Each heald shaft requires one front crank lever D, one rocking bar C, two hooks A and B, one needle H, two levers I and I′, and either a peg or a hole in one lag for each lever. The machine is placed over one end of a loom so that the point F of the lever D shall be in the centre of the reed space. In this dobby a slight lateral movement accompanies each vertical movement of a heald shaft, but the machine has been modified to give a true vertical lift.

An open shed is formed, for when the knife K is at the outer end of its slot, with a hook A drawn forward, the knife L is at the inner end of the other slot, with a hook B in position for drawing. Since the inward movement of K corresponds with the outward movement of L, it follows that the centre D′, and therefore the heald shaft, will remain stationary, except in so far as changing the direction of inclination in C, and the excess of movement in K, L over that in A, B will alter it. Time and freedom for the hooks to rise and fall is provided by causing a draw knife K, or L, to move inward for a short distance after the hooks A, or B, have become stationary. But this movement combined with the swing of the balk C seldom causes a heald shaft to sink more than $\frac{1}{4}''$ to $\frac{3}{8}''$. In some machines the healds are kept stationary by removing the draw knives K, L from the three-armed lever M, and mounting them upon an extra balk, in which there are curved slots for two bowls upon the lever M to work in. The slots permit one draw-bar to remain stationary while the other moves to release its hooks and receive fresh ones.

Messrs. Butterworth and Dickinson added parts which were intended to shield pegs, similar to No. 1, Fig. 62, from injury. They caused the levers I, I′ to be lifted away from the pegs before and during rotary movement in the barrel S. But on the completion of such movement the

levers assumed their normal positions. This plan was not generally adopted on account of each peg receiving a blow when contact with the levers was restored.

W. Williamson dispensed with the levers I, I′ and the needles H, and made two sets of single pick lags, with pegs similar to Nos. 2, 3, 4, Fig. 62, to act directly upon the hooks. One set was pegged for odd picks, the other for even picks of the pattern, and each operated its own set of hooks. Both barrels were also positively driven.

In a Hattersley dobby cards may serve instead of lags as the selecting medium. When this occurs the heavy-ended levers I, I′ are replaced by two vertical rows of wire needles, which protrude about $\frac{1}{2}''$ below a needle plate and are furnished with disc-shaped heads for the hooks to rest upon. The needles in one row are approximately $3\frac{1}{2}''$ long, and they are kept vertical by passing them through holes in two plates; their discs rest upon the upper plate, and the lower hooks rest upon the discs. The needles in the other row approximate to $13''$ in length and pass through holes in three plates, but are set midway between those in the first line, and upon the discs of these needles the top hooks rest. An octagonal card barrel occupies a similar position to, and takes the place of, the lag barrel S. Its office is to carry a chain of cards into contact with the lower ends of the needles. This barrel is mounted in two levers, which are rocked upon their centres by a connecting rod and an eccentric fixed upon the crank shaft of the loom. Each upward oscillation will cause a card to impinge upon the needles and lift those that face solid parts of the card. Rotary movement is given on alternate picks by a pawl and ratchet operated from the knife lever M. Unlike a lag dobby, the hooks are normally on the knives K, L, and the cards and needles must lift those out of contact that are not to be drawn; hence the barrel, although turned once for two picks, is pressed against the needles for every pick.

Provision is made in some of these dobbies for levelling all healds before repairing broken warp. This is done by fixing a swivelling bar beneath the hooks in the top row and fitting an arm upon it which carries a pendent handle. By pulling down this handle the bar lifts all hooks out of contact with the top knife, then, on the next outward movement of that knife, no hooks will be drawn.

Messrs. Hattersley recognised that when the draw knives K, L move in parallel slots the rear end of each hook falls into a lower plane and its head is liable to be thrown up far enough to permit it to slip from a knife In order to remedy this they now make the slots to converge, so that as the knives move outward a hook-head from the top row will be drawn downward, and one from the bottom row upward, as in Fig. 75.

Cross-Border Dobbies

With a dobby of the Hattersley type difficulty was experienced in weaving cross-bordered fabrics, such as handkerchiefs and towels, on account of the lag space being limited. Many attempts were, however, made to weave such articles, as, for example, by pegging one pattern on alternate lags and another pattern on intervening lags, then giving the barrel a movement of two lags instead of one, until a change became necessary. The barrel was then moved a single lag to bring the second pattern into operation. As a rule the weaver was called upon to effect this change. But measuring chains, provided at suitable intervals with deep links, have been driven from the taking-up roller. Each

deep link dislocated the driving gear and stopped the loom in time for a change of pattern, when the weaver turned the lag barrel one tooth. Similar measuring motions have also been made to effect such changes automatically, but most of them lacked precision, and defects in the pattern were frequent at the changes.

In the year 1885 Ward Brothers, and at later dates other machinists, added parts which change from pattern to pattern with ease and certainty. Fig. 69 shows the method adopted by Messrs. Lupton and Place. It consists in the use of two lag barrels S, S′, one to carry the border lags, the other those for the body. Both barrels are mounted in a pair of arms 1, which are set-screwed upon a rocking shaft 2. A third arm 3 is also fixed upon this shaft, and terminates in a stud for the support of a casting 4 with a horn at each end. 4 is loosely mounted, and as the lever M rocks, a stud 5, fitted upon M, may make contact with either horn of 4, and cause the barrel shaft 2 and the barrels S, S′ to rock simultaneously. Whenever one barrel is moved away from the levers I, I′, the other barrel is taken into contact with an additional set I″, I‴. The precise means adopted to rock the barrels S, S′ largely determines the value of a device of this kind. Here a short barrel 6 is mounted upon a shaft 7; it is behind the rear frame-work, and beneath the lower line of hooks B. Each lag on 6 is provided with, or left without, a single peg. A lever 8, fulcrumed at 9, rests upon the lags, and its outer end is slotted to receive a stud in the double horn 4. When 8 is lifted by a peg, the outside pattern barrel S′ engages with the levers I″, I‴. When 8 is undisturbed, the inside pattern barrel S is in action.

The barrel 6 moves once only for each revolution of either the border or body lags, for a peg in each lattice as S, S′ puts in action the otherwise idle back balk C; at such times C impinges upon a stud in a lever 10, which is fulcrumed at the top and carries a pawl 12 at the base to drive a ratchet upon the barrel 6. The lever 10 is normally held back by a spiral spring 11. If the last lag brought into position by 6 is similar to the preceding one no change is effected in the barrels S, S′, but if one is pegged and the other is without a peg a change will occur in S, S′. Each set of pattern lags can therefore rotate any number of times without a change of weave, and there is no necessity for a border repeat to equal, or be a measure of a centre repeat.

The levers I, I′ are united to a corresponding set I″, I‴, either by forking the light ends of one set and pushing those of the other set between the prongs, as at 13; or the ends of one set may simply overlap those of the other set. Both plans will cause a peg in a lag on S or S′ to engage a hook A or B with a knife K or L. Two pawls, R, R′, are mounted upon a stud in the knife lever M, and each may drive its own barrel whenever rotary movement is necessary. But one barrel turns inward, the other outward, and one set of lags must be pegged as at B, the other as at C, Fig. 63. The centre of the working barrel is always higher than the centre of the shaft 2, and two flat locking springs 14, Fig. 69, bear upon the cam-shaped terminals of the outer arms 1. In lieu of the foregoing, a cam may be mounted upon a separate shaft to rock the barrels positively in either direction, in which event the cam locks as well as rocks. Both devices prevent a driving pawl R or R′ from vibrating the working barrel.

Curved brackets, fitted to the front framework, limit the upward movement of a barrel. There is the usual

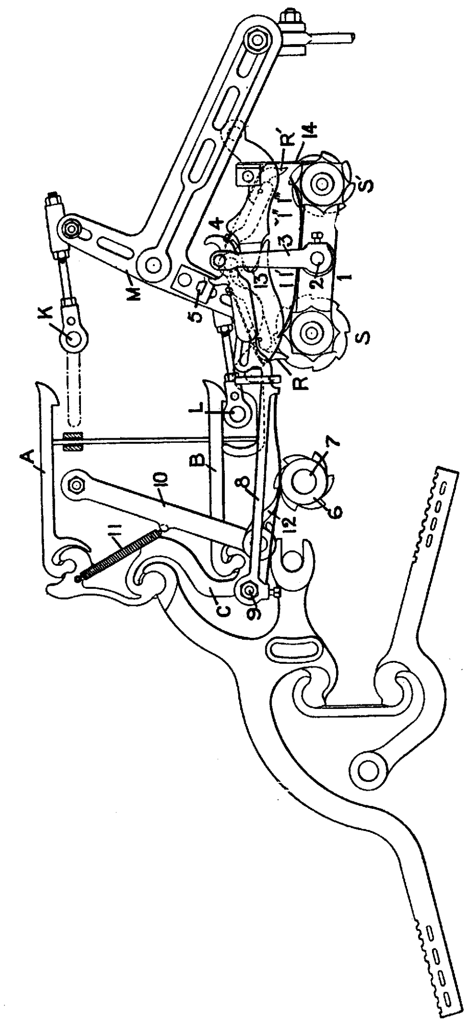

Fig. 69.

hand adjusting wheel on the forward end of each barrel shaft S, S′, and also one on shaft 7, to facilitate pick-finding.

In a recent type of cross-border dobby, Fig. 70, introduced by Messrs. Ward Brothers, the rocking shaft is dispensed with and the lattice barrels work in fixed bearings. In its usual form two pattern barrels S and S′ are used, but for some special designs of cloth, where the use of two pattern barrels only would necessitate long chains of lattices, the three-barrel motion illustrated has been introduced.

Whereas in other motions a chain of lattices has been blanked or rendered inoperative by swinging the lattice barrel away from its feelers, or by lifting the feelers away from the lattices, in this motion the result is obtained by stopping a lattice barrel with the space between two lattices directly opposite the feelers, as at S′ and S″. Each barrel is provided with two ratchet wheels R, R′, and each wheel is provided with a driving pawl P or P′, the pawls for the two ratchets of each barrel being on the same stud. A set of three-holed measuring lattices M acting on three levers L, L′, L″ determines which of the three pattern barrels S, S′, or S″ is operative. A blank under any lever, say L, lowers the corresponding outer pawl P into contact with the outer and smaller ratchet wheel R on the pattern barrel S, and that barrel is driven by the small ratchet wheel, the back pawl P′ being inoperative as it is raced by its large ratchet wheel. The two barrels S′ and S″ are meantime inoperative, their outer driving pawls P being lifted out of contact with the small ratchet wheels by pegs in the measuring lattice M acting on the levers L′, L″. These two barrels are pushed forward by their inner pawls P′ and large ratchet wheels R′ till the space between two lattices is opposite the feelers and they remain in that position until a change is required, as determined by the measuring

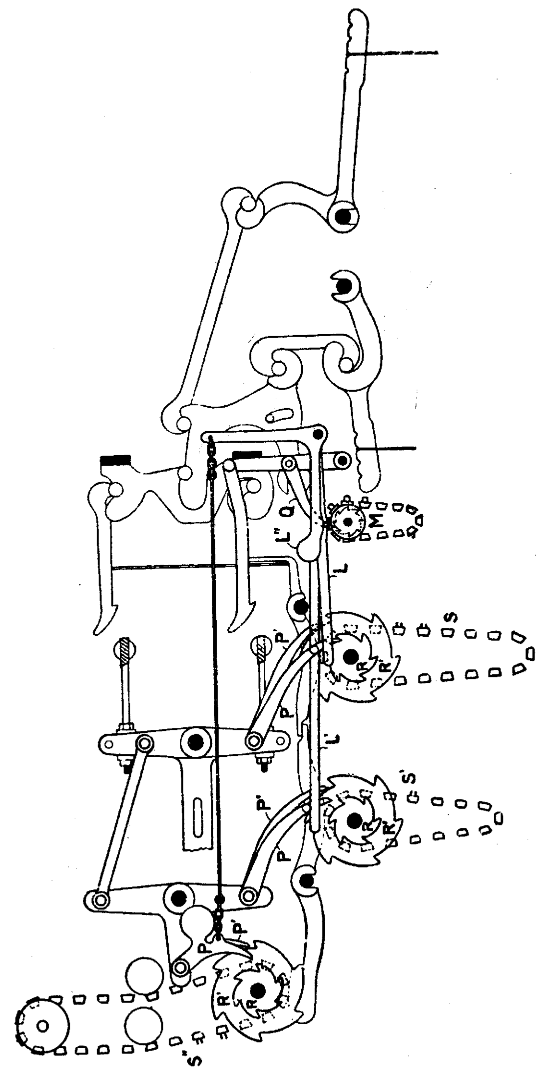

Fig. 70.

lattice M. M is driven by a ratchet and pawl Q from a rocking lever controlled by the first bottom hook of the dobby. M is moved forward one lattice at the end of the repeat of a pattern, but whether a change of pattern takes place or not depends on whether the lattice brought under the levers L, L′, L″ differs from its predecessor or not. To change, for example, from pattern barrel S to S′, a peg under lever L would lift the outer pawl P of barrel S out of action. S would then be pushed over to its inoperative position by its pawl P′ acting on the large ratchet wheel; the pawl P′ then rides idly on the same tooth of the large ratchet wheel so long as S remains inoperative.

Simultaneously with the above action a blank under lever L lowers the outer pawl P of barrel S′ into contact with the smaller ratchet; P completes its stroke and places the first lattice of pattern S′ into work. A peg under lever L″ keeps S″ still inoperative.

In this way any number of repeats can be made from any pattern, and a change can easily be made from any one to any other. All pattern barrels rotate in the same direction, and thus there is only one hand for pegging purposes. A special form of star wheel, having six large and six small slides arranged alternately, so that the barrels are held steadily in either the usual or the inoperative position, is fitted to each pattern barrel. Fig. 70 also illustrates Messrs. Ward Brothers' latest improvements in double jack dobbies, the teeth in the jacks being dispensed with and each jack lifted by its own link.

The Burnley Dobby

During the years 1888 to 1893 Messrs. Lupton and Place developed a dobby of original design and action.

The framework is triangular in shape, and supports at its apex a shaft A, Fig. 71. This shaft carries two levers B, and also two fulcrum pins C, D for a series of cast-iron arms E, F.

The working parts are actuated by a crank and connecting rod from the bottom shaft of the loom. The pendent arms E, F are vibrated alternately and give motion to the heald shafts through jack levers G. These levers are fulcrumed at H, and bent almost at right angles to place their notched ends J in line with E, F, while their outer ends are united by links L to the heald leavers I.

Two pendent arms E, F serve, instead of draw hooks, to lift one shaft. This occurs whenever the lower end of E or F is pushed by a peg O over one of the notches J. On the next oscillation of the levers B, the bent end of a jack lever is forced down by either E or F, and the levers I, I in rising carry a shaft up with them.

To protect the pegs from injury a flat spring K is fixed upon a stationary bar T, T, to face each arm, E, F, and the lower end of each spring is passed through a slotted slide U, which also governs a pendant. Immediately an unpegged portion of a lag faces a spring, the latter moves out with its slide and draws a pendant out of contact with the notched end of J. But when a peg O faces a spring, that spring gives way, and, at the proper moment, carries back its slide and pendant until the latter is over a notch in J.

A lattice is made in two parts; odd picks from the design form one chain, and even picks the other. The chains are passed round separate octagonal barrels M, N, and an intermittent rotary motion is imparted to them by a pushing catch P, centred upon an arm Q, on the top shaft A. Consequently P, Q partake of the rocking of A, and as P acts upon a ratchet wheel on the shaft of N, the barrels

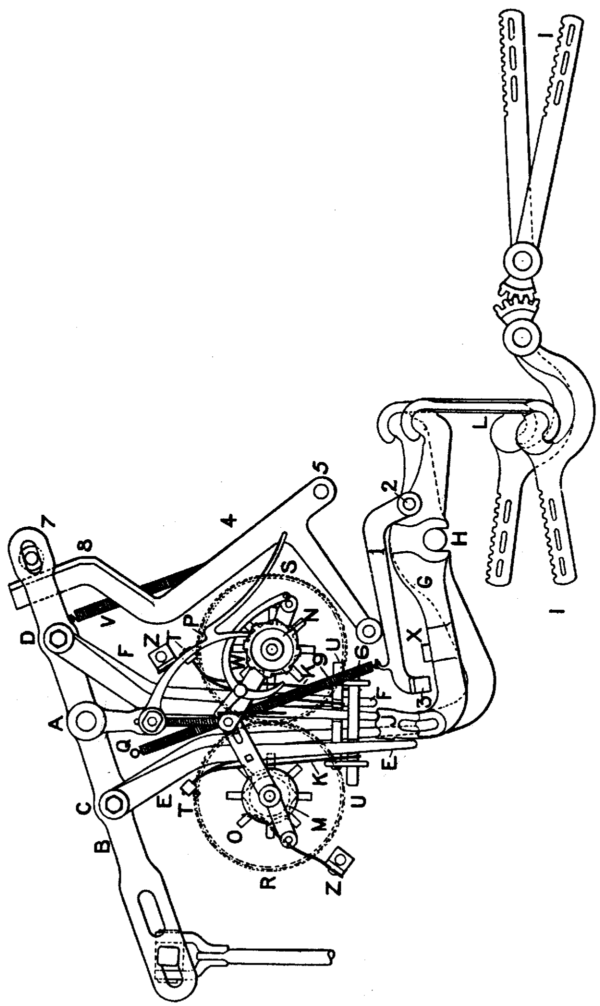

Fig. 71.

are turned for alternate picks. Both lag barrels M, N are connected by spur wheels R, S, hence both are moved simultaneously.

A reversing motion is applied to the dobby to assist a weaver to find the proper starting-place after unweaving, or after the weft has broken. A lever W has for its fulcrum the shaft of barrel N, and mounted upon W is a pawl that may engage the inside of an inverted ratchet wheel on the shaft of N. By drawing down a cord attached to W, the pawl P is lifted, and the lever W reverses both barrels, while the loom is stationary.

A cross-bar X limits the upward movement of the jack levers G; it can be fixed nearer to, or farther from, the fulcra of G, and so regulate the depth of shed, but when parallel to H the lift of all the shafts is equal. An unequal lift will be obtained by fixing the forward end of X farther from H than its rear end, for the front notches J will thereby be pushed farther down, and the pendants E, F will move through a greater space before disturbing the front healds. A stout spiral spring V is attached to the inner end of B, to balance the lifting tackle, and two flat springs Z bear upon star wheels to steady the barrels M, N.

The chief merits of the machine are that the parts are easily detachable, and cast iron is applied to resist a compressing force, instead of, as in most dobbies, a tensile force.

Positive Closed Shed Dobby

For heavy work a positive shedding motion is the best type to use, provided other parts of a loom are equally positive in action; but there are many looms which limit the usefulness of such a dobby. For instance, if used with a cone-pick, multiple shuttle-box loom, the advantage of being able to work the loom and dobby backwards together is neutralised by the picking motion ejecting the shuttles from the boxes, and probably also by the box-indicating mechanism continuing to turn forward. Such defects are, however, due to the picking and box motions rather than to the dobby.

In one make of positive dobby a spur wheel A, Fig. 72, is secured upon the bottom loom-shaft to gear with a wheel B, which is compounded with a bevel C. Both B and C turn loosely upon a stud D, fixed in a cross rail. The bevel C engages a similar wheel at the foot of an upright shaft E, and a third wheel F, near the top of E, drives a bevel G, on the dobby shaft. This shaft carries two pairs of eccentrics H; each pair is coupled to place the large side of one at the top when the large side of the other is at the bottom. Two rods, I, I, pass from two eccentrics to the griffe J, and corresponding rods from the remaining pair of eccentrics are connected to the bottom bar K. Hence, as the eccentrics turn, J and K move in opposite directions.

In section the hooks L are $\frac{7}{8}''$ by $\frac{1}{4}''$. They are formed with a catch at the top, and rest upon the bar K in two lines, with the catches facing each other, so that the front line when vertical will miss a blade in the griffe J, while the back line will be over a second blade of J. When in action the front row pull the heald shafts down, and the back row lift them. This is done as follows: From every hook in the front row a rod M passes down to a lever N, which is centred in the middle and has a cord tied to its opposite end, and also to a bottom heald shaft 6. From every hook in the back row a rod O is taken to a lever P, and P is connected by toothed segments at T to a second lever Q. These levers are respectively fulcrumed at R, S.

