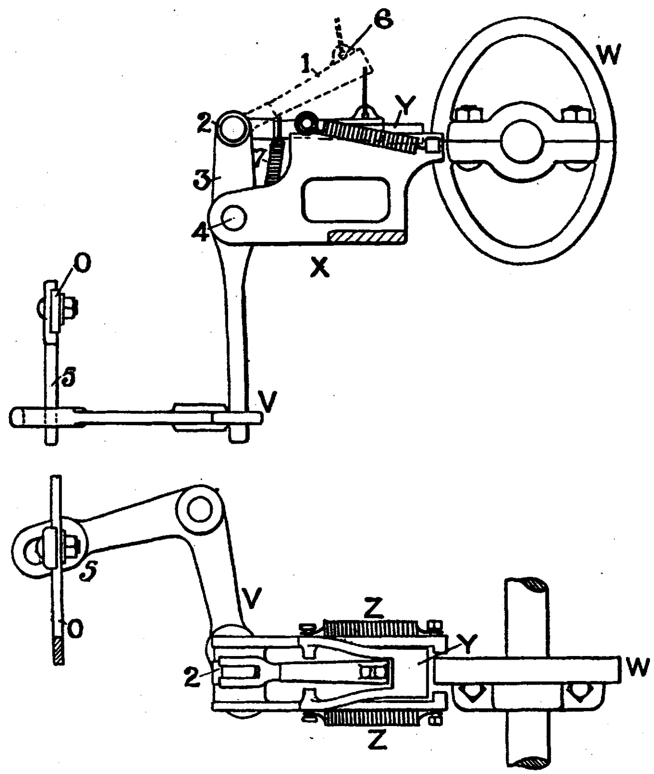

FIG. 187.

Figs. 188, 189 show Jackson's pick in plan and elevation respectively. This mechanism derives its movements from the bottom shaft A by means of an arm B, which has

an antifriction roller C mounted upon its outer end. By the rotation of A, the bowl C makes contact with the under side of an arm D. The arm D is keyed upon a

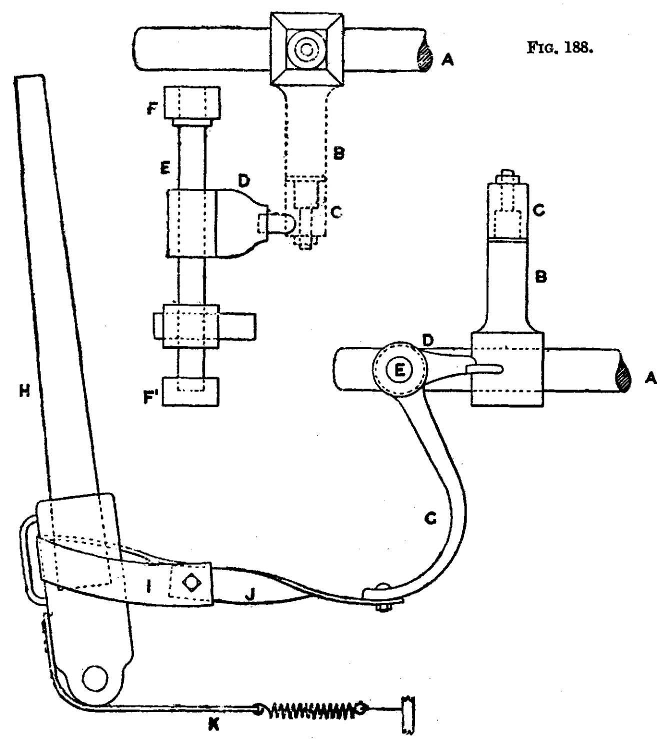

FIG. 188.

FIG. 189.

short shaft E, and E is held in the same horizontal plane as the shaft A by brackets F, F'. The shaft E forms a fulcrum for the lever D, G; the long arm G is curved and connected with the picking arm H by bending a strap I round the shoe of H, and bolting a second strap J to both I and G.

As the bowl C pushes up the arm D, the shaft E partly revolves; in so doing the arm G tightens the straps J, I, pulls the picking arm H inward, and drives a shuttle through the warp. A spring and strap K are employed to draw back the arm after each movement. It will be observed that if a loom furnished with this pick be run in the opposite direction, contact between C, D will slacken the straps I, J, and a shuttle will remain undisturbed.

Jackson's pick is used on pick-at-will looms, but a double striker B is provided at each side instead of a single one; and a lateral motion is given to the short shafts E by box tappets and lever connections. Lateral motion in E takes the arms D out of reach of the strikers B, C, and when moved the shafts may retain their positions for any number of picks.

Both flat and coiled springs have been connected by their forward ends to picking arms. Flat springs were alternately lifted, and coiled springs alternately compressed, by cams, then suddenly liberated at the proper moment to pick. Although these contrivances are not extensively used, they develop power gradually, and maintain a fixed energy in the picker for all speeds of a loom.

Picking from the Crank Shaft

In order to utilise the superior energy stored in a crank shaft instead of the inferior energy stored in a bottom shaft, Smith Brothers in 1834 introduced the principle of picking from a crank shaft. But a pick delivered from a crank shaft is comparatively harsh, owing to the short time during which a striker acts upon a receiver and to the difficulty of correctly shaping either a striker or a receiver.

If, while a picker is lightly pressed against a box end, one of these looms is slowly moved, it will be found that in some cases a picker is only moved by a striker about $\frac{1}{3}$ the length of a shuttle box. Whereas a similar experiment made with a cone pick will show that a picker is moved by the striker fully $\frac{2}{3}$ the length of a shuttle box.