Cords 3, 4 unite P, Q with a top shaft 5. A lever N reverses the motion of a hook L, and sinks a shaft, but the levers P, Q act in unison with a hook and provide a straight lift.

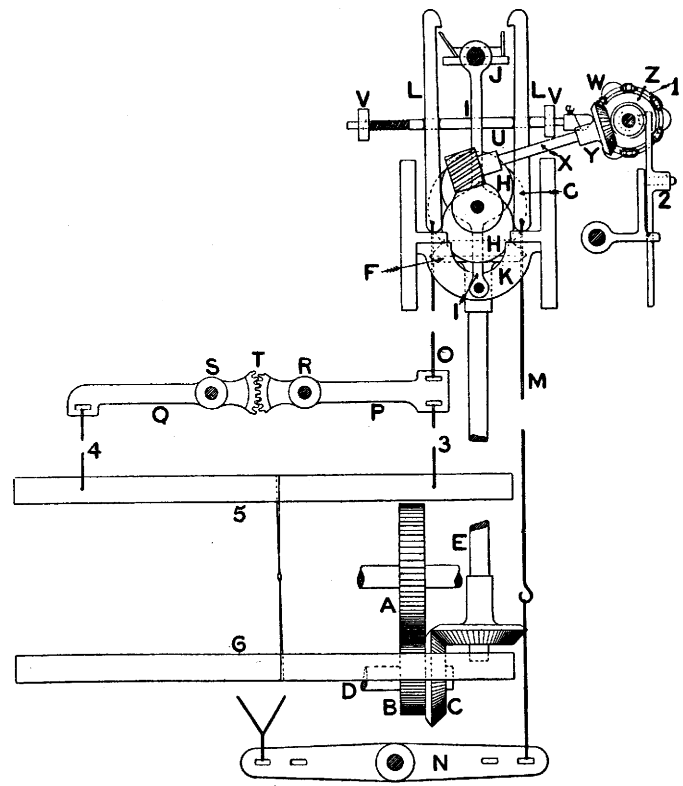

FIG. 72.

Inside the machine framing the needles U are almost square in section, but they are rounded at each end to work in the holes of two needle plates V. Each needle is slotted at two places to receive two hooks L, and each has a semicircular sheath for the lags W to operate. The latter are made of iron, and the pegs are rounded on the top and so disposed that consecutive needles are moved by alternate pegs for any length of time, but the disused set can instantly become active by pushing them endwise into range with the needles, and, by so doing, a new pattern is obtained. A chain of bowls and collars, similar to those of an oscillating tappet, may be substituted for metal lags.

A continuous rotary motion is given to the lag barrel 1, by driving an inclined shaft X from the dobby shaft by a double worm and a worm wheel; a bevel Y on X also engages with a bevel Z on the shaft of 1. A fast boss on the barrel shaft has a ring groove cut in it, and the wheel Z is loosely fitted in a keyway on the shaft of 1, to permit of a lateral movement in both the lags W and the barrel 1, so that the idle set of pegs shall slide opposite the needles U whenever the position of lever 2 is altered.

The Knowles Positive Open Shed Dobby

The Knowles dobby, as made by Messrs. Hutchinson and Hollingworth, is original in construction and positive in action; it forms an open shed, gives a straight lift to the shafts, and governs the shedding, the picking, the shuttle boxes, and the taking-up motions; it also contains a levelling apparatus for placing all the healds in one line before drawing-in broken threads; and the dobby, and all it controls, can be worked backwards manually by turning a wheel.

Movement is derived from one end of the crank shaft by gearing a pinion A, Fig. 73, with a stud wheel B. The wheel B is compounded with a bevel C to drive a similar wheel D, situated at the base of an upright shaft E. The

wheel D, together with the parts G′, F, form a clutch for detaching the driving when movement in the dobby is to be reversed. By operating a lever the top piece F will rise to open or sink to close the clutch. Of the three parts, F and D are loose upon E, but G′ is a hoop which is placed close to D, and fastened to the shaft E. A hole is drilled through G′ and into the upper part of D, to receive a stud from the underside of the movable piece F. This stud is long enough to pass through the hoop G′ and enter D when the clutch is closed, but when the clutch is open the stud is withdrawn from D and the dobby stops. An arrangement by which contact between F and D can only be made when the slay occupies one position is essential, or the sheds would open and close at the wrong time. Instead of a manually controlled clutch, a cup, formed in the top of D, may have a cam groove of gradually increasing depth, cut to receive a freely fitting pin that passes through G′. When the loom is started this pin travels in the groove until the deepest end is reached, when shaft E begins to rotate. At the same instant the weighted end of a catch swings outward and the catch, by entering a notch in G′, locks the pin in position. So soon as the loom stops, the catch automatically falls out of the notch and the dobby is free to be turned backward.

Two bevel wheels H, I are fitted upon the shaft E and drive similar wheels J, K that are fast upon the lower and upper segment cylinders L, M. The wheel H drives from the top of J, and I from the bottom of K, thus causing one to revolve in an opposite direction to the other. The cylinders L, M take the place of griffe bars in ordinary dobbies, and lift and sink the shafts by means of a series of teeth that extend about half-way round each. Their teeth act upon the gears G, the vibrating levers N, and the connecting bars R, Fig. 74. These three parts are fastened together to form one piece. A vibrating lever N is made

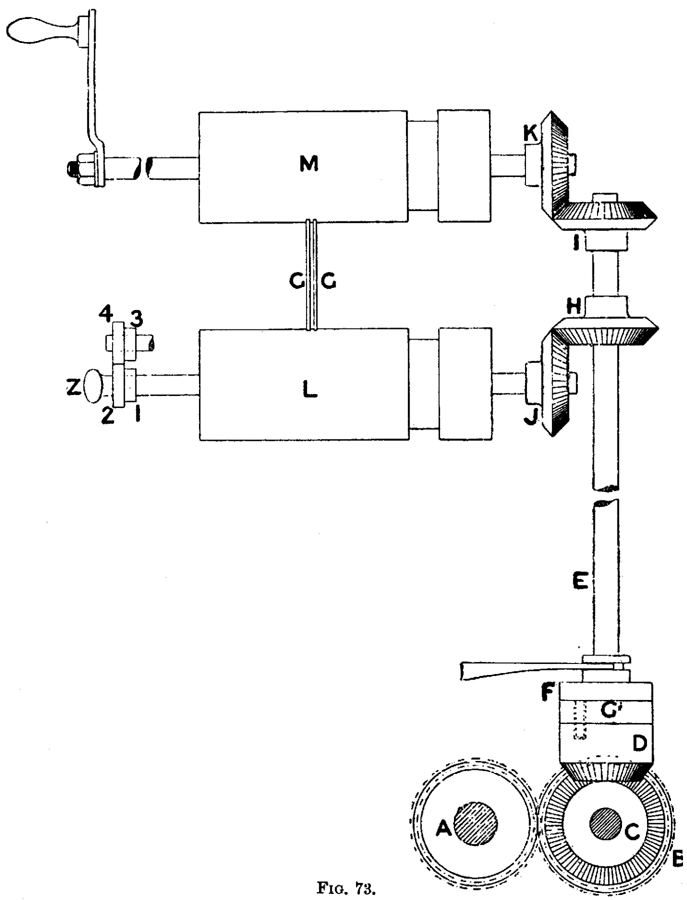

Fig. 73.

from two thin metal plates which are riveted together at different points, and kept apart at others by strips of metal

to form a fork. N is centred at O, and rests at P upon a pattern chain which is built up by threading rollers and bushes upon spindles as for an oscillating tappet. Each roller will lift, and each bush will allow a lever N to fall, therefore a vibrating lever equals a needle in other dobbies.

A gear G does duty for a hook; it is a toothed wheel $\frac{1}{8}''$ thick by $5\frac{1}{4}''$ in diameter, from which a tooth is removed at one point, and three or four teeth are removed exactly opposite the first gap. This wheel is passed between the plates of N, where it is supported by, and turns freely upon, a pin. The movement of a gear G is limited by a steadying pin in N entering a semicircular slot in G.

A connecting bar R conveys motion from a gear to a harness jack S. Two metal plates are also used in the construction of R; they are connected in the middle by rivets, but are separated to form forks at each end. A gear G is placed inside one fork, and the rivet which unites G, R serves as a crank pin, for G will be moved from one dead centre to another, and in so doing will cause R to rock. The opposite end of R is notched and hooked upon a nipple in the cranked harness jack S. From the arm U, rod and strap connections pass over guide pulleys to a top heald shaft, and from the arm V, similar connections pass under guide pulleys to a bottom shaft; hence, as a jack S oscillates on its centre T, each forward movement of the arm U will lift, and each upward movement of V will sink a shaft.

A vibrating lever N, a gear G, a connector R, and a harness jack S, together with bowls, bushes, and connections, are required for each heald shaft, and these parts are so placed that fifteen gears occupy a horizontal space of 8 inches.

The levelling apparatus consists of a flat bar X, which is furnished with a handle at one end. X is placed at right angles to and immediately below the vibrator levers N, and it has two diagonal slots for the reception of fixed studs. By pulling the bar forward it slides, upon the studs, up two inclined planes and lifts all the levers N, to clear the gears G, from the cylinder L; then at the next revolution M will engage all gears that have the small gap uppermost, and cause them to make half a revolution. Once the large gaps are at the top, all the heald shafts will be lifted, and they will remain up until the bar X is restored to its normal position. The chain barrel Y is driven by a train of five wheels, and can be stopped, moved forward, or backward at pleasure by operating a clutch Z, Fig. 73. Thus, if Z be half opened, the wheels 1 and 2 are loosened upon L, and the barrel Y becomes stationary. If Z is closed, the wheel 1 drives the wheel 5, Fig. 74, direct, and turns the barrel forward; but when Z is fully open, the wheel 1 is released from, and 2 is fastened upon, the shaft of L. The stud wheels 4, 3, being compounded, will be driven by 2, and since 1 and 3 both engage with the wheel 5, it follows that 2 will drive 4, and 3 will drive 5 in the opposite direction to that when 1 is the driver.

Instead of the clutch described above, the cylinder M may be loose upon its shaft and that shaft be lengthened to receive a spur wheel at the front, and a loosely mounted bevel, similar to K, at the back. Both bevels gear with I on the upright shaft E, Fig. 73. The bevel K is fixed upon the boss of M and drives continually in one direction. Between these bevels a hoop, provided with a ring groove for a lever to fit in, and a projection at either end to serve as a clutch, may slide in a keyway cut in the shaft of M. Each bevel has a recess formed in its boss for the reception of a projection on the hoop. When this hoop engages the bevel K the chain barrel Y turns in its normal direction. But when the boss engages the loose bevel, the shaft of M

rotates in one direction, while the barrel continues to turn normally; the taking-up motion is also reversed with the chain barrel.

The driving gear found between the cylinder M and the

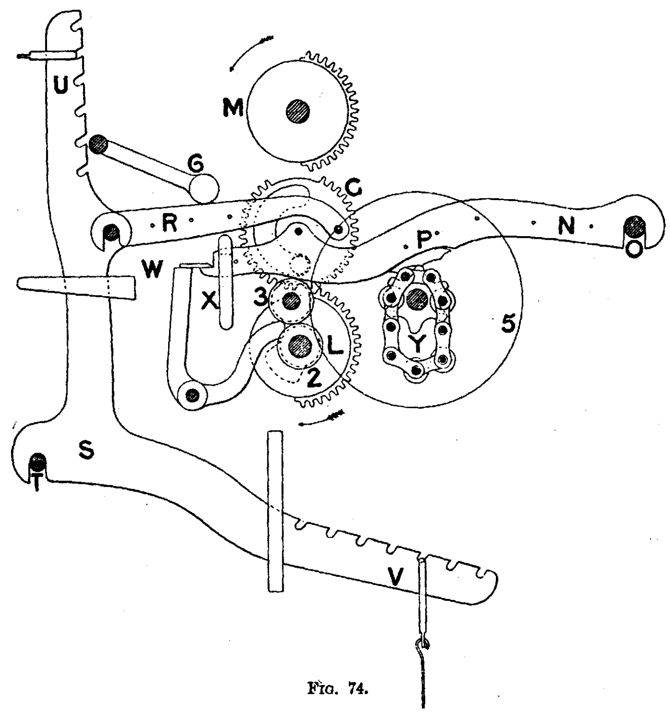

FIG. 74.

chain barrel Y may also differ from that previously described. Thus, a wheel on the shaft of M drives the largest of a pair of compounded wheels, and the smallest drives the barrel wheel 5. But the wheel 5 is now a star wheel with six notches, and between the notches it is furnished with ordinary teeth. The largest compounded wheel carries a stud which engages the notches in 5 in order to accelerate the removal from, and replacement of bowls and bushes beneath, the vibrating levers N. The smallest compounded wheel has three teeth removed facing the stud in the other wheel, so that when the stud drives the wheel will be inoperative, and when the stud is inoperative the wheel will drive.

While the gears are turning, all the vibrating levers N are locked in position by mounting a knife W on arms that project from a shaft which is rocked by a cam secured to the bottom cylinder shaft. This cam is shown in dotted lines to be behind the wheel 2; it thrusts the knife between the lifted and depressed ends of all levers N immediately before the gears begin to move, and a weight 6 rests upon the lifted vibrators to assist in steading their movement. Instead of a single weight 6, each vibrator may be steadied independently by the action of a bar and spring.

A bowl acts through a vibrator-lever N to lift a gear G into contact with the teeth of the top cylinder M; then, provided the small gap of G is uppermost, G makes half a revolution and lifts a shaft, but if the large gap is on the top, there is sufficient room for M to pass without touching G. As a consequence, a shaft can remain up for two or more picks in succession. A bush permits a gear to drop into contact with the bottom cylinder L, and if the small gap of G is at the bottom, G will be turned half-way round, but in an opposite direction, and a shaft will sink; if the large gap is below, G will remain stationary.

When a heald shaft is in a state of rest, the crank pin used for riveting the gear and connecting lever together is in the same horizontal plane as the centre of the gear; hence movement is from one dead centre to another, and a

shaft begins to rise or fall slowly, but increases in velocity to the centre, and from that point to the end of its movement a decrease takes place proportionate to the increase.

When hairy yarn is used it is sometimes necessary to move one portion of the warp slightly in advance of another. This may be accomplished by causing the teeth on the cylinders L, M to diverge slightly from each axis. Or, one shed may close before another opens if one cylinder bevel, J, K, is set a few teeth in advance of the other.

The Hattersley Positive Dobby

Messrs. Hattersley have made their dobby positive in action by attaching to a balk C, Fig. 75, a cranked heald lever D, D′, and by using over and under connections essentially similar to those of the Knowles dobby. Each lag S′ is furnished with metal pegs, but only serves for a single pick; this necessitates important modifications in both needles and hooks. The needles H are oblong in section, and have a lip H′ formed upon them to support a hook B in the bottom line, but a corresponding hook A in the top line is supported by the same needle in the usual manner. A peg in a lag S′ will, therefore, lower two hooks simultaneously, and the next knife K, or L, to move outward will take one of them. Each hook is provided with a lower and an upper catch; the former is actuated by the knives, but the upper catches of lifted hooks impinge against a fixed stop bar O′, P′: the catches and bar then prevent such hooks from moving forward. A second pair of knives, K′, L′, move out and in with K, L; at every inward movement they push back the tilted balks C against the stops O, P, for, unlike a negative dobby, there are no springs upon the healds to effect this movement. The four knives travel in converging slots W, W′, and the three-armed lever M, Fig. 76, is placed near the inner end framing, hence the hooks are pushed, not drawn out.

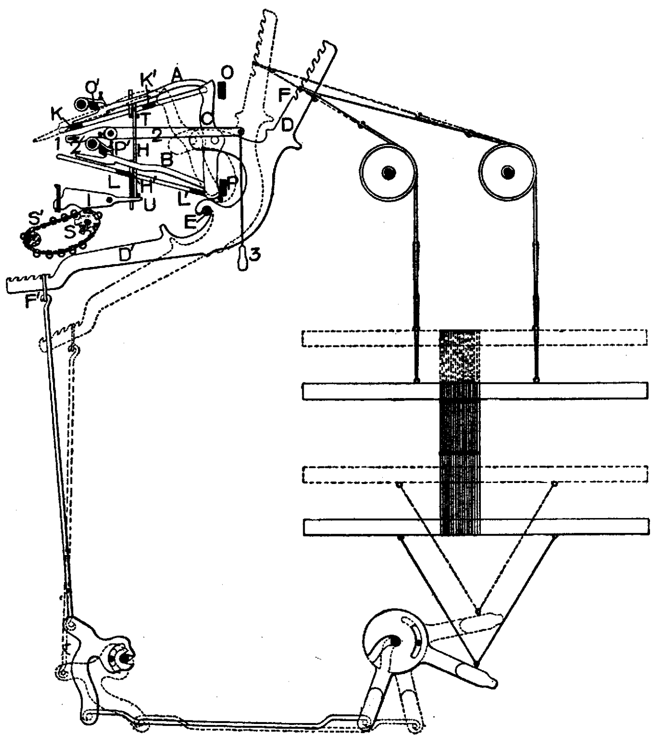

FIG. 75.

Hattersley's ordinary levelling motion forms part of this dobby, namely, a bar 1 is placed against the underside of all hooks in the upper row; it is fixed in one arm of a lever 2, and by drawing down a handle 3, attached to the

other arm, the hooks in the top row are lifted above the top knife, therefore no shaft will be disturbed when that knife next moves outward.

The knives K, K′, L, L′ are differentially driven. When

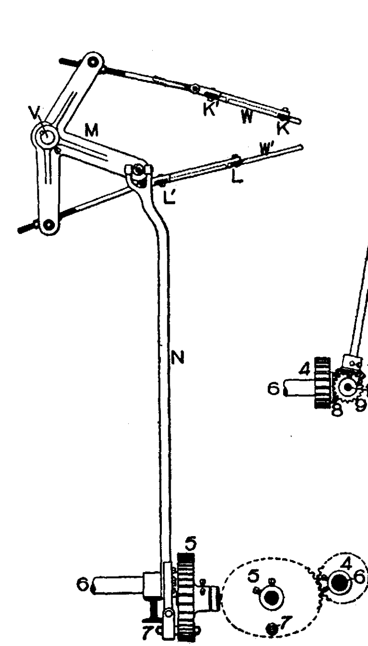

FIG. 76.

midway in their course they move the healds at a maximum speed, but as they approach either extremity the speed is reduced. This is accomplished by an eccentric wheel 4, and an elliptical wheel 5, Fig. 76. The wheel 4 is fixed upon the lower loom-shaft 6, and drives 5 round a stud. 5 also carries a crank pin 7, to which the lower end of a rod N is attached; the upper end being connected to the three-armed lever M. The lag-barrel S is divided into two portions; one operates the shedding, the other the picking and shuttle boxes. It can be driven forward or backward, or be stopped, at pleasure, in the following manner:—A bevel wheel 8 is compounded with the eccentric wheel 4, and drives two loose bevels which are set to face each other on a shaft 10, and both gear with 8, at all times. Between these wheels a hoop, with a ring groove in the middle and a clutch face at each end, is loosely mounted upon a key in the shaft 10. By moving a lever one notch, the picking may be put out of action, in which event the lag-barrel S continues to turn normally. The hoop may also be engaged with either bevel; one will cause the wheel 11, on the shaft 12, to turn in the opposite direction to the other, and a similar motion will be conveyed to the lags. On the top of 12, a slide and peg 13 are fastened to drive intermittently a face star wheel 14, which is secured upon the shaft of S. By withdrawing a spring pin 16, each section of the lag-barrel may be turned by a hand adjusting wheel. The device for driving the lags is also used to drive the taking-up motion.

PART VI

JACQUARD SHEDDING

A JACQUARD machine is a piece of apparatus for selecting and lifting the warp threads for each shed. It is used for large patterns in which all or most of the threads in a repeat move independently, and by its aid elaborate details

and flowing lines may be readily reproduced in a texture. The harness that accompanies this machine has been used, with other selecting parts, for several centuries.

Joseph Marie Jacquard has received the credit for inventing the machine that bears his name, but his contribution towards the solution of the problem was small compared with the contributions of his predecessors. Between the years 1725–46 several Frenchmen developed and almost perfected this machine. Working models of their inventions are to be found in the Conservatoire des Arts, Paris, and in the Municipal College of Technology, Manchester. These afford conclusive proof that Jacquard invented little that is essential to the machine. Even the claim that by combining the scattered pieces of former inventions he produced a beautifully simple and compact machine cannot be maintained, for except in the prism Jacquard's machine was inferior to one invented by M. Falcon in 1728. In 1746 M. Vaucanson invented a machine which chiefly differed from the Jacquard in having an endless band of perforated paper passed round a perforated cylinder, and rotated automatically, instead of an endless chain of paper cards turning on a four-sided perforated prism. Both machines occupied similar positions on the loom, and both cylinder and prism received lateral and rotary movements. The cards and prism were invented by Falcon, but Jacquard perforated the prism on each face.

The parts of a Jacquard are cards, prism, needles, needle board, heel rack, hooks, and griffe, together with suitable framing and means for causing each part to do its appointed work. Of these Jacquard, 1801–4, used Falcon's cards, prism, needles, heel rack, hooks, griffe, and framing, but he drilled the needle board and prism to form diagonal instead of vertical rows of holes, and perforated the cards to suit the arrangement of the needles. This plan was soon abandoned in favour of Falcon's. The Jacquard machine is essentially Falcon's invention inverted to give a direct, instead of an indirect action, and fixed in a similar position on the loom to Vaucanson's machine. Jacquard also added parts which enabled the prism to move out, make $\frac{1}{4}$ of a revolution, and move in again; but these movements closely resembled those for Vaucanson's cylinder. As left by Jacquard, the machine was without grid, the hooks were simply coiled at the bottom, and a short horizontal piece was left for each to rest upon; they were easily turned from the griffe, and when turned were useless.

This machine has been used for more than a century, and during that time most of its parts have been modified. Inventors have endeavoured to increase the speed, reduce the cost of working, and render all the parts reliable. As a result of these numerous efforts it is impossible, within the limits of the present treatise, to deal with all the modifications of the original model, but the most important will be considered. The various makes may be classified as single-acting, centre shed, double-acting single cylinder, double-acting double cylinder, open shed, twilling, and machines specially constructed to reduce the number or size of the cards required for a given pattern.

The size of pattern obtainable from a Jacquard depends upon the number of figuring needles available and the closeness of the warp threads. It is also customary to name a Jacquard according to the number of needles it contains, as a 100 or a 400 machine, those needles intended for selvages being omitted.

The usual sizes are—

100	in which the needles	are arranged in	4	tiers and	26	to a row	=104
200	,,	,,	4	,,	51	,,	=204
200	,,	,,	8	,,	26	,,	=208
300	,,	,,	6	,,	51	,,	=306
300	,,	,,	8	,,	38	,,	=304
300	,,	,,	12	,,	26	,,	=312
400	,,	,,	8	,,	51	,,	=408
500	,,	,,	10	,,	51	,,	=510
600	,,	,,	12	,,	51	,,	=612
800	,,	,,	8	,,	51	two sets	=816
900	,,	,,	12	,,	77	single card	=924
900	,,	,,	12	,,	51+26=		924
1200	,,	,,	12	,,	51	two sets	=1224

For higher numbers, and also for some of those given above, it is a common practice to place two or more machines of smaller capacity over one loom.

Cards are pieces of millboard which are cut into a suitable size for covering the needle space of the machine they are intended to be used with. A 400 card for a machine of the usual gauge is $16\frac{3}{8}''$ long by $2\frac{7}{16}''$ wide, and a 600 card is $16\frac{3}{8}''$ long by $3\frac{7}{16}''$ wide. The weight of uncut cards varies considerably; if used with a 400 hand-loom machine one hundred may not weigh more than $3\frac{1}{2}$ lbs., whereas cards of the same size for power-looms may exceed 7 lbs. per hundred.

Single-Lift Jacquards

When perforated, laced, and wired, as described on pp. 278 to 302, cards are suspended by the wires from a cradle, and passed over a four-sided wooden prism called a cylinder, see A, Fig. 77. Each face of A is perforated to correspond with the number and disposition of the needles in the machine. Every hole is drilled as large as the rigidity of the cylinder will admit of; this is done to leave a needle free to enter a hole without risk of touching

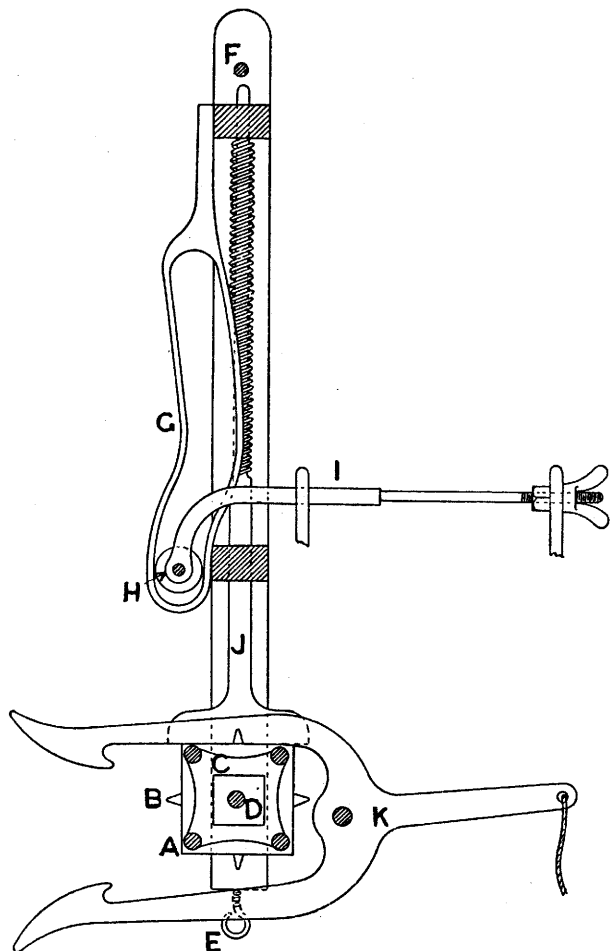

Fig. 77.

the wood. Two tapering wooden pegs B are driven into

every face, and protrude about $\frac{1}{2}''$; or two similarly shaped brass pegs may be supported upon spiral springs and secured by sinking an adjustable brass plate into the surface of the cylinder. The pegs are outside the first and last rows of holes and midway between the cylinder edges; they draw forward and hold each card in turn, with its holes over those in the cylinder; but two flat springs on the outer and two wire springs on the inner faces of the cylinder assist the pegs to hold the cards in position.

A metal lantern C is fastened on each end of A; its rounded edges coincide with the cylinder edges, but between these the metal is removed to a depth of about $\frac{1}{2}''$. Beyond each lantern are two gudgeons, D, which support the cylinder; their bearings are in a frame that either swings upon centre pins or moves horizontally. Those who favour a swinging cylinder claim that little power is required to move it; that the parts are not liable to wear through neglecting to oil them, and that a minimum of oil is required. On the other hand, the cards are liable to be thrown off the pegs, and the cylinder holes are carried above or below the needle centres instead of remaining facing those centres; the framing must also be taller than that required for a sliding cylinder.

Some cylinders are moved from the griffe, others move independently of the griffe. The former method is usual for single-lift machines, but there is a tendency to push descending hooks off, and to wear notches in, the lifting blades, as well as for the needles to puncture the cards. This defect is fully explained in Dobby Shedding, p. 87.

Independent cylinder motions are general for double-lift machines, and are to be preferred, because they can be timed to suit the movements of the griffe. Fig. 77 shows a common method of working a swinging cylinder from the griffe. The cylinder A is supported in bearings which rest upon screws E, for the purpose of vertical adjustment. In hand-loom machines the batten consists of two upright and two cross pieces of wood. In power-looms metal is used. The batten swings upon two centre pins at F, which are screwed into brackets projecting from the machine framing; the screws are pointed to enter conical holes in the batten, and they also provide for lateral adjustment.

A metal swan neck, G, is screwed to the upper and lower rails of the batten. It has a curved groove for the reception of a bowl H, and H is supported by a pin between the prongs of a forked rod I. This rod has a thread cut upon its rear end and is fastened to the griffe block by lock and wing nuts; near the batten it is square in section and passes through a similarly shaped hole in the griffe to prevent the bowl H from twisting. As the griffe moves I and H up and down, the curved slot in G causes the cylinder A to be alternately pushed away from and drawn against the needles. The period during which A is held stationary against the needles is regulated by the length of the vertical portion of the slot at the base of the swan neck G. See also Fig. 82.

When pressed against the needles a cylinder face must be parallel with the needle plate and be free from any tendency to rotate. In order to provide for these requirements two hammers, J, are fixed in the batten with the head of each resting upon the upper surface of a lantern C. The shank of each hammer is square in section near the head, but is cylindrical for the greater part of its length. The cylindrical portion passes through a round hole in the upper, and the square portion through a square hole in the lower, rail of the batten. An open-coiled spring is

loosely mounted upon each hammer shank to abut upon the square part and the upper rail, thus leaving the hammers free to move up and down without twisting. In case a cylinder A is removed, the hammers J are prevented from falling out of the batten by turning two thin pieces of wood or iron, secured upon the lower cross rail, into grooves cut in the square portions of the hammers' shanks.

A forked catch K, with a hook on the inside of each prong, swings freely upon a pin in the machine framing. Normally the upper prong rests, by gravitation, upon the top of one lantern, and the lower prong is quite clear, even when the cylinder edges are vertical. This catch is set to permit the cylinder to move out a short distance without obstruction, but ultimately the outer edge of the lantern is engaged by the catch, when further lateral movement of that edge is stopped and a rotary one set up to the extent of $\frac{1}{4}$ of a revolution. As the cylinder turns, each hammer head is lifted, and the contracted springs assist in steadying the movement.

A weighted string is tied to the straight end of K, and if the top catch is acting, the weight is suspended from a fixed hook, but if the cylinder is required to turn in the opposite direction, the weight is released; it then pulls the bottom catch against the underside of the lantern, and lifts the top one out of the way.

A sliding cylinder A, Fig. 78, is supported in two bars L, that move in four brackets, bolted in pairs to the outside framing. Upon each bar a swan neck G is fastened, and the pins on which two bowls H turn project from the ends of the griffe. Therefore, as H, H move up and down vertically, the bars L receive a lateral reciprocating motion. Sliding bars have been indirectly connected to two levers by spiral springs, so that, in case a cylinder is presented to the needles cornerwise, the springs will expand and thus prevent serious injury.

Similar lanterns, hammers, catches, bearings, and adjusting screws to those already described are found in both types of machines.

A machine invented by Frederick Goos in 1842 has its

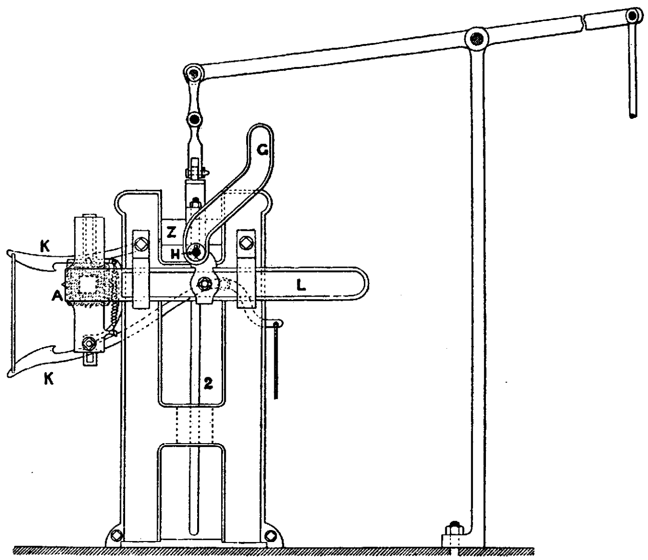

FIG. 78.

cylinder A, Fig. 79, turned in the usual manner by catches, but it slides upon adjusting plates placed inside a pair of slotted arms. The griffe Z works in two slots in the end framing, and has a rack at each extremity with teeth that extend beyond the framing, and engage with a series of studs on the inside of two wheels 5. The studs are arranged in semicircular form, so that as the griffe Z moves

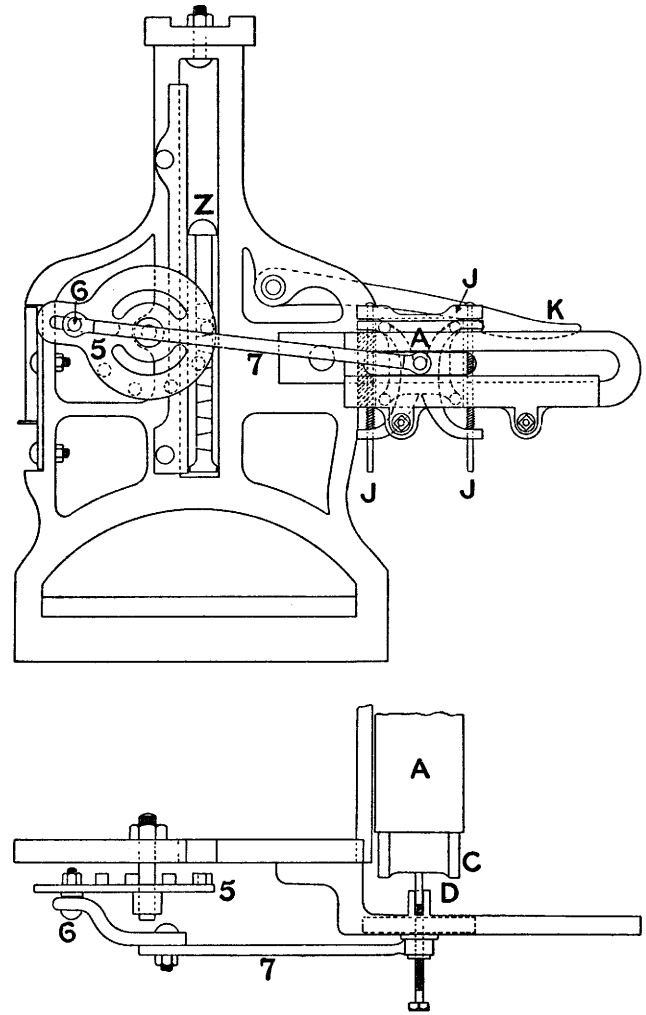

FIG. 79.

up and down, the wheels 5 will turn approximately half-way round and force out and draw in the cylinder. Two arms 7 unite the cylinder A with the wheels 5 by studs 6. These arms are made in two pieces to facilitate adjustment, and the studs 6 pass the back centres of the wheels 5 to give a pause to the cylinder each time the needles are pressed back.

Each hammer J is pulled against the cylinder A by two springs which are loosely threaded upon a pair of shanks that point downward.

Instead of rotating a cylinder by a single or a double catch, various methods have been devised for rotating it positively. For example, Messrs. Schaum and Uhlinger, of Philadelphia, U.S.A., have discarded the four-sided prism, and in its stead they mount two large pulleys upon a shaft, and insert twelve conical pegs into the periphery of each, at equal distances apart. The shaft and the pegged pulleys are positively, but intermittently, driven by a twelve-sided star wheel which is mounted upon the rear end of the pulley shaft. Two chains and four chain wheels are employed to drive the star wheel. One chain is driven from the crank shaft of the loom and communicates motion to a pair of chain wheels; these are compounded by means of a clutch, so that by opening the latter the cards may be turned forward or backward by a winch handle. The second chain is driven by one of the compounded wheels, and conveys motion to a shaft fitted parallel with, but beneath, the pegged pulleys. This shaft is provided with a collar and crank pin; as the former rotates, it rolls against the curves of a star wheel, while the latter enters a notch and drives the star. At each movement of the star wheel a fresh card is placed in front of the needles. The pegged pulleys and cards receive a slight

lateral movement from a pair of swan necks attached to the griffe; and inside the pulleys a perforated board advances with the pulleys and presses each card into contact with the needles.

With a four-sided star wheel, an ordinary cylinder could be similarly driven.

Another plan is illustrated in Fig. 80, where a connecting rod A is vibrated by an eccentric on the main shaft of

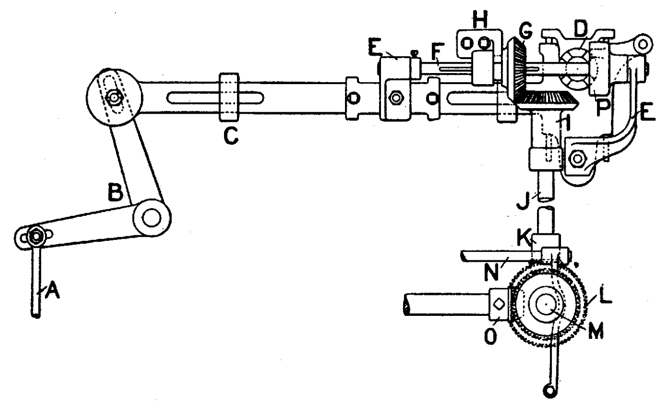

FIG. 80.

the loom. By means of a cranked lever B, the rod A gives a horizontal reciprocating movement to two rods C, which support the cylinder D. One of these rods has two bearings E, E for a shaft F, hence they partake of the sliding movement. A key is fitted in F, and a bevel wheel G is loosely mounted upon it. A ring groove in the boss of G receives the lower end of a bracket H which is rigidly bolted to the machine framing for the purpose of preventing the wheel from sliding with the shaft. Upon one cylinder gudgeon a four-notched face star wheel is fixed, and upon F a crank pin is mounted in a collar P. The periphery of the collar bears against the curves of the star wheel to steady it, and the pin enters the notches to drive it.

A vertical shaft J carries two bevel wheels; the upper one, I, gears with G, and the lower one, K, gears with a bevel L on a horizontal shaft M. The last-named shaft can be driven from any convenient part of the loom, but it is usually furnished with two bevels, both of which are capable of sliding upon a key in M. The teeth of one are set to face those of the other, and a similar wheel O drives them, but can only engage one at any time. By moving a lever N one wheel will slide into, and the other out of, gear with O, and thus reverse the direction of movement in the wheels, shafts, and cylinder.

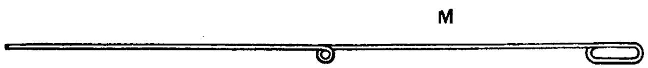

FIG. 81.

Cards operate hooks through the medium of needles M, Fig. 81. They are made from round wire; one end being straight, the other bent to form a loop approximately $\frac{3}{8}''$ long. An eye is made by coiling the wire to form an opening large enough for a hook to pass through. The distance from point to eye depends upon the position of the hook that a needle is to govern. In a 400 machine there are eight rows of hooks, and all the needles of one row have eyes and points equidistant, but since the hooks are placed row behind row, the needle eyes must be formed in eight different places to bring each facing its hook. Needles are arranged in horizontal rows; the number of rows and the number in each row vary with the capacity of the machine, but 612 needles usually occupy a space of 13·75″ by 3·025″, although machines are built with 1078 needles, forming

14 rows of 77 that only occupy a space of 13·64″ by 2·48″.

The straight end of each needle is passed from $\frac{1}{4}''$ to $\frac{3}{8}''$ through a needle board N, Fig. 82, or an iron plate, drilled to the gauge of the cylinder, viz. 0·275″, but with holes just large enough to allow the needles to move to and fro, also with two large holes to receive the cylinder pegs. The looped ends of M are supported by a heel rack O, consisting of a scalloped framing capable of holding stout wires in parallel tiers. The loops pass on their flats between the wires, and a pin P is threaded through all in one vertical row of needles. The pins and loops limit the lateral movement of all the needles and prevent them from being withdrawn from the needle board or the heel rack.

Holes are drilled through a detachable spring box Q, to correspond with the positions of the needles, each being large enough to receive a brass spiral spring S, from $1\frac{1}{4}''$ to $1\frac{5}{8}''$ long, by $\frac{3}{16}''$ in diameter. Vertical pins R are passed through holes in the rear of the box Q, and athwart the lines of springs; each holds one row of springs in position, and permits of their removal in case repairs are necessary. The forward end of a spring abuts against the rear end of a needle loop, and pushes it upon a pin P; by so doing, the needle point is thrust in advance of the board N, but can be forced back by exerting sufficient pressure to contract a spring S. This occurs every time a blank in a card is carried by the cylinder A to within $\frac{1}{8}''$ of the needle plate N.