One application of this principle was patented by Mark Smith in 1855. It is known as the "carpet pick," and Figs. 190, 191 illustrate it in front and side elevations. A is a portion of a crank shaft, B a fly-wheel, and C a striker bolted upon B. An inclined shaft E is placed outside the end framing; it is supported in a footstep F and by an upper bearing G. The shaft E carries a short arm D, a collar H, and a curved arm I; the latter is connected to the picking arm K by passing a strap J round a shoe in the usual manner.

An axial movement is given to the shaft E by a box tappet L, which is keyed upon the bottom shaft. A bowl O, mounted upon a stud in a lever M, works in the tappet groove, and as the tappet rotates, the lever M oscillates on a pin N. A fork formed on M at the opposite extremity to N impinges against the collar H, and either lifts E or leaves it in its normal position. If the former, the arm D is higher than the striker C, and the picking arm K remains inoperative; if the latter, D and C are brought together, and a pick is delivered. By altering the form of the tappet L and rotating it at a suitable speed, two or more shuttles may be driven from one side of a loom in succession. This is also the case in the two following modifications.

Alterations in the method of moving a picking arm D have formed the subject of several patents. Two only of these will be described. The first was patented by

A. Lees and J. Clegg in 1857. Instead of lifting the shaft E axially, these inventors hinge the arm D to E, as in Figs. 192, 193, and provide a cap-bearing G which only permits of rotary movement in E. The latch D rests upon a lever P, and a cam L acts through P to operate D. In order to miss a pick, the full side of L lifts D above the striker C. At other times D faces C.

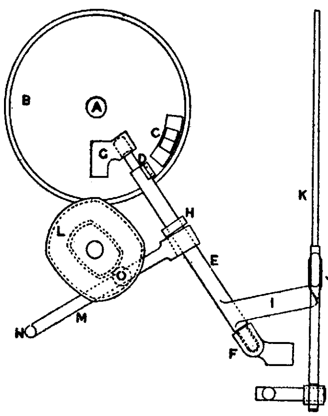

Fig. 190.

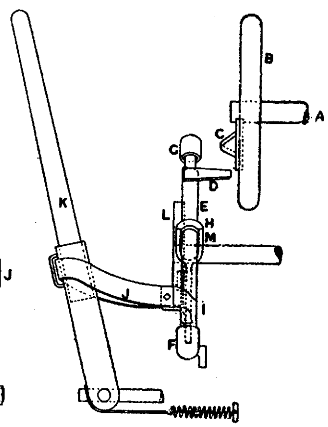

Fig. 191.

In 1883 W. Yates invented an upper bearing G, Figs. 194, 195, having an inclined plane, formed by placing two flanges obliquely to the framing. The top of the shaft E is free to move in the groove of G, and the shaft rests against the face of a cam L. This cam is set-screwed upon a light shaft and is driven by wheel gearing from the crank shaft: as L revolves, E is pushed up, and out, until the arm D is beyond the reach of the striker C.

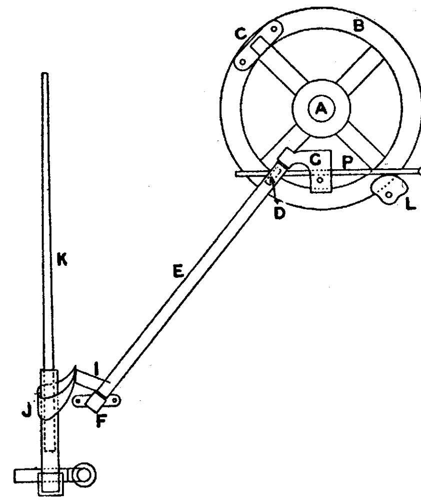

Fig. 192.

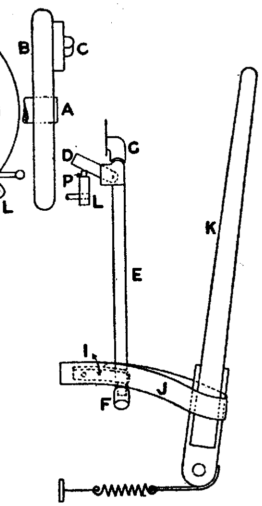

Fig. 193.

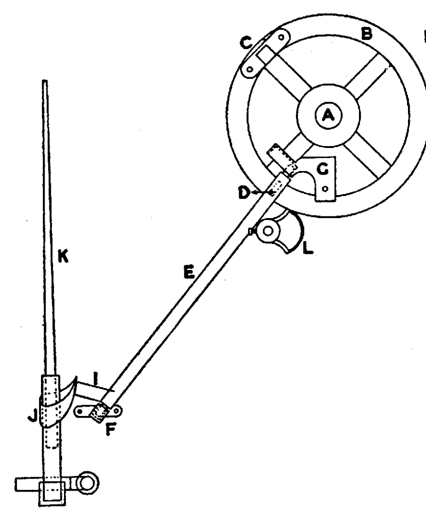

Fig. 194.

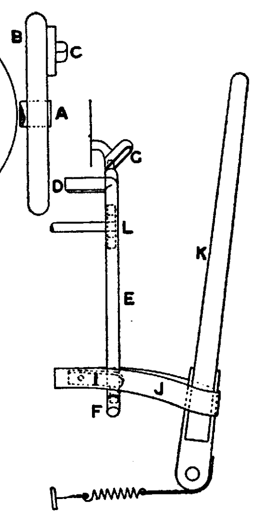

Fig. 195.