The hooks T are bent at both extremities; the upper bend forms a catch, and the lower one a loop about $1\frac{1}{2}''$ long. Each hook is held in a vertical position by passing it through the eye of a needle and allowing the loop to rest

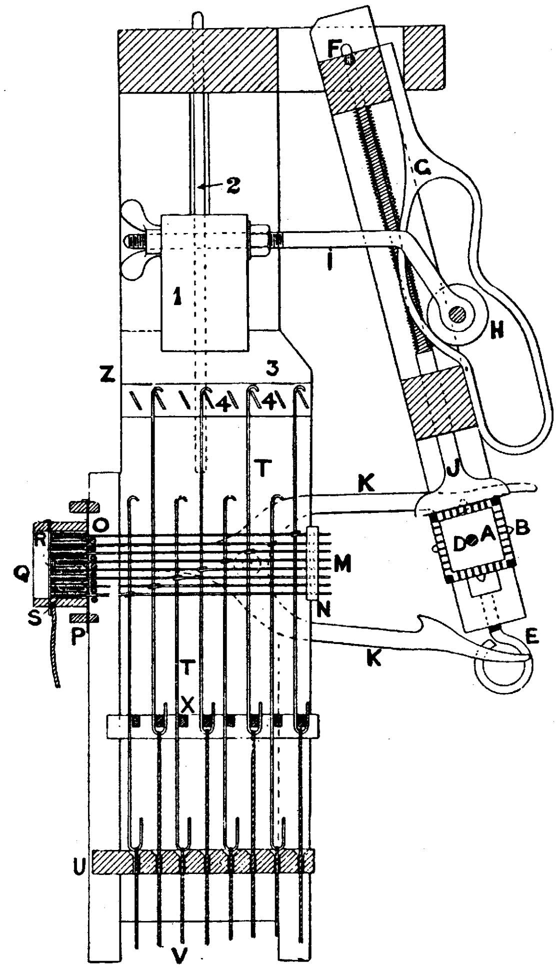

Fig. 82.

upon a bottom board U. This board is perforated in parallel rows at a distance of 0·275″ from hole to hole. But for machines with hooks $10\frac{1}{2}''$ long the distance from row to row varies from $\frac{13}{16}''$ between rows 1 and 2 to 1″ between rows 7 and 8. The difference is intended to prevent the descending griffe knives from injuring the stationary hooks, for all needles are pushed back uniformly, but the bottom row being farther from the heads of the hooks than the top row, will cause their hooks to move through a greater space than those in the top row. In machines with long hooks the spaces are all equal, and from $\frac{7}{8}''$ to 1″ apart, because the difference in movement usually diminishes in proportion to the increased length of the hook.

The upper face of a bottom board U has a separate recess for the base of each hook T to sink into; by this means the board helps to hold the hooks with their heads facing the griffe blades.

A neck cord V is usually fastened on the loop of every hook by a "double hitch," see G, Fig. 118, for by this plan the hooks will not cut the cords to the same extent as if knots were used. An endless cord is also made by warping thin twine to the required length and thickness, and after tying the first and last strands and twisting all together, the neck cord is dropped over a hook, as in H, Fig. 118. Hooked wires have also been used instead of neck cords, but they lack flexibility. A neck cord terminates about 8″ below the bottom board. If the heads of the hooks were allowed to turn, the griffe could not lift them, so turning is prevented by a grid X, consisting of two end pieces of wood or iron, into which strips of wood, or stout wires, are fitted at right angles. A bar of this grid rests loosely in the loops of each line of hooks T, and when the machine is in motion the grid rises and falls with the hooks. For satisfactory work, the bottom bend of a hook should be, say, $4\frac{1}{2}''$ instead of $1\frac{1}{2}''$ long, for then a lifted grid would remain inside the loops of all hooks left down.

Brackets bolted to the top of the Jacquard, or supports rising from a platform, carry a fulcrum pin for a lever which is connected by a rod to a crank, or cam, fitted on some convenient part of the loom; a link also unites the lever with the griffe Z. In these machines the griffe gives motion to the cylinder A, and to the hooks T. All parts of a griffe are attached to a block 1, that either moves vertically in the slotted end framing, or else a pair of spindles 2 rise and fall in double bearings fixed about 6″ apart. In machines with 26 hooks to a row, two thin wrought-iron plates 3 are bolted to the griffe block, but in those with 51 or more hooks to a row, a third plate is placed midway between the outer ones. Each plate has a narrow, diagonal slit, about 1″ in depth, punched through it for every row of hooks. Bars, or knives of strong hoop iron, 4, with feather edges, are threaded through the slits and retained by passing a wire through holes previously drilled in the knives and outside the plates 3; after which the wire is bent at each end to make it secure. Every knife edge is fitted close to a row of hooks, but is not allowed to press against them. A knife and a hook form an angle large enough to permit the lower edges of the former to pass the heads of the latter. If the knives were upright, they would descend upon the unlifted hooks and bend them.

The action of a Jacquard is as follows:—Cards are passed over the cylinder A and pressed against the needles M; the needles enter the perforations and remain stationary, but blank places push back the needles and tilt the heads of the hooks T, for each neck cord V serves as a fulcrum for a hook to move on. At this time the upper edges of the knives 4 are from $\frac{3}{16}''$ to $\frac{1}{4}''$ below the heads of the hooks, and as Z begins its upward movement, the blades lift vertical hooks, but miss inclined hooks.

A mounting thread is tied to a coupling and to a neck cord V, hence a rising hook will lift the coupling and the warp it controls to the top line of a shed.

The cylinder A begins its outward journey when the griffe is from $\frac{5}{16}''$ to $\frac{3}{8}''$ above the level of the hooks to be left down, the springs S immediately force the free needles M into their normal positions, the catches K turn the cylinder $\frac{1}{4}$ of a revolution, and the next card is in position for repeating the operations. Single-lift machines are still used in the manufacture of silk, cotton, linen, and woollen fabrics when, for other than shedding reasons, high speeds are unattainable.

Since Jacquard introduced his machine, mechanicians have not only modified and improved its details, but have aimed at setting aside most of the features considered essential to it.

The great cost of cards has led to endeavours to discard them, or to reduce their numbers and dimensions. Celluloid, and endless bands of perforated paper, approaching the thickness of ordinary writing-paper, have been used. Wire gauze, and canvas made from various textile fibres, have had some of their meshes closed with varnish to form a pattern, and have been used as card substitutes. Endless bands of flexible metal have also been painted with an insulating varnish, rotated automatically, and acted upon by electro-magnets placed in front of a Jacquard, but without important results.

Neck cords have been carried entirely through the machine and used instead of hooks. Hooks have been made to hold a needle point forward without spring or other contrivance; but at present these and other similar changes have a limited application.

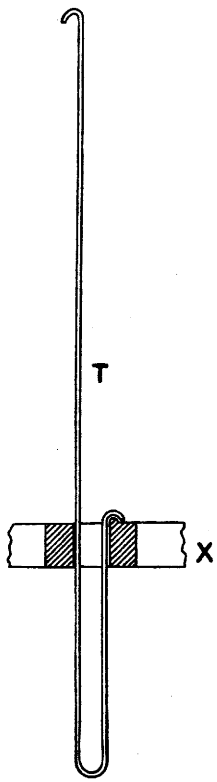

Fig. 83.

A beneficial change in the hook is shown in Fig. 83, where the bottom loop is turned up about 6″ and curved sharply outward to form a second catch. A cast-iron grid plate X has semicircular ribs, approximately ¼″ in diameter, running in parallel lines lengthwise of the machine; X supports the bottom bends of the hooks T, and a separate slot for each hook effectually prevents turning, for the hooks are never lifted out of the grid. When single-lift machines are fitted with these hooks, the bottom board is retained, but it merely serves as a guide to the neck cords, for the hooks do not touch it by from ½″ to ¾″.

With a coiled needle eye it is difficult to remove a damaged hook. On this account a modern needle has a cranked eye, as in Fig. 84. Extensive application has proved this needle to be efficient, and it leaves the hooks accessible for repairs.

Clinton G. Gilroy, in his *Art of Weaving*, says it is not perhaps generally known that M. Jacquard did not employ

perpendicular wires (as at T, Fig. 82) in the first machines which he constructed, but knot cords and trap boards. In John Murphy's *Art of Weaving* we are told that shortly after the introduction of Cross's counterpoise harness (about 1816) the French draw loom was imported from France, and the machine he describes is a cord machine. The inventor of the cord machine may, therefore, be Jacquard, but it has been attributed to William Jennings, of Bethnal Green, and the date given as about 1830. In it a neck cord V, Fig. 85, is passed vertically through the bottom board U, and the eye of a needle M through a perforated trap board Z, that takes the place of a griffe, and through a board W, at the machine head from which

Fig. 84.

all the harness cords are suspended. Above the head board a loop is formed upon each neck cord at X, for a piece of twine to be passed through the loops in one line, and so prevent the cords from lifting. Each neck cord is knotted immediately above the trap board when the latter is in its lowest position. The holes in this board are large enough to allow a knot to pass, but a saw slit runs into every hole and is only wide enough to take a neck cord;—see the detached portion of a plan view of Z—hence if any of the needles are pushed back their neck cords are pressed into counter-sunk slits which retain them, and when the trap board begins to rise, all cords in the slits are carried up with it. But since straight cords have their knots over the holes they will be left down. A batting board Q pushes the needles forward immediately the trap board reaches the bottom. In addition to the bottom board, another and similar one is placed somewhat more than the depth of a shed below the first, and between them each neck cord has a leaden weight secured upon it to keep it in tension.

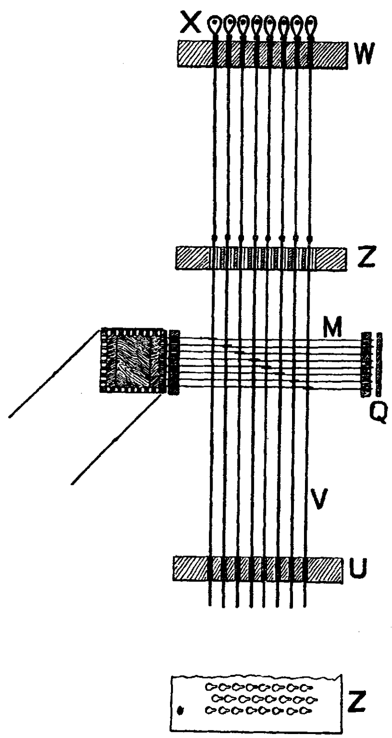

FIG. 85.

Occasionally the head and the trap boards reciprocate laterally, for the purpose of moving the cords out of the saw slits with greater certainty.

In 1842 F. Goos introduced a form of hook which dispensed with the spring box and springs. As now made, for machines with from 200 to 400 needles, the hooks T, Fig. 86, are $10\frac{3}{4}''$ long, and the straight leg is only $1\frac{1}{2}''$ shorter than the hooked one. Both legs are $\frac{5}{16}''$ apart at the bottom, but the top of the short one touches the long one. A stationary grid of stout wire 8 is bolted to the end framing $4\frac{1}{4}''$ below the hook heads, and each wire passes between the loops of one row of hooks; therefore, when any of the needles are pushed back, the legs of T are separated, and the springy nature of the

wire forces the needles forward as soon as they are liberated by the cylinder. To prevent the hooks from turning, a grid X is carried up and down by the griffe. This plan works well, but the parts are difficult to repair.

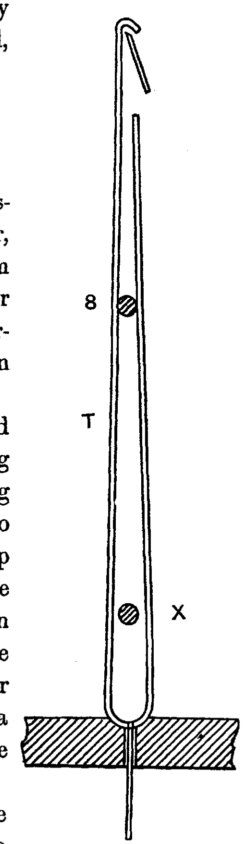

FIG. 86.

CENTRE SHED JACQUARDS

Owing to the necessity for closing one shed before opening another, single-acting Jacquards can seldom be run at more than 80 picks per minute; and the want of a counterpoised harness puts great strain upon the loom.

The Ainley Jacquard was invented in 1876 with a view of remedying both these defects, but in opening each shed it imparts a movement to every thread of warp, and sets up an objectionable swinging in the harness, especially when more than 150 to 160 picks per minute are attempted with a 45″ or a wider harness. The lifting crank of a loom has also to sustain the entire weight of the harness.

In construction the parts are simple and as readily repaired as those in other machines of equal capacity. Fig. 87 shows all that is essential to the machine: 4 is one blade of the griffe Z, the frame of which is united by a strap to a quadrant on the lever Y. A rod 12 also couples

Y to a lever 13, and a similar rod 14 connects the grid X with 13. An ordinary lifting apparatus is used to set the

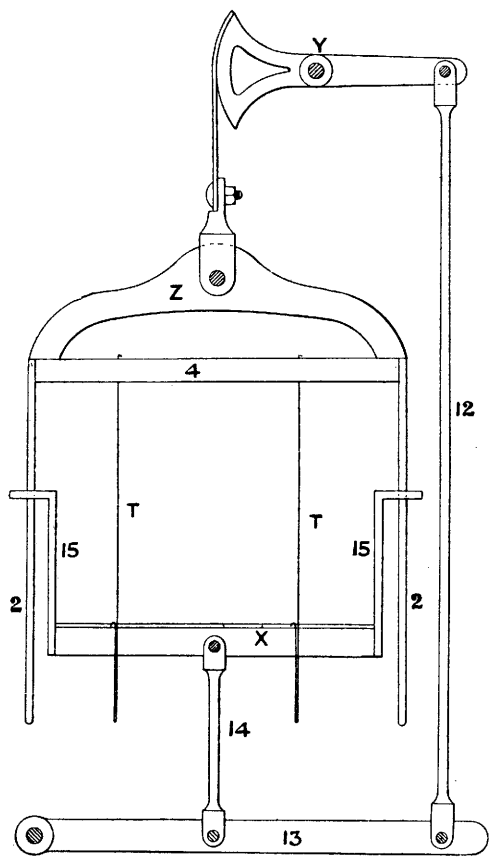

FIG. 87.

parts in motion; but as 4 ascends ith all vertical hooks T to form a top shed, the grid X descends simultaneously

with all inclined hooks, therefore a shed is opened in about half the time required to form one by a single-lift machine. When motion is reversed, the blade 4 and grid X move towards each other. Both are steadied by fixing a pair of spindles 2 upon the griffe frame, and passing them through bearings formed in the brackets 15, which are bolted upon X. When the number of rising and falling hooks is unequal, a weighted lever may be lifted with a light shed, and in falling it will help to lift a heavy one to the centre.

In the United States of America and on the Continent of Europe, centre shed Jacquards are in extensive use. But it is unusual to actuate the griffe from above, as in Fig. 87, owing probably to the practice of placing looms in storied buildings where head room is limited. By lifting the griffe from below a Jacquard becomes more compact, and the plan might with advantage be more generally adopted in this and other styles of machines.

Double-Lift Single-Cylinder Jacquards

Double-lift Jacquards possess an advantage over single lifts, in so far as the saving of power is concerned, for the weight of a falling shed helps to lift a rising one, and, since they move the warp through a reduced space, less strain is put upon the threads. But their chief advantage consists in giving increased speed without increased wear and tear; for most, if not all, the moving parts work at half the speed of the loom shaft. Where the fabrics are thin, and the weight to be lifted is irregular, double-acting machines at times cause cracks to show in the figure; this may be due to the warp threads passing each other about the same time the slay is beating up the weft.

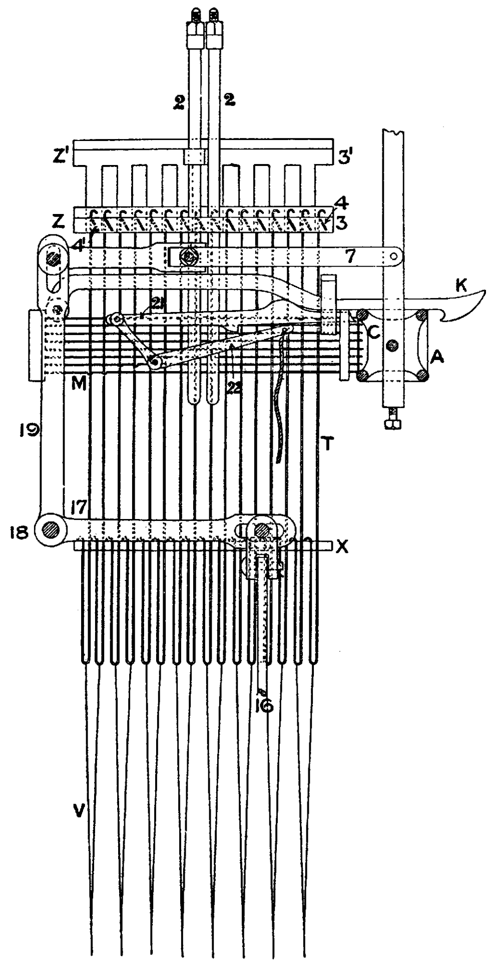

Fig. 88.

In 1854 John and William Crossley introduced a machine which embodied the principle of governing two hooks from one needle; thus a 408-needle Jacquard had 816 hooks arranged in 16 rows of 51 hooks each. Originally alternating rows of long and short hooks were used, and the neck cords from one long and one short hook were united. The cylinder was drawn in by the descending griffes, and pushed out by an open-wound spiral spring. The needles, also, had coiled eyes. But this plan was discarded in favour of that illustrated in Fig. 88, in which a pillar rises from a platform to provide a bearing for the fulcrum pin of two lifting levers (see J, K, Fig. 111). The inner end of each lever is connected to a griffe Z, or Z', by links and studs. Two rods connect the outer ends of these levers to a double-throw crank on the bottom shaft of the loom. Or, two racks may be bolted upon the cross heads of the griffes Z, Z', so that their teeth shall face each other. A spur wheel is then keyed upon a cross shaft to connect and drive both racks in opposite directions. An arm at one end of the shaft receives motion from a lifting rod operated by a single-throw crank from the main shaft of the loom. Upon each end of the griffe frame Z a wrought-iron plate 3, Fig. 88, is bolted and slotted to receive eight griffe blades 4; a plate is $\frac{1}{16}''$ thick by $2\frac{3}{4}''$ deep, and the blades are $1\frac{3}{8}''$ deep. Two similar plates 3' are bolted inside the end frame of the griffe Z', but they are 8″ deep, and contain seven vertical slots, each $6\frac{1}{2}''$ deep. A slot is wide enough to allow a knife of Z to move up and down inside it. The plates 3' support a similar series of blades 4' in slits near the bottom of the teeth. The frames Z, Z' are steadied by keying a pair of spindles 2 upon them, and causing the spindles to move freely in bearings formed on the machine framing.

The hooks T are 16″ long by $\frac{5}{16}''$ across the bottom bend; they are supported by a grid X, and sink $4\frac{1}{2}''$ below it. All the rows are about $\frac{15}{16}''$ apart, and hooks from contiguous rows are coupled by tying two neck cords V together at about 9″ below the grid. The needles M are $16\frac{1}{2}''$ long, and have double-cranked eyes formed as shown in Fig. 89; those in the top row actuate the hooks in rows 1, 2, and successive rows of needles govern following double rows of hooks.

The motion of the cylinder A is independent of the griffes Z, Z′; it is derived from a crank on the main driving shaft, and is conveyed by a rod 16, to an arm 17, which is keyed upon a horizontal shaft 18, and 17 should be long

Fig. 89.

enough to leave 16 vertical when the driving crank is on the top or bottom centre. Two arms 19 are also fastened upon 18 to actuate two bars 7, attached to the batten of a swinging cylinder.

As the crank revolves it vibrates the rod 16, the levers and shaft 17, 18, 19, the bars 7, and the cylinder A. Each part being adjustable, it follows that A can be set to strike the needles M when either griffe Z or Z′ is too low to allow the hooks T to be pushed off, also that the duration of the pause can be varied. If the pause is too short, some hooks will be lifted that should be left down; if too long, the cylinder will move rapidly, throw the cards off the pegs, and the needles will puncture them. When the griffe cranks are on their top and bottom centres, the cylinder crank should be on or near its front centre.

A single catch K, Fig. 88, turns the cylinder A forward, but a bar 21 is used to turn it back manually; this bar slides in a bearing bolted to the framework and is on a level with the top corner of the lantern C; a catch on the underside limits its forward movement, and a curve on the top edge lifts the catch K off the lantern C before a backward motion is given to A. A cranked lever 22 moves freely upon a pin, and one arm supports the rear end of the bar 21; the other arm has a cord tied upon it for the weaver to pull. Every time the cord is pulled, the bar 21 slides out and turns the cylinder A one-fourth of a revolution in the backward direction.

The griffes Z, Z′ rise and fall alternately, and a card is pressed against the needles when both griffes are at opposite extremities of their movement. A hole in a card will leave two hooks vertical, and the next griffe to rise will lift one of them. If, on the succeeding card, a blank is opposite the same needle, before that needle can push back the lowest hook it must act through the lifted one; this puts a certain amount of strain upon both hooks and needles, but it can be reduced by allowing a lifted hook to swing slightly in the grid X, the knife serving as a fulcrum.

By tying two neck cords together, both hooks act upon the same warp thread. If one hook lifts a thread to the top shed, immediately that hook begins to fall the thread falls with it; for although the second hook begins to rise as the first begins to fall, the lifted hook left the second neck cord slack, as at V, Fig. 90, and until it tightens the rising hook can have no effect on the warp. At the centre of a shed the ascending and descending hooks meet, and the former again takes the thread to the top. But where the warp threads are to change positions, one arrives at the bottom as the other arrives at the top (see Fig. 12).

When in action this machine has a tendency to twitch the warp and break the neck cords as the direction of motion is reversed; the rapid strokes of the cylinder upon the needles also injure the cards, and prevent the machine from moving as rapidly as one with two cylinders. Still, its speed greatly exceeds that of a single lift. Its central features may be summarised as follows: It lifts a warp thread any number of times in succession without allowing it to sink to the bottom. It forms a shed in a shorter time, and puts less strain upon the threads than a single lift, hence weaker yarns can be used; but weft is beaten home in a semi-open shed. Since the cards form one set, there is no fear of their proper sequence being destroyed. Its defects are: That the cards are liable to be thrown off the cylinder, to be broken, and punctured by the needles. The hooks and needles are subjected to considerable strain, the neck cords break, and double necks are more difficult to tie up level than single ones.

Two flat steel springs, fastened by set-screws to the upper cross rail of the batten, press a card against the outside face of the cylinder, and two pieces of steel wire, similarly attached to the batten, press a card upon the inner face of the cylinder; hence the springs hold the cards on three faces, and to a large extent prevent them from leaving the pegs.

High speeds often set up excessive vibration amongst the hooks and cause a falling griffe to descend upon the hooks left down and bend them. This has led makers to lengthen the hooks above the needles, and deepen the griffe blades, so that in their lifted positions the bottom edge of a blade will be always below the heads of the unlifted hooks. Or the same result may be achieved by extending a hook leg above the top bend, and thus prevent

the lifted griffe blades from reaching the top of a stationary hook.

Notwithstanding these and similar changes, the majority of Jacquards now in use are furnished with blades and hooks as previously described.

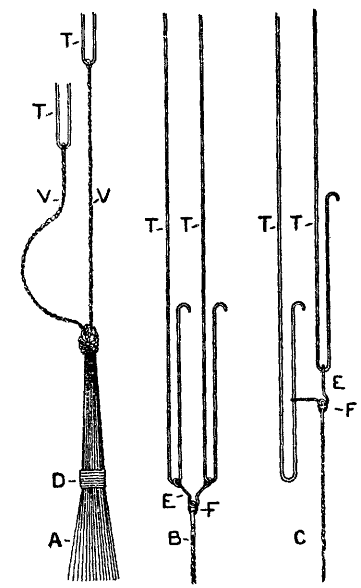

FIG. 90.

Many devices have been placed upon the market which aim at removing the objectionable double neck cords V. One consists in the substitution of a double hook for two single ones, as in Figs. 96, 105; others in connecting the lower portions of two hooks by a clip which rises and falls with a moving hook and slides up and down a stationary one. For a device of the latter type J. Hillas, in 1889, achieved the greatest measure of success. His invention is illustrated at B, C, Fig. 90, together with the plan A he desired to supplant. The drawing A shows the lower portions of two hooks T with their accompanying neck cords V; one hook is lifted, the other left down, and one cord is tight, the other slack. To these neck cords a group of mounting threads D are attached. In the drawings B, C a wire link E unites two hooks T and carries a ring F, from which a single neck cord is suspended. At B both hooks are down and the link rests on the base of the loop of each, but at C one end of the link is suspended from the loop of a lifted hook, while the other end has ascended the short leg of the unlifted hook. When the opposite hook lifts, the position of the link will be reversed. At the change of direction, the effect upon the warp is easy, but the links and hooks wear each other.

The device on Crossley's machine for turning cards back only partially fulfils the requirements, for it is frequently necessary to turn cards forward as well as back; the former can only be done by ascending to the level of the Jacquard and turning the cylinder by hand. A better plan is shown in Fig. 91, where a four-sided star wheel A is fixed upon one of the cylinder gudgeons B, and adjacent to it a lever C is loosely mounted upon B. This lever is provided with a stud at D to serve as a fulcrum for a bent lever E, and a stud F, in E, is capable of engaging the star wheel and turning the cylinder in either direction. A spiral spring G unites one arm of E with C, and opposite ends of a cord H, I are attached to C and E respectively. The cord must be long enough to place the loop in a convenient position for the weaver to operate. Two projections J, on C, limit the swing of E, as well as cause C and E to swing together.

If the cord H is tight and I is pulled, as in the left-hand portion of the figure, the stud F, being above the centre of A, will turn the cylinder backward. But if I is tight and H is pulled, as in the right-hand portion of the figure, F being below the centre of A, the cylinder will turn forward.

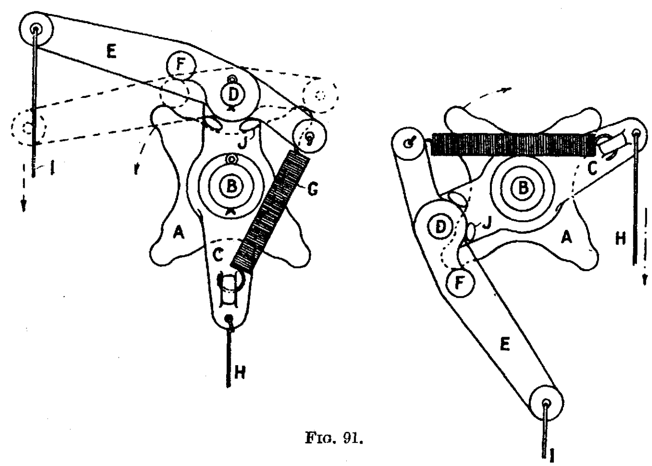

FIG. 91.

DOUBLE-CYLINDER JACQUARDS

Double-lift double-cylinder Jacquards are theoretically the most perfect, for everything moves at half the speed of a slay, and wear and friction are reduced to a minimum. But a set of cards is divided into two parts—one providing for odd picks, the other for even ones, and this gives considerable trouble to the weaver. As the cylinders strike alternately, they should present the cards to the needles in consecutive order; in practice, however, it is difficult to apply anything that will prevent the cards from getting out of their true sequence. High speeds have rendered this a serious matter, for a considerable length of material is woven in a short time, and if the cards are not working properly, either the damaged fabric must be unwoven or the piece will be spoiled.

In Fig. 92 this machine is seen to consist of two single-lift Jacquards combined in one frame. All the hooks T face the cylinder from which they are governed, but the bottom loops of one set are bent forward, while those of the other set are bent back; this is done to distribute them equally along the surface of the grid X. Two neck cords V from contiguous rows are tied together, therefore the hooks forming pairs are actuated by the needles M, through cards on different cylinders. If one needle is at the top of one set, the other is at the bottom of the other set; for this reason half the cards must be laced so that their progressive numbers will read from left to right, while those of the other half will read from right to left.

Both cylinders A, A′ are coupled by bars, so that when one touches the needles the other is as far from them as possible; they are moved independently of the griffes Z, Z′, by similar mechanism to that described for the Crossley machine, but the eccentric for driving these cylinders works at half the speed of the former, hence it must be driven from the bottom loom-shaft, as at O, Fig. 111, or by gearing from the top shaft. Assuming the cylinder A to be pressing card 1 against one set of needles, cylinder A′ will be holding card 2 facing the other needles; then as A moves out, the griffe Z ascends, A′ moves in, and griffe Z′ descends.

Numerous parts have been applied to prevent the cards from being presented out of sequence, but defective construction, complication of parts, or extra trouble for the weaver caused most of them to be discarded. A detector is often found on these machines; it consists either of two pieces of wood placed on a level with the weaver's eye,

and numbered in large figures 1, 2, or of two tufts of

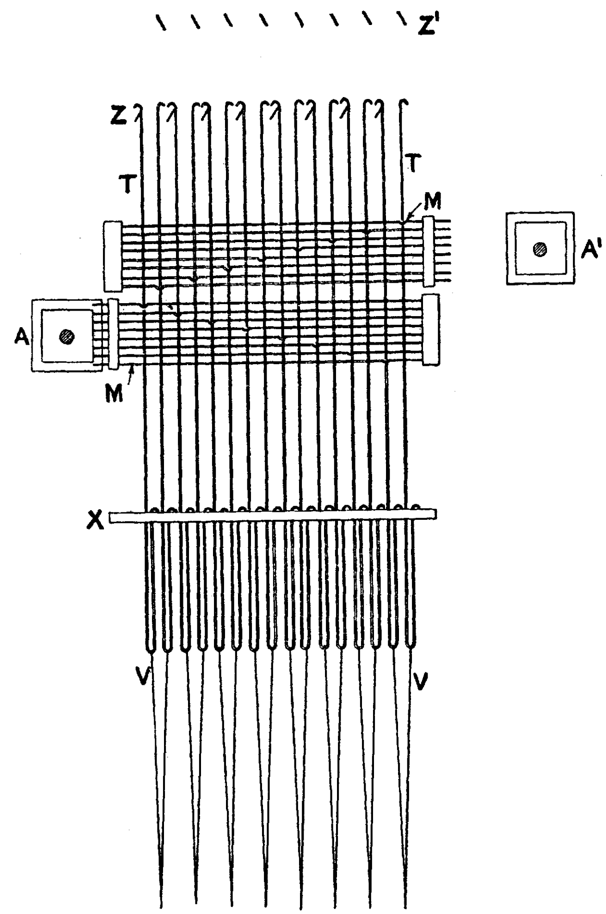

FIG. 92.

threads that differ in colour. Each is suspended by a mounting thread from a spare hook in opposite sections of the machine, and holes are cut in the cards to lift them in succession, but at intervals of 4, 8, 12, or 16 picks. So long as the fall of number 1 is followed by the rise of number 2, the cards are working correctly, but immediately 2 rises before 1, or when an interval of one or more picks intervenes between the lifting of 1, 2 boards or tufts, the weaver knows something has gone wrong. The above plan cannot prevent faulty cloth being made. The following contrivances stop a loom when the cards go wrong.

Green and Barker's Stop Motion

In 1888 Messrs. Green and Barker patented a stop motion for double-lift double-cylinder Jacquards. They couple the neck bands of two spare hooks T, T′, Fig. 93, and carry a cord down from T, T′ to a cranked lever 43, which is so placed that when vibrated its vertical arm thrusts the starting handle from its detent and stops the loom. A pawl 44 is loosely fitted upon this arm to rest on the top of a fixed hook 45, until 43 is oscillated, when 44 and 45 engage and become locked. The loom is then incapable of running until the cards have been restored to consecutive order and the pawl lifted. A second lever 42 has a slotted head for the purpose of spanning the hooks T, T′; it receives a rocking motion from a crank pin in a wheel 46, which is driven by a pinion 47 on the bottom loom-shaft; the teeth of 46 and 47 are proportioned as 1 : 2, to move the lever 42 against the hooks T or T′ once in two picks.

The inventors state that spare holes in the cylinders A, A′, outside the cards, may be pegged to move the hooks T, T′; but this is an uncertain method, for if the cards were off the pegs either cylinder might continue to turn without

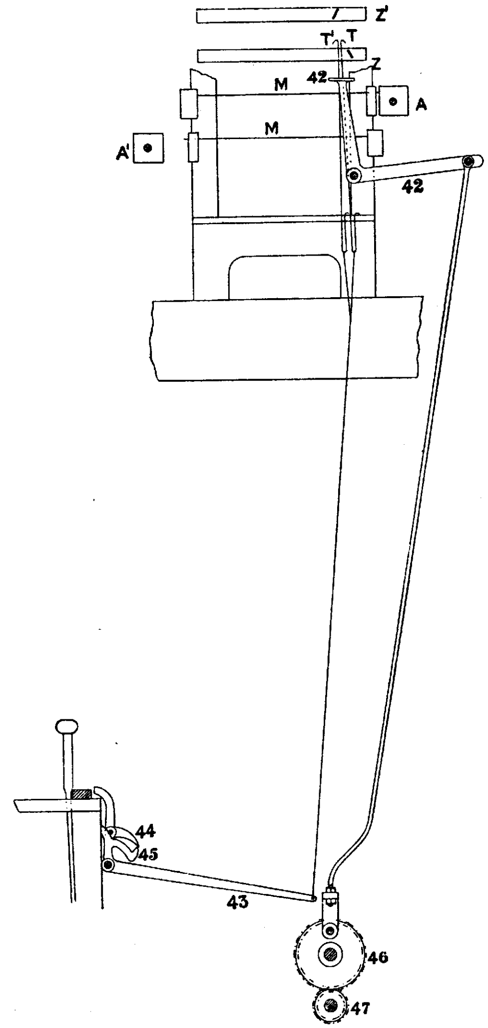

Fig. 93.

moving the cards. It is preferable to cut holes in alternate cards of each set to face the needles M, so that, if the cards are working correctly, a hole will be opposite the top needle M when the head of 42 is pushing hook T off the griffe Z, and a hole will be opposite the bottom needle M when the head of 42 pushes hook T′ from the griffe Z′. Blanks in the cards will then cause each needle to push a hook T or T′ off its griffe when the head of 42 is not acting upon it. But immediately the cards on one side get out of sequence with those on the other side, a hole in a card will face a needle when the head of 42 is not pressing back the hook controlled by that needle, and the hook will then lift and stop the loom.

Riley and Riley's Stop Motion

In 1886 Messrs. Riley and Riley patented a simple stop motion for double-cylinder machines. It requires two spare hooks at the driving side of the loom, and these must be moved by opposite griffes and needles. The hook T, Fig. 94, is furnished with a coiled eye through which the lower arm of a wire lever 42 passes; this arm is coiled midway between its fulcrum and the hook to serve as a spring, and is loosely fitted upon a pin in the framing; its upper arm takes into a supplementary eye in a needle M that governs a hook T′.

A spiral spring is threaded upon M, between the extra eye and the needle board N, and its office is to hold T′ off the griffe. A cord from T′ goes down to the lower arm of a lever 43, Fig. 93, which must stop the loom in case T′ lifts. A lingoe is employed to pull T down after each upward movement.

The cards are cut to stop a loom in case they are not

presented progressively; thus, every time the hook T is lifted, the needle M and hook T′ are pushed forward, and if a hole in the following card is opposite M the hook T′ will rise to stop the loom, but a blank will simply press

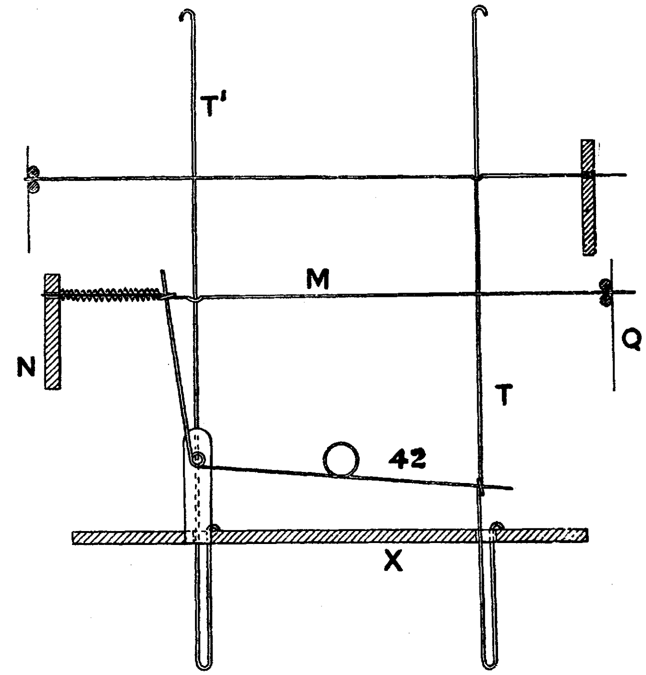

Fig. 94.

back M and T′ and bend the lever 42 at the coil. Hence a hole opposite the top needle, if followed by one opposite the bottom needle, will cause T′ to lift and the loom to stop; therefore any system of cutting can be adopted that will push back T′ while T is lifted.

For example, let odd-numbered cards be put on the top cylinder, then, for a scheme which repeats upon 8 picks, cut holes in 1, 3, but leave 5, 7 blank. Cards 2, 4 must be blank, and 6, 8 cut. For a scheme of 12 picks to the round, 1, 3, 5 may be cut, and 7, 9, 11 left blank, if 2, 4, 6 are blank, and 8, 10, 12 are cut. In case the cards cease to rotate correctly a hole will fall opposite the needle M while hook T is lifted; T′ will then rise and stop the loom.

Open Shed Jacquards

To make changes only when changes are necessary is the ideal system of shedding, because friction and breakages are thereby reduced, and steadiness is increased; but repeated efforts to build a satisfactory open shed Jacquard have left the question in doubt as to whether the advantages of open shedding are not more than counteracted by the difficulties experienced in working these machines.

In 1877 Messrs. I. Thomis and J. Crabtree procured a patent for converting a double-lift single-cylinder Jacquard into an open shed machine. They united two hooks by one tail cord, and in the loop of the cord they placed a grooved pulley. From a plate attached to the axis of this pulley connections were made with the harness. If a griffe lifted one hook, say, 6″, the pulley axis was lifted 3″, and if for the following pick the other griffe lifted the remaining hook, the pulley was stationary, for one griffe descended as the other ascended. But to lift a griffe twice as far as a warp thread was undesirable.

In 1890 R. Wilkinson patented a method of forming an open shed without giving additional lift to a griffe. He uses a double-acting single-cylinder machine, and connects one neck cord A, Fig. 95, to two hooks B, C. The cord A passes under a grooved pulley D, and two plates E are

employed to unite D with a similar pulley F. A supplementary neck cord G is secured to one of a series of fixed

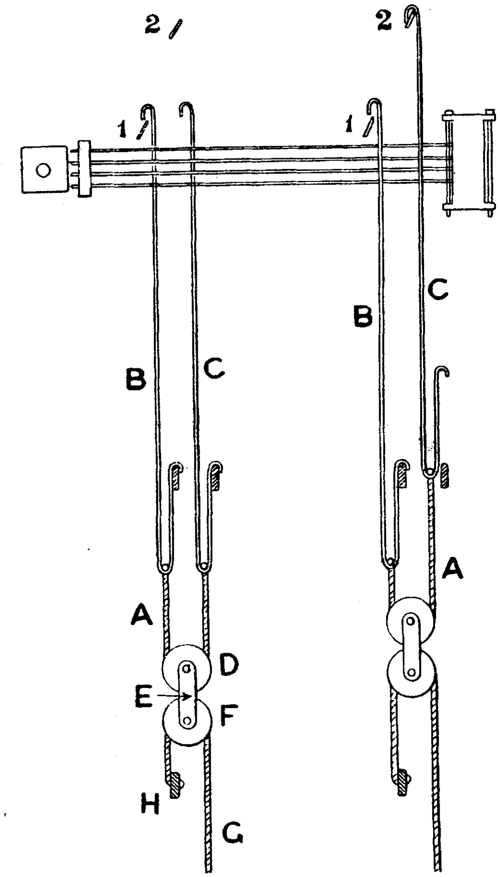

FIG. 95.

bars H, which are placed lengthwise of the machine and between alternate lines of hooks. After being led round the pulley F, the other end of G is made fast to the mounting threads.

If both hooks which govern a warp thread are down, that thread is in the bottom shed line, but by lifting one hook it is raised to the top line, and may be retained in that position for any length of time, provided the reciprocating griffe bars lift one hook at each upward journey; for the cord given off by the fall of B is taken up by the rise of C without putting additional strain upon either machine or warp. But the neck cords A, G wear rapidly.

An open shed machine, invented in 1889 by Cheetham and Sutcliffe, is constructed on the double-lift single-cylinder principle, with needles M, Fig. 96, to move double hooks, both legs of which are 15″ long and equally bent at the top. This form has been adopted to avoid the trouble arising from the use of double neck cords. Each hook rests upon a bottom board U, through which a single neck cord V passes. At $4\frac{1}{4}''$ above U an internal bend T′ is formed on the back leg of each hook for the purpose of suspending it from a stationary griffe Z2, the latter being bolted to the end framing $7\frac{1}{2}''$ above V.

All the griffe blades are $1\frac{1}{4}''$ deep; those of the top griffe Z′ are fixed in slotted plates 11″ deep, while those of the bottom griffe Z are secured to plates $2\frac{1}{4}''$ deep. A second plate is bolted inside each end of the frame of Z and drilled to allow eight horizontal pins 1 to pass through; the pins project from opposite ends of wrought-iron plates 23, and 23 are similar in form and number to the griffe blades, but are 2″ deep. Their lower edges are parallel with, but $\frac{1}{8}''$ above and $\frac{1}{4}''$ in advance of the knives 4. All engage with projections on two sliding bars 24, only one of which is shown in the drawing, and the plates are capable of swivelling on the pins 1.

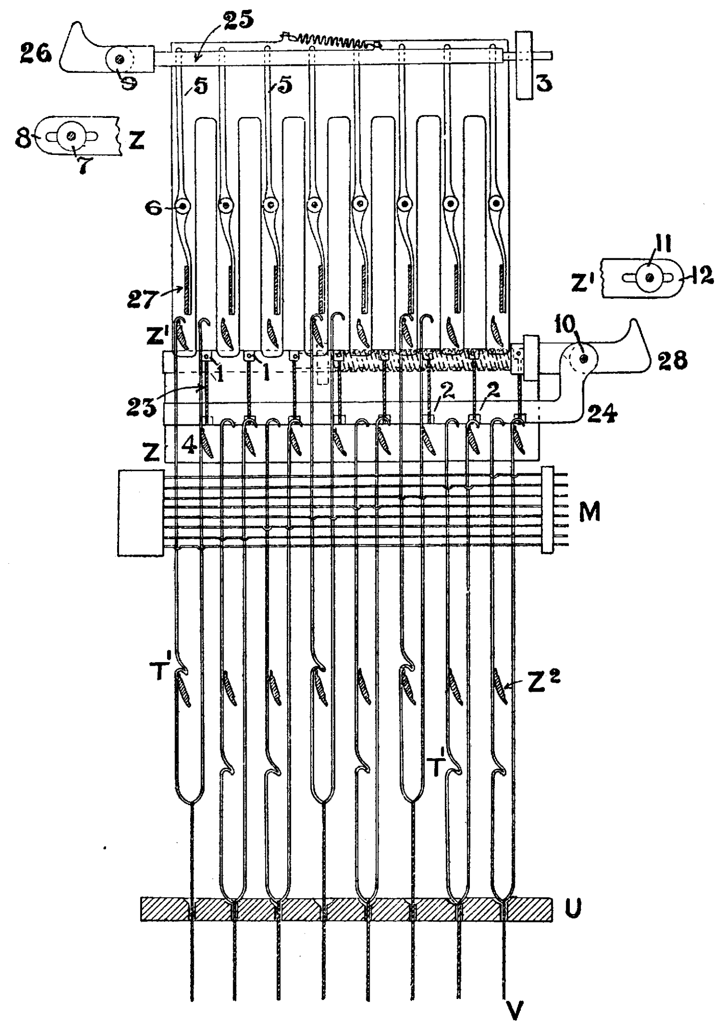

FIG. 96.

A hole is drilled in the rail 3 near each end of the upper griffe frame Z′; the holes, together with brackets, hold two horizontal sliding bars 25 against the inner edges of Z′. The bars 25 are drilled vertically to take the ends of eight upright iron pins 5, which are centred at 6 upon the long griffe plates of Z′, and their lower ends carry a second set of plates 27, which are fixed in the same positions with relation to griffe Z′ that the plates 23 occupy to griffe Z.

Two swivelling pieces 26 are fitted by pins 9 to the sliding rods 25; their inclined upper surfaces are brought into contact with two antifriction bowls 7 that are free to turn upon studs secured by brackets 8 to the ends of the bottom griffe frame Z. As these bowls are carried up by Z, the pieces 26 turn upon their respective pins 9 and allow the bowls 7 to pass; but when the griffe Z descends the pieces 26 are rigid, and the bowls, by bearing upon the inclined surfaces, force back the sliding bars 25, vibrate the plates 27, and carry their lower edges against the free heads of the falling hooks, thus preventing the rising griffe Z′ from carrying those hooks up again.

Two pendent arms 12 from the griffe Z′ move similar bowls 11 into contact with similar swivelling pieces 28 that project from the frame of Z, and thus the free head of each descending hook is again pushed out of reach of the ascending griffe Z, but this only takes place when the blades of Z, Z′ are level.

Each griffe Z, Z′ carries the catches T′ about $\frac{1}{4}''$ above the top of the stationary griffe Z2; the hooks then spring over the bars and are suspended in that position until the pattern requires them to change it. At each change they are pushed off by a blank in a card and sink with the griffe that happens to be up. When the cylinder A presses a card against the needles M, all the catches T′ are lifted above Z2, hence the force required to push them clear of Z2 is little more than that needed to press back a needle and hook in a Crossley machine. The plates 23, 27 make it a difficult matter to repair injured parts, and if a loom is turned backward they are liable to bend the hooks.

The Verdol Jacquard

Of the Jacquards specially constructed for the economical reproduction of design in fabrics there are two kinds: *a*, those intended for general use, and, *b*, those for special use. Of the machines included in class *a*, that invented in 1884 by M. Verdol is the most important. It is a small-gauge machine, in which the selecting needles are placed in zigzag lines and so close together that 896 needles only cover a space of 1″ by $11\frac{1}{2}''$. This is done to economise paper and reduce the chances of it being distorted under the varying hygrometric conditions of the atmosphere. All the needles are moved by an endless band of thin paper, which is doubled in thickness at both ends and along the centre. At all thickened places peg holes are cut for pegs to draw it forward. Thirty yards of this paper are equal to 1000 cards and weigh two pounds; as compared with cards this represents a reduction of $\frac{49}{50}$. Except for accidents, the inventor claims that his paper is almost indestructible.

Several causes militate against the extensive use of this machine in high-speed looms. First, the varying humidity of the atmosphere in weaving sheds tends to rumple the paper; a defect, however, that the inventor now claims to have overcome. The remaining causes are dust, oxidation, and vibration.

In a machine so closely packed with wire and requiring such delicate adjustment, firmness, freedom from fibrous dust and rust are essential, otherwise the parts will become clogged or move unsteadily, and imperfections in the fabric will be of frequent occurrence.

A small-gauge Jacquard of the ordinary description is employed, with its needles arranged in multiples of 112 up

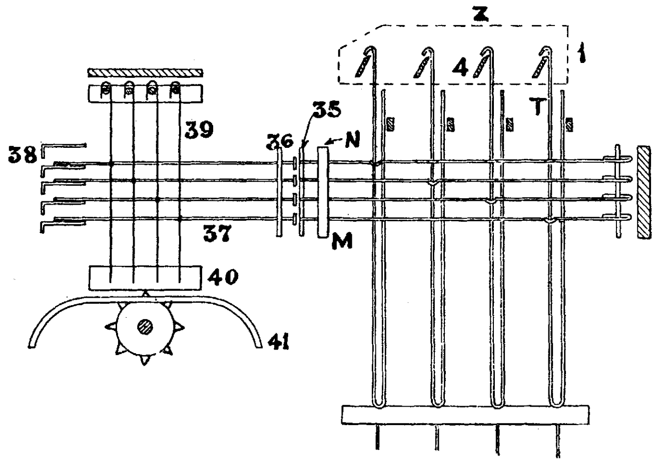

FIG. 97.

to 1792. It is complete in every respect up to the needle plate N, Fig. 97, but instead of a cylinder and cards, a box is made to slide to and fro before the needles M. The box contains two plates, 35, 36, and both are drilled exactly like the needle plate N; the former takes the points of M, the latter supports in a horizontal position a series of drivers 37, which are about 6″ in length. A driver faces each needle and is furnished with a disc head to render contact with M certain. At the opposite end of the box a series of rectangular parallel bars 38 are so secured as to

leave room for the rear ends of the drivers 37 to pass between, and each horizontal arm forms a support for one row of drivers.

A series of fine steel needles 39 are suspended by a hook from a slotted grid, in which they are free to rise and fall. Each is provided with a coiled eye to govern a driver 37. The vertical position of 39 is maintained by a plate 40, which is perforated in zigzag rows to the gauge of the paper and paper plate 41. All the needles 39 enter but do not normally protrude through the plate 40. A curved and perforated metal plate 41 is employed in lieu of cylinder; the paper band is passed between 40 and 41 and rotated by wheels, from the periphery of which pegs project at regular distances. The pegs pass through slots in 41 and take into peg holes in the paper. The plate 41 moves vertically through a space of $\frac{3}{16}''$ to $\frac{1}{4}''$ to force up plate 40 and move the needles 39 into contact with the paper. A blank lifts a needle and also a driver until the rear end of the latter is against the vertical arm of an angle bar 38, but a hole leaves both undisturbed.

Instead of lifting the parts 40, 41, Herm. Schroers, of Krefeld, causes the rack of bars 38, the rear ends of the drivers 37, and the needles 39 to rise and fall. An upward movement of 38 carries the needle points into the needle plate 40 before the band of paper is moved, and a downward movement of 38 makes contact between the needles and paper, hence the paper merely rotates.

Immediately the needles 39 and the drivers 37 have been actuated by the paper, the box advances against the Jacquard needles M, and where a driver is lifted against an angle plate its head will push back a needle, and therefore a hook T from the griffe Z; but where any driver is left down, its head will be pushed back by a needle M, and its straight end will pass between the angle plates without disturbing a hook.

The vertical needles should fall by gravitation, aided in part by the weight of the drivers; still, to render sticking impossible, a trap board is brought down upon the grid to level them after every lift of the griffe. The parts of this invention can now be attached to any existing Jacquard, or they can be removed in a short time and replaced by a cylinder and cards.

Verdol's machine is in extensive use on the Continent of Europe, but unless a firm discards other makes of Jacquards, complications are likely to arise. For instance, two sets of perforating machinery will be required, and when a sheet of paper has to be cut from a design the plant is both elaborate and costly. Cost is often reduced by cutting a set of inferior cards on the piano card-cutter, after which a repeater transfers the cutting to the sheet of paper. Further, a number of sets of cards and paper bands may have been prepared for the same pattern; if half are for ordinary and half for Verdol's machines, the looms fitted with either may be required for a different class of work; there may then be a number of sets idle, and yet a demand for that pattern would necessitate cutting extra sets to suit the looms available. If all the Jacquards were of one type, trouble of this kind would be impossible. The new plan by which any Jacquard can be used with or without Verdol's attachment has, however, simplified matters in this respect.

The Electric Jacquard

So long ago as 1853 M. Bonelli attempted to employ electricity instead of cards to move the needles and hooks

in a Jacquard. At that time electricity was imperfectly understood, and its practical application was very limited. The complex nature of Bonelli's machine militated against its adoption. It required the following additions to a 400-needle Jacquard: namely, 400 armatures, 400 electro-magnets, 400 metal feelers, 800 covered wires, a battery, parts for putting all in operation, and suitable framing to support them.

In 1860 Bonelli introduced a machine details of which are given in Fig. 98, and its operation was as follows:—The feelers 49 were dropped into contact with the pattern sheet, and where they rested upon metal the electric circuit was complete, and the magnets 51 were magnetised. All such magnets, by preventing the armatures 53 from moving forward with the frame 52, drew their heads inside the plate 54. But those feelers that rested upon varnished portions of the pattern plate broke the electric circuit; and, consequently, when the frame 52 moved forward, it carried with it the armatures that faced dead magnets, and their heads remained outside the locking plate 54. In the first case this was equal to presenting perforated cards, and in the second blank cards, to the needles. The feelers 49 next rose, the pattern sheet partially rotated, and the operations were again repeated.

Patterns of two or more colours could be produced by superposing successive metal plates, each representing a different colour, and insulating them by layers of varnish. Or patterns could be composed of movable metal types, set up in the same way as printing types.

Since Bonelli placed his invention upon the market electrical science has made remarkable advances, and many able inventors have endeavoured to improve upon the original model. Several are now engaged in devising new parts and in perfecting the actions of old ones. Amongst these the following have obtained recent patents, namely,

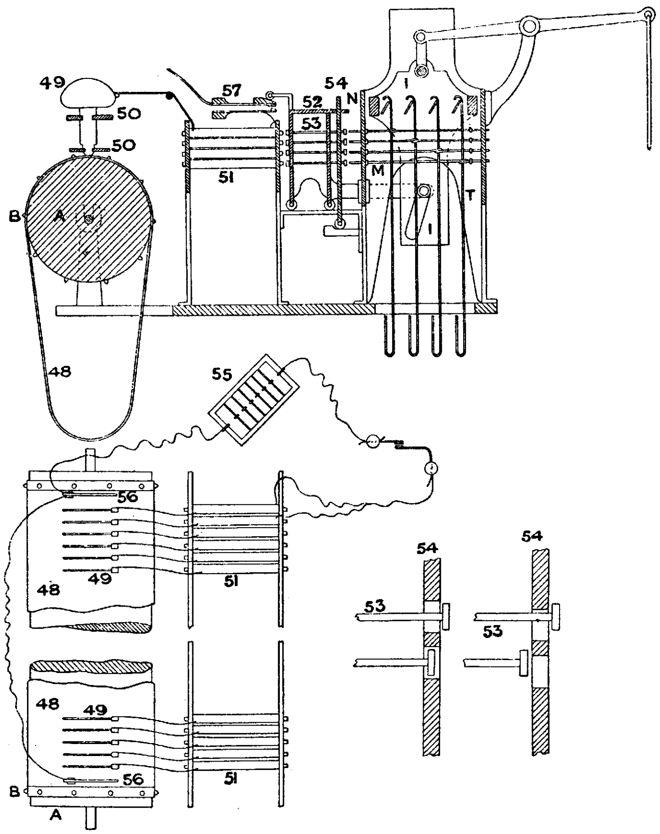

Fig. 98.

Tschörner and Wein in 1887; Kauffmann in 1892; Gates in 1896; Kleinberg and Czczepanik in 1896; and Dr. Carver, who since 1896 has given the subject much

attention. They have effected improvements upon Bonelli's invention, and have apparently solved several of the problems connected with electrical selection. But although a few of these machines have been erected in mills, the inventions remain more or less in the experimental state. It is, however, probable that in the near future an electrically controlled Jacquard will be an accomplished fact.

Jacquards for Special Use

The Jacquards included in class *b* (see p. 175) are those which have been designed for the economical production of bordered fabrics, swivels, damasks, carpets, two or more ply fabrics, and many others.

A specially constructed machine is employed to manufacture fabrics with two designs that form cross stripes, and one design surrounded by a border as for handkerchiefs, table-covers, bed-covers, and towels. It effects a considerable saving in cards, as all the foregoing may be woven from one repeat of each pattern. For example, let it be assumed that the table-cover has six repeats of the body pattern; then, as compared with an ordinary machine, $\frac{5}{6}$ of the body and $\frac{1}{2}$ the border cards would be saved, for in the former two repeats of the end border and six repeats of the body and side border would be required. Or failing that, the loom would stop while the cards were changed for each fabric. Thus: after weaving the first border the body cards must be put on and they in turn will be removed for the last border. Rather than adopt such a course, however, manufacturers of cotton goods often incur the cost of a full set of cards.

Cross-Border Jacquards

In all cases where the speed of a loom is strictly limited by other than the shedding mechanism, and where single-acting Jacquards may be economically employed, cross stripes and cross-bordered fabrics may be woven with a double-lift double-cylinder Jacquard (see Fig. 92). The border cards are then passed round one cylinder and the body cards round the other. Two connecting rods are provided for the same crank pin, but only one is used at any time, and that will work one cylinder and one griffe until a change is necessary. The first rod is then removed from the crank pin and the second one placed upon it, to operate the other half of the machine and weave the second pattern. Or one jointed rod may be used as at V, W, Fig. 111. Both plans convert a double-lift machine into a single-lift, yet they avoid complications, and allow changes to be made in a short time, but they are obviously unsuitable for high-speed looms.

Another plan has been introduced by a manufacturer in Saxony, who employs two cylinders, one to swing from above, the other from below. Each swan neck forms an open fork, and when a change is necessary the griffe must be lifted until the bowl leaves the forks, then the upper cylinder can be turned up, or the lower one turned down. To disconnect the griffe and swan necks, however, an extra strain is thrown upon the warp.

In 1883 Messrs. Davenport and Crossley patented one of the best-known of these machines for high-speed looms. It is constructed with two cylinders and a duplicate set of needles. Both sets of needles move the same hooks, but when in action the machine is a double-lift single-cylinder, for one cylinder is always stationary. By passing the

border cards round A′, Fig. 100, and the body cards round A, and so connecting A, A′ that by moving a lever one stops and the other starts, any number of repeats of each pattern may be woven from one repeat of cards. The hooks T, Fig.

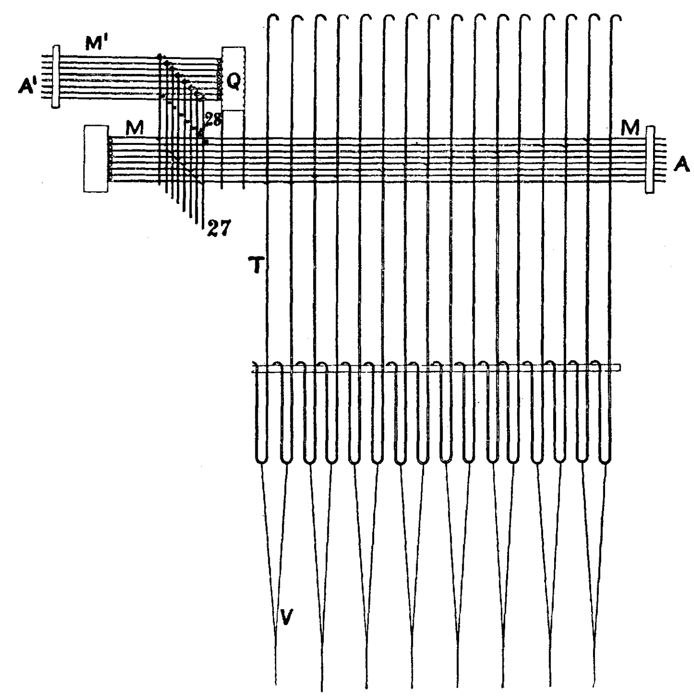

Fig. 99.

99, in a 400-needle machine are $19\frac{1}{4}''$ long. The needles M are $23\frac{1}{2}''$ long and each has an extra cranked eye. A needle M′ is 8″ long and has a coiled eye immediately over the extra crank in M. A hooked pin 27 is passed through an eye of M′, also through the extra crank of M, and is suspended from M′ by its hook. The top row of M′ is thus connected by pins 27 to the top row of M, and succeeding rows of needles are united by succeeding rows of pins; as a consequence, if the numbered side of each card on the cylinder A faces the needles, the numbers of those on A′ must be inverted to face the cylinder, or the pattern will be spoiled.

Eight horizontal bars 28 are $\frac{3}{8}''$ wide by $\frac{1}{8}''$ deep, and long enough to reach across the machine. Each is set behind one row of pins 27 to serve as a fulcrum for all pins in one row; hence if a supplementary needle M′ is pushed back, the pin 27 will be tilted sufficiently to draw back one needle M and two hooks into the positions they would occupy if the point of M had been pressed back by a blank card. The top bar 28 is passed between the two bottom rows of needles M′, the bottom bar is between the top rows of M, and the six remaining bars are equally distributed between M, M′.

The long needles M are steadied by causing the heel-rack pins of M′ and the spring box pins Q to pass between them.

This machine contains more wire than is desirable, and the parts are difficult to repair, but it has been greatly improved by substituting flat bars 28 and hooked pins 27 for eyed pins threaded upon a fulcrum, as in Nuttall's automatic card-repeating machine, from which the idea was taken (see Fig. 154).

The cylinders A, A′ may be put in and out of action either manually or automatically; but the following device is in most general use:—A connecting rod 16, Fig. 100, a horizontal arm 17, a shaft 18, and two vertical arms 19 are all as in Crossley's single-cylinder machine; but the arms 19 are employed to rock a vertical lever whose fulcrum is at 9. The cylinder bars 7, 7′ are each slotted and

notched to receive two studs 20, 20′, which are fixed upon opposite ends of the rocking lever 9. When the stud 20 is in the notch of 7, the cylinder A is in action and the

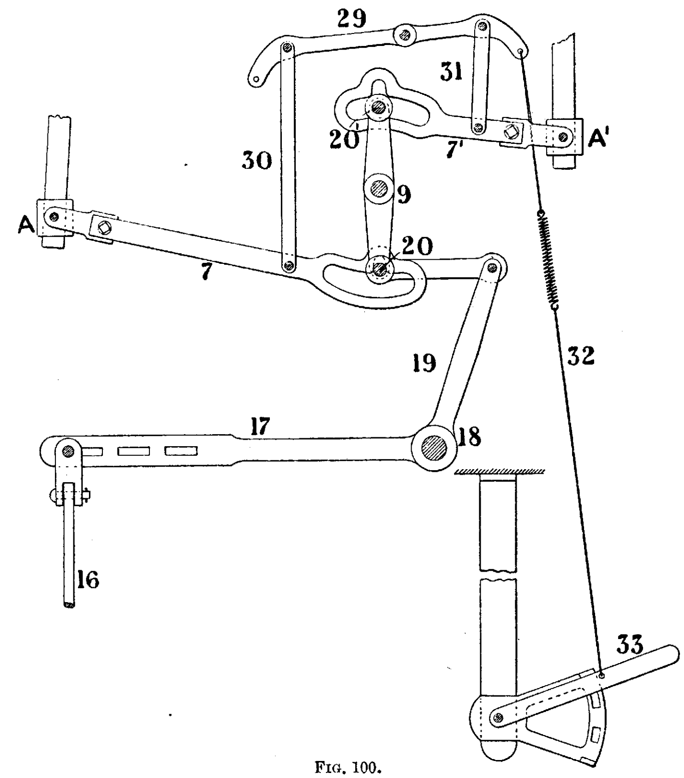

FIG. 100.

stud 20′ is in the slot of 7′. Changes are made by a lever 29 and links 30, 31. The link 30 is bolted to the arm 7, and 31 to 7′. A cord or wire 32 is secured to 29, and also to a quadrant handle 33, the latter being retained in a fixed position by one of two projections on the quadrant face. By moving 33 to the next stop, the studs 20, 20′ change places, and the cylinder arms 7′ begin to move as the arms 7 become stationary.

A cross-border device applicable to Jacquards, invented by J. T. Whalley and introduced by James M'Murdo in 1919, is illustrated in Figs. 101, 102. The hooks and needles are arranged as in Fig. 99, but both cylinders S and S′, Fig. 101, carrying respectively the body and the border pattern cards, beat in to their needles continuously and simultaneously, receiving their motion from the rocking shaft M through the links O, O′. The slotted arms T, T′ guide the cylinders in their horizontal paths. Each cylinder is provided with two catches P, P′, one for rotating the cylinder forwards, the other for reversing it. These catches are extended beyond their fulcra and their tail ends rest on a chain of lags Q, mounted on a lag barrel J. Spiral springs R keep the catches steady. By suitably pegging the lags any of the four catches can be put into or out of gear, and the cylinders can be rotated forwards or backwards, or put out of action. One or other of the cylinders is out of action on each pick, and that cylinder then presents to its needles a fully cut card, one such card being introduced into both body and border sets (see Fig. 103).

The changing mechanism is put into operation by one or other of the needles A or B, Fig. 102, when acted on by a long card O, Fig. 103. The needles A, B are placed out of range of cards of ordinary length, and a long card O must be introduced into the set wherever a change is required.

The lag barrel J, Fig. 102, is turned, when required, by two pawls K, L, and a double ratchet I, K and L receive reciprocating motion from an arm N fixed to the rocking

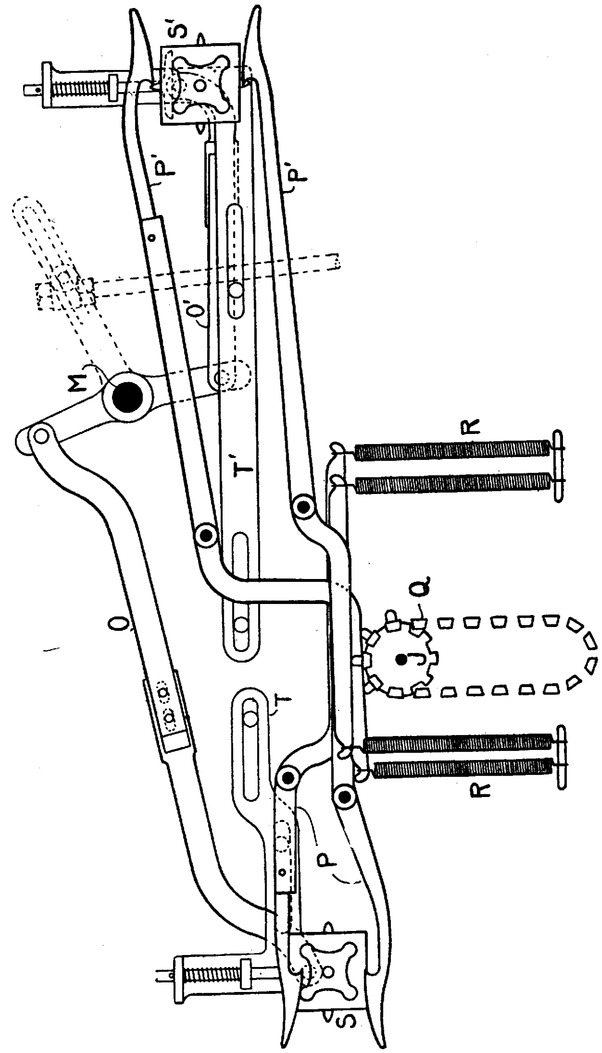

Fig. 101.

shaft M, but in the inoperative position shown in Fig. 102, K slides idly on a long tooth of the outer ratchet I, while L is kept out of contact with the inner ratchet by a plate H which is supported by one of three projecting lugs on the ratchet I.

When a change is required, a long card O acts on either needle A or B, the latter conveying its movement to A through the lever wire C, fulcrumed at D. The turned-

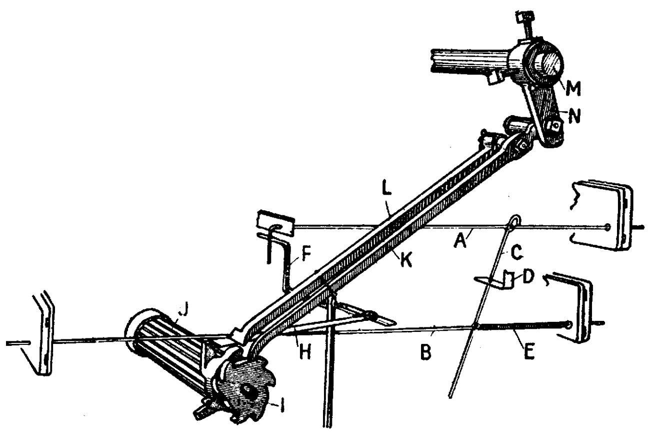

FIG. 102.

down end of A acts on the lever F which withdraws H from the supporting lug on the ratchet I, and L is lowered into contact with the tooth on the inner ratchet. L drives the lag barrel J forward one lag, and allows pawl K to come into action on the outer ratchet. K moves J forward one lag on each of the two succeeding picks, at the end of which H is lifted by the next lug on the inner ratchet, carrying the pawl L out of action and stopping the lag barrel J until the mechanism is again set in action by

another long card O. Thus J moves forward three lags every time a long card O is presented to the needles.

The arrangement of the pattern cards is shown in Fig. 103, which illustrates the lacing for a body pattern of 100 picks. Card number 100 for the last pick of the pattern is laced as the first card in the border set, being placed between the fully cut card and number 1 of the border set. This is done so that the body pattern can be repeated, number 100 being presented to the needles by the border pattern cylinder whilst the fully cut card in the body set is presented. The movements of the lag barrel and cylinders during the change would be as follows:

Pick number.	98.	99.	100.	1.
Movement of lag barrel J.	Moves one lag.	Moves one lag.	Moves one lag.	No movement
Movement of body pattern cylinder S.	Turns forward. Presents card number 99.	Turns forward. Presents fully cut card.	Turns forward. Presents card number 1.	Turns forward Presents card number 2.
Movement of border pattern cylinder S′.	No movement. Presents fully cut card.	Turns forward. Presents card number 100.	Turns back. Presents fully cut card.	No movement Presents fully cut card.

The body pattern can thus be repeated as often as desired. To reverse the body pattern the lags would be pegged so that on pick number 100 the cylinder S turns back, presents card number 99, and continues to turn back till the repeat has been woven. The border pattern cylinder S′ would move as before.

When it is necessary to reverse a pattern in this way, whether a body or a border pattern, a second changing card O must be introduced into the set, and this would be card number 2. In that case six lags must be provided every time that pattern is woven, since each of the two long cards O requires three lags. Only one of these sets of three lags is used for the change; the other three lags must all be pegged the same so as not to affect the movement of the cylinders.

The long cards O are unable to pass through the card cradle, but a neat arrangement of card wires is provided which keeps these cards folded on the top of the cradle.

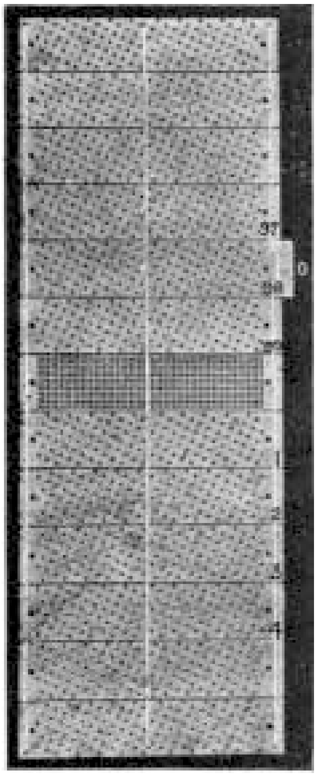

FIG. 103.

TWO PATTERNS ON ONE SET OF CARDS

Two patterns are sometimes cut on each card, the first on odd-numbered rows of every card, and the second on even-numbered rows. In such a Jacquard alternate rows of needles are removed. A motion may be attached to the cylinder or cylinders, or the needle plate may be moved automatically in a manner resembling one of those described for a decked dobby (see pp. 84, 92). After weaving as many repeats of pattern one as are required, either the cylinder or the needle plate is moved and pattern two brought to face

the needles. If eight repeats of one and two repeats of the other pattern are necessary, the economy effected consists in using one repeat of cards, doubled in width, but of the usual length, instead of $8+2=10$ repeats of single-width cards. Only patterns containing an equal number of picks to a repeat, or those in which one is a multiple of the other, can be produced by this plan.

In 1900 Walter Paton patented a cross-border Jacquard having two cylinders fitted upon the same side of the machine, one to stand farther out than and above the other. The bottom cylinder A, Fig. 104, carries the body and side border cards, and the upper cylinder A′ carries the end border cards. A acts through double-cranked needles M, upon two hooks T, each of which is 27″ long, in the same manner that the cylinder of a Crossley machine acts, and two hooks are united by neck cords V to operate one warp thread. A′ acts upon a separate set of needles M′ to control the same hooks as the needles M. Each needle M′ has for eyes two long cranks, which permit M to press back the hooks without obstruction. Yet the front of each crank in M′ is available for operating a hook in the usual manner.

One cylinder may be put in or out of action by a similar plan to that illustrated in Fig. 100; or automatic mechanism may be employed. In either event the efficiency of the machine will be largely determined by the mechanism for operating the cylinders. In other respects the machine is simple and, except that the top needle M is 10″ from the hook head, the design is satisfactory.

The cord machine (see pp. 151, 152) was altered in 1889, by H. Fawcett, to weave cross-bordered fabrics. In order to accomplish this he made the needles straight at both ends and to project beyond two needle plates. One cylinder controls the side border and body cards, the other those for the end border. When one cylinder is in action the other is away from the needles and inoperative. The trap board has a saw slit on each side of every hole, hence, other things permitting, a cord will enter a slit no matter

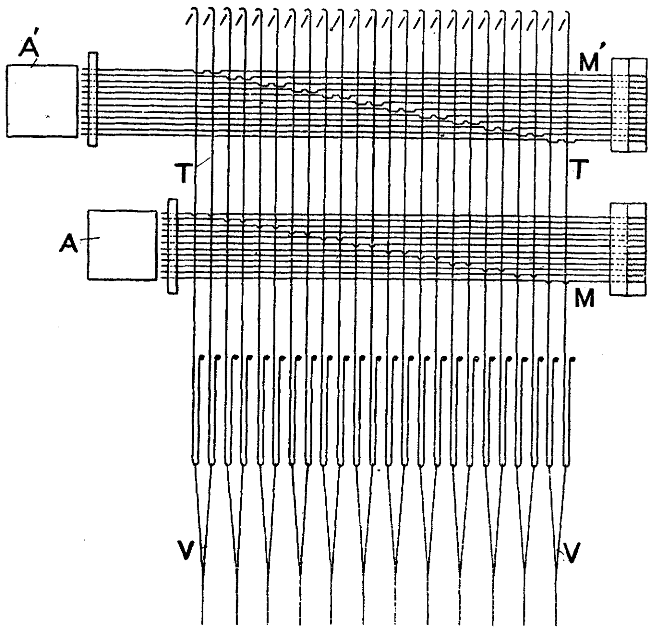

Fig. 104.

which end of its needle is pressed back. After each card has been presented, a batting board restores the needles to their normal positions, and since there are two cylinders there must be two boards. But immediately before a set of cards is changed one board is moved vertically out of reach of the cylinder which is to become active; the other

is moved level with, and between, the needles and the stationary cylinder. Beneath the trap board a species of grid is fitted horizontally; its bars are parallel with, and enclose, the neck cords. By moving this grid laterally whenever a change from border to body or body to border cards has to be made, one set of slits in the trap board will be closed, but the other set will be left open for the cords to enter. In order to clear the cords from the slits, the suspension board, the trap board, and the bottom board all move laterally for each pick.

Double Shed Jacquards

Jacquards have been built to weave fabrics that require two picks of weft, or one weft and one wire, to be superposed, both being simultaneously passed through separate sheds in the warp. In the case of swivelled fabrics, the lower shed receives ground weft, and the upper one swivel weft.

Messrs. Howarth and Pearson, in 1868, constructed such a machine with the object of doubling the production of a loom. The device is shown at Fig. 105. This machine makes imperfect cloth, because the ground weft floats under the figure in precisely the same manner as swivel weft.

In the manufacture of pile fabrics, where wires are woven into the pieces in the same manner as weft threads, and subsequently withdrawn or cut out, a loom is furnished with a compound harness, consisting of healds for controlling the ground warp and a Jacquard for controlling the pile warp. Two sheds are opened simultaneously, one to receive a shuttle, the other a wire. The healds form a single shed, but the Jacquard forms a double one. This is done by using hooks which are approximately 27″ long, and by lifting them from two places. Thus the grid has a sufficient vertical movement imparted to it to carry all the hooks to the top of the first shed, and the griffe moves far enough to carry a selected number of hooks to the top of the second shed. Both grid and griffe are moved by cams and levers in the usual manner.

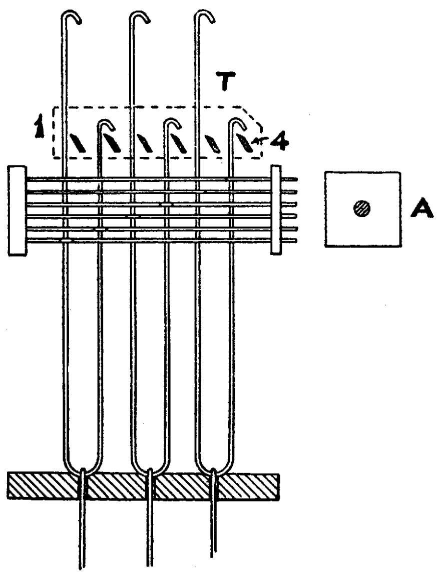

FIG. 105.

Instead of the foregoing, a cord machine (see pp. 151, 152, and 191) may be employed in conjunction with healds. In that event a knot is tied upon every cord on a level with the upper face of the bottom board, and a vertical movement, equal to the depth of the bottom shed, is given to that board. Meanwhile the trap board carries up a number of cords to form the second shed.

COMPOUND JACQUARDS

Certain compound fabrics whose figured effects depend solely upon colour are made by the aid of Jacquards having two sets of hooks to one set of needles and cards, as in Fig. 106. All hooks moved by the griffe Z are placed in succeeding rows to face the cylinder, and lift when vertical; while all hooks moved by Z′ face the spring box, and are left down when vertical.

Each needle M governs two hooks that occupy corresponding positions in both sections of the machine. But succeeding needles in one vertical row do not govern succeeding hooks. It will be noticed that needles 1 to 8 respectively control hooks 1 and 9, 5 and 13, 2 and 10, 6 and 14, 3 and 11, 7 and 15, 4 and 12, and 8 and 16. This is done to avoid crossing the harness at the comber boards, for the neck cords from the first four hooks are connected to successive couplings in the comber board No. 1, Figs. 127, 128, and those from hooks 5 to 8 are attached to couplings in board No. 2. Hooks in the second section of the machine are similarly connected to couplings in boards 3 and 4. The griffe Z governs one warp, Z′ another. The cylinder and griffes have separate actions and only move once in two picks. Thus while A presses a card against the needles M, the griffe Z rises with the vertical hooks T. If one warp is blue, the other white, threads of blue will be lifted by Z, and a pick of white weft will be passed between white warp threads in plain or twill order. But the white threads are lifted independently of the Jacquard, as explained on pp. 243 to 246. Z then sinks, and Z′ in ascending takes with it the white warp threads that occupy positions corresponding with those of the blue warp previously left down by Z, and blue weft is passed through a plain or twill blue shed, also formed independently of

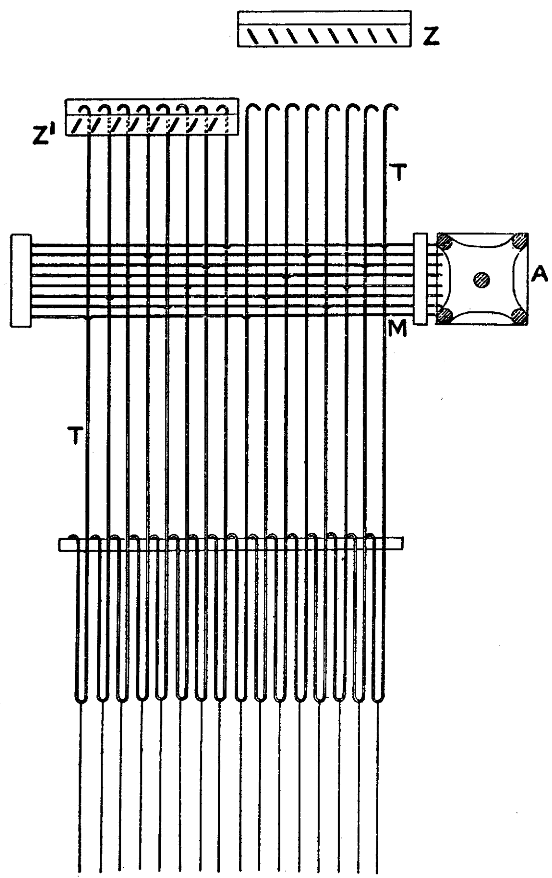

FIG. 106.

the Jacquard. During this time card 1 has remained pressed against the needles, but the cylinder A now brings

card 2 into contact with the needles, and the foregoing process is repeated.

This machine is excellent for the work it is capable of doing, but its application is necessarily limited.

SCALE JACQUARDS

Scale harnesses (see pp. 246 to 253) preceded scale Jacquards by many years. But at the present time there are several machines which do similar work to that formerly done by harnesses. The machines possess advantages over a harness whether the shafts are placed below the comber board, or slightly below the bottom board of a Jacquard. In Fig. 107 two vertical sections A, B of a scale machine are shown. In section A each figuring needle M is seen to govern two adjacent figuring hooks T, and the tail of each hook rests upon a twilling bar C, which is in turn supported by a grid D. The twilling bars C are laid at right angles to the needles, and each can be lifted at pleasure to cause a line of hooks to rise. This is done by adding an extra hook T′, section B, to each end of every row of figuring hooks. A hook T′ has a coiled eye at G for the reception of one end of a twilling bar C. By lifting a corresponding hook T′ at each end of the machine, a twilling bar will carry up all the figuring hooks T in that line. Outside the space allotted for figuring needles M, two small sets of cards are placed upon the cylinder H, and these are cut to lift single threads of warp to bind ground portions of the fabric, while the large cards weave the figure by lifting contiguous warp threads in pairs. Beneath the coil G, the twilling hooks T′ are straight and are passed through guide holes in the grid D. In the drawing each needle M′ actuates two twilling hooks, hence any ground weave made by this machine

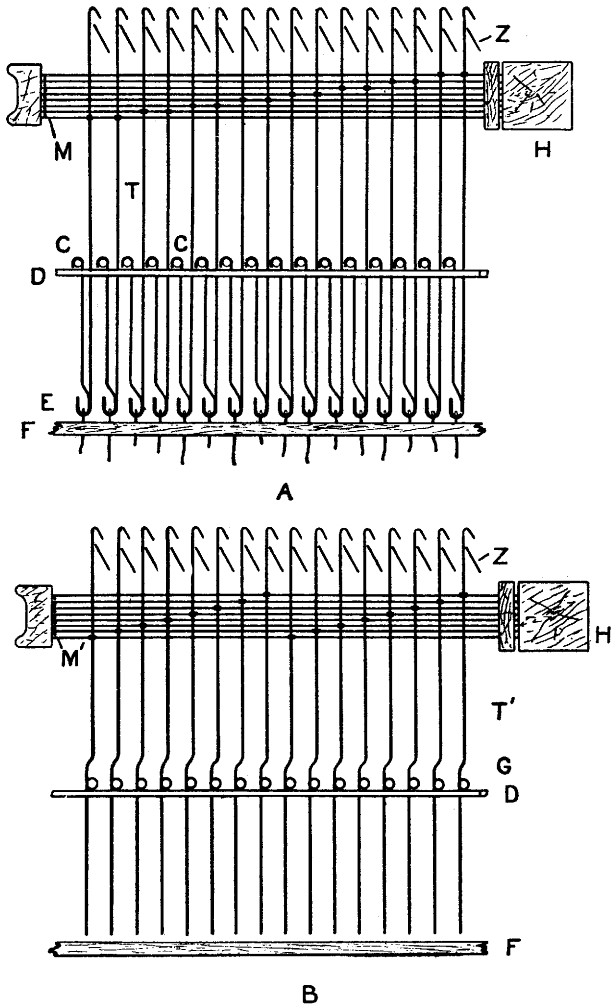

FIG. 107.

must repeat upon 8 threads. But by using two rows of needles at each end of the machine every twilling hook may be put under separate control, and patterns of 16 threads to a repeat may be woven. Also, each figuring needle M may control three or four hooks T, and by so doing a design will be made three or four times as large as it could be made with an ordinary Jacquard. The base of each hook T is bent to facilitate the attachment or detachment of a harness. See also K, Fig. 118.

Twilling Jacquards

Where large patterns are to be made from closely placed warp, the cost of employing ordinary Jacquards of sufficient capacity is almost prohibitive, especially now that most patterns have a short run. Inventors have endeavoured to solve the problem of reducing the number of cards, by devising special harnesses, and by constructing special Jacquards. It is the latter that will be dealt with here.

In 1859 J. Shields invented a machine that was capable of lifting and leaving down warp, irrespective of the perforations in a card ; also of making one card serve for two or more picks. The idea has been developed by several succeeding inventors, of whom Barcroft, and Tschörner and Wein, have devised the best-known plans.

The Bessbrook Jacquard

The "Bessbrook" Jacquard was invented by H. Barcroft in 1869, and is applicable to textures in which the entire fabric is bound together by a twill, a satin, or some other regular system of interlacing.

The action of the cards is to lift all warp where figure is to be formed, and leave it down where ground is required; this would not produce a useful texture. Parts are therefore added to prevent one thread in each repeat of the figure binding weave from rising, and to lift one thread in each repeat of the ground weave. Even this is inadequate; one needle must actuate two, three, or more hooks, and one card must suffice for two, three, or more picks. The advantages of a twilling machine over an ordinary Jacquard will be apparent if it is assumed that a machine of each kind has 400 needles. Then if a twilling machine with three hooks to one needle gives three picks to one card, the warp threads to one repeat equal $400 \times 3 = 1200$, or a range equal to that of three ordinary 400-needle Jacquards; but the latter would require three cards to one pick, instead of three picks to one card, or nine times as many as a Bessbrook. There are other advantages; for instance, a considerable alteration in the closeness of the weft threads would distort an ordinary pattern, but with a Bessbrook machine such an alteration would merely require more, or fewer, picks to each card, in proportion to the alteration; thus, instead of three picks to a card, two or four could be inserted, or again, two for one and three for the next card. Changes in the closeness of warp threads would require two hooks to be moved by one needle, three by another, or four by all; but with a given count of reed the greater the number of picks to a card, and hooks to a needle, the more irregular the outline of a figure becomes.

There have been several modifications of the Bessbrook, but the leading idea in all has been to lift each hook at pleasure from two places, and for each pick of weft to move two or more griffe bars from an inclined to a vertical position, so that entire rows of hooks shall be left down;

also to cause hooks in the rows adjacent to the vertical blades to be lifted, whether a card has acted upon them or not; at other parts of the machine, only vertical hooks will rise.

The inventor accomplishes these things as follows:—A hook T, Fig. 108, is 15″ long, and a closed loop is formed

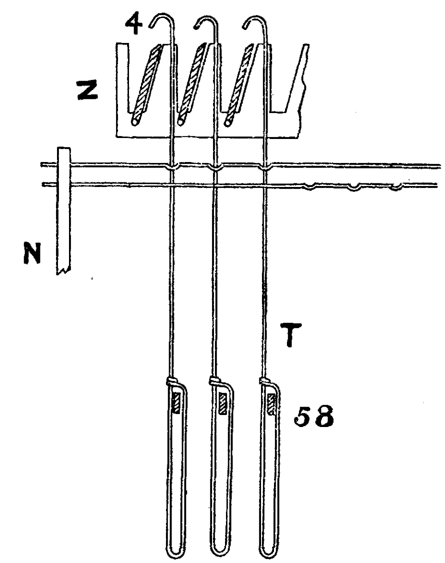

Fig. 108.

at the bottom by twisting the end of the short leg round the long one; the length of this loop must exceed the depth of a shed. When not in action the hooks in each row are supported by a bar 58, which passes through the loops and rests in a slotted framing 59, Fig. 109. A hooked rod 60 is attached to each end of every bar; it rises to the level of ordinary hooks, and is supported by, but held back from, the griffe Z by a needle M′. The needles M′ are 16″ long, and have a collar 61 upon each. An open spiral spring is threaded upon each needle to impinge against the needle plate N and the collar 61.

The griffe frame Z, Fig. 108, is slotted to receive and limit the angular movements of the blades 4. The basal ends of 4 terminate in pins that enter holes in the griffe frame, and each blade can be turned from an inclined to a

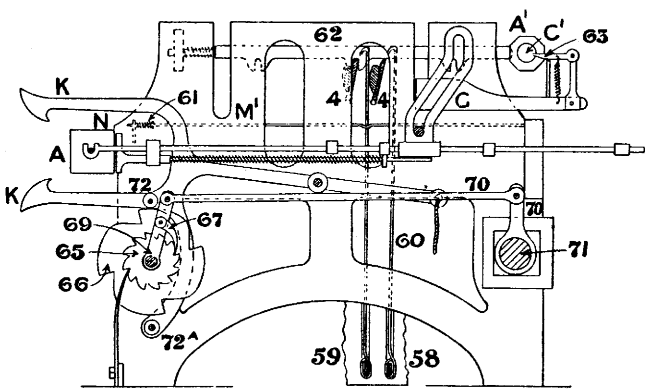

Fig. 109.

vertical position. Two or more blades are moved simultaneously by flat bars 62, Fig. 109, which have notched projections on their lower edges. Each bar 62 is cylindrical at one end, to receive a spiral spring, and that end is passed through a perforated plate, but the other end is flat and works in a grid. Immediately in front of the flat ends a pegged cylinder A′ is placed parallel with the cylinder A, but at the opposite side of the Jacquard. A′ is fixed in bearings in the griffe block; it moves up and down with the griffe, and is turned $\frac{1}{8}$ of a revolution for each pick

by a finger 63 that is free to be lifted, but cannot be depressed. A lantern C′ is attached to one end of A′ and when it strikes the finger 63 the cylinder moves, causes a fresh set of pegs to bear against the ends of the twilling bars 62, and the bars place certain blades out of reach of their hooks. Two curved pieces of brass are secured upon each blade to face the thick hooks 60. As a blade is turned up the brasses move two hooks 60 over an adjacent sloping blade, close two spiral springs 61, thrust forward two needles M′, and cause a bar 58, with all the hooks it controls, to be lifted at the next upward movement of the griffe. In order to operate the last pair of hooks 60, two brasses are mounted upon a swivelling piece placed behind the back row of hooked rods.

The cylinder A receives a sliding motion from a pair of swan necks G, which are bolted upon side shafts, but the double catch K only turns it when required. K is operated by compounding a ratchet 65 with a tappet 66, and fitting them upon a stud. The ratchet is moved one tooth for each pick by a pawl 67, and 67 is held in the teeth of 65 by a spring. The pawl is fulcrumed on an arm 69, which is in turn centred upon the tappet stud, and connected by a rod and lever 70 to the vibrating griffe shaft 71.

A bowl 72 is secured to the lower leg of the catch K, and rests upon the tappet 66. An elevation on the latter holds both legs of the catch free from the lantern of the cylinder and prevents A from turning, but a depression in 66 brings either the top or bottom leg into contact, therefore the shape of the tappet 66, and the number of teeth in the ratchet 65, determine how many times the same card shall be presented to the needles.

This cylinder may be worked forward or backward at pleasure, for a third arm from the catch K also carries bowl 72A, which is controlled by the tappet 66. 72A ma be put into or out of action by attaching a weighted co to the rear end of the catch lever. If this weight upon the lever, the lower catch K will act, but if the weig is supported upon the loom framing, the upper catch K wi turn the cylinder.

When the barrel A′ is pegged to produce the desir weave, the twilling bars 62 will turn two or more grif blades vertical for each pick, and push correspondi hooked rods over adjacent slanting blades. The cylind A presses a card against the needles, and the griffe Z rising lifts all vertical hooks except in those rows whe the blades are vertical, and also all hooks in those ro where the thick hooks 60 have been pushed over the grif for the latter are lifted from the bottom loops by the ba 58. A pick is passed through the shed, the griffe descends, the barrel A′ is turned, other twilling bars ar thick hooks are moved, and, although the same card pressed against the needles, the griffe goes up with a fre set of hooks.

The number of rows of hooks and needles depend up the number of picks to a repeat of the binding weav also upon the number of hooks governed by one need For example, the needles of a 400 machine, if arranged f an eight-thread satin, may each have two, three, or fo eyes; in which case there would be 16, 24, and 32 ro of hooks respectively. But if arranged for a ten-thre satin, the needles would have two and three eyes alternatel and there would be 20 rows of hooks.

A Bessbrook Jacquard is not adapted to the simultaneo production of ground binding weaves, which differ fro

to a pressure harness (see pp. 250, 253). But a Jacquard invented in 1887 by T. Tschörner and K. Wein enables one weave to be wrought in the ground and another in the figure. Its essential features consist in mounting each griffe blade A, Fig. 110, and each twilling bar B in separate frames, and in lifting each independently by a rod. The rods are attached to jacks placed over the Jacquard, and the jacks are moved in one direction by tappets at the end of a loom, but springs provide the opposite movement. Both ends of the machine framing are slotted vertically in two lines, so that projecting lips, from the griffe frames, may pass through the upper slots; similar lips from the twilling frames B pass through slots in the bottom line. By this means both sets of frames are moved vertically. Each undisturbed blade A provides binding points for the figure, and each lifted bar B provides those for the ground. The hooks E are made of flat sheet-iron, cut to the required shape, and projecting lips F permit those in one line to rest upon a twilling bar B. The needles K may have several eyes coiled one behind another, or they may be cranked alternately to right and left so that the needles in one vertical line shall govern two rows of hooks from front to back; also, one needle may govern more hooks than another, as in the Bessbrook machine.

A card N equals several picks, but during the time it is in use the cylinder remains away from the needles and stationary. A griffe blade can only lift vertical hooks, yet the needles may push some back in every row. But when once lifted, all the griffe blades except those required for binding remain stationary until a card is changed, at which time all sink to the lowest point. In weaving an eight-thread satin at least seventeen tappets are needed—eight for the griffe blades, eight for the twilling bars, and one for the cylinder. Seven of the griffe blades and one twilling bar rise for the first pick, and the eighth blade

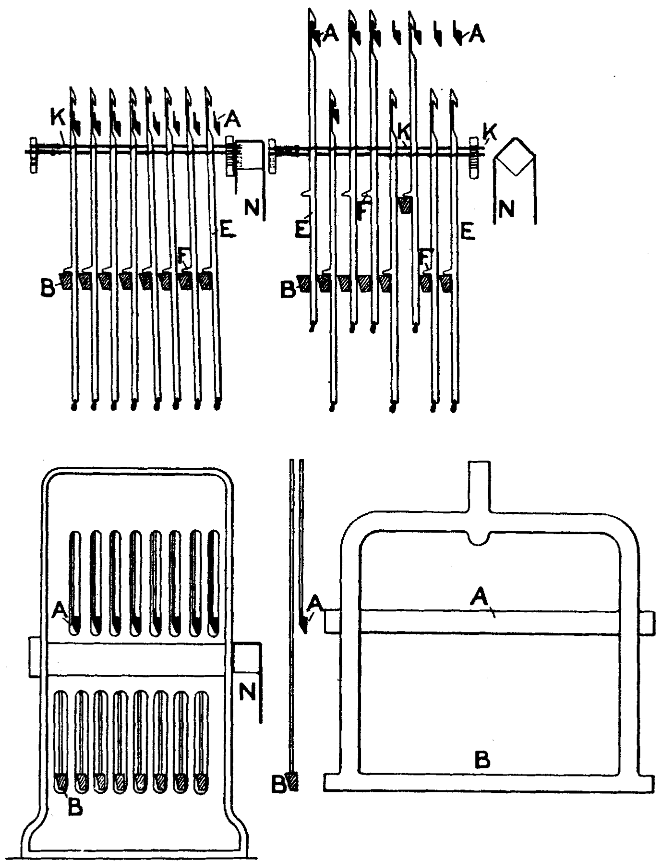

FIG. 110.

rises far enough to engage the heads of the vertical hooks in that line. For the next pick this blade rises and another sinks, but not far enough to liberate its hooks, for

those hooks must be again lifted for the succeeding pick; a fresh twilling bar is lifted, and the first one sinks. In a similar manner provision is made for the formation of different open sheds from the same card.

JACQUARD AND HARNESS LIFTS

The griffe of a single-lift Jacquard is generally actuated by fixing an eccentric or a crank A, Fig 111, upon the main driving shaft B, and connecting A by a long rod C to a lever D above the griffe E. But since such an arrangement of parts does not give a dwell sufficiently long to allow a shuttle to move across the loom, it becomes necessary to pick before the griffe has reached its highest point. Thus, if the lifting crank is 45 degrees in advance of its bottom centre as a shuttle enters the warp, when it reaches a point 45 degrees past that centre, the shed, although closing rapidly, will be as deep as when the shuttle entered. But little more than $\frac{1}{4}$ of a pick is available. By securing the upper end of a short rod from the crank to a lever fulcrumed at a height of from 12″ to 18″ above the crank centre, and by connecting this lever by means of a second rod to the griffe lever, a considerable additional pause may be obtained. For the effect of shortening a connecting rod, see Beating Up, Part XVI.

The griffes of a double-lift Jacquard are usually actuated from a double-throw crank F, which is fitted upon the bottom loom-shaft G. From the cranks motion is conveyed by two rods H, I to two levers J, K, placed above the griffes L, M. A single cylinder is vibrated, as on pp. 156, 158. But two cylinders are moved from the bottom loom-shaft by an eccentric O, a rod P, a shaft Q, an arm R, two arms S, and two adjustable bars T, the latter being

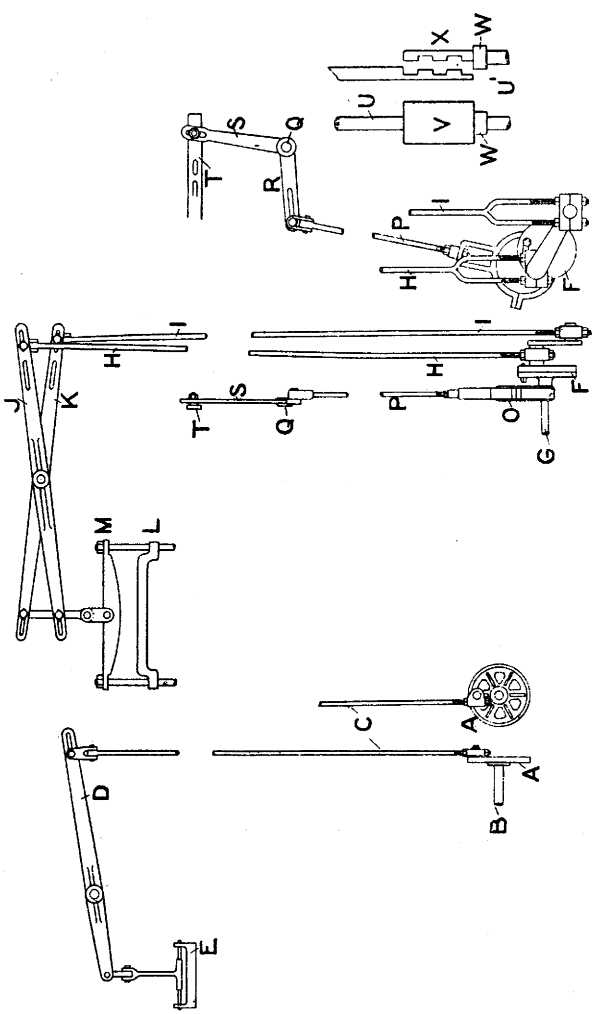

Fig. 111.

made fast to the battens of the cylinders. The double-throw crank is set with its pins in a vertical plane when the slay cranks are slightly past their bottom centres, and when the cylinder crank is near its front centre. When the slay cranks are on their top centres, the griffe cranks are horizontal, and the shed is half open, but at the beating-up point the griffes are forming a shed for the following pick.

A double-lift double-cylinder Jacquard, if used to weave cross-bordered fabrics, may have a single crank on the top loom-shaft to operate a rod U′, with a collar W set-screwed upon it. But two rods U are fitted upon the griffe levers, one of which is always inoperative. Either rod can be used at pleasure, for they are broken at X and the ends are toothed. The teeth of one rod U may be made to engage those of U′ by slipping a loose boss V upon U, and when U, U′ are united the boss is dropped upon the collar W as shown at V, and will prevent the pieces from becoming disconnected until V is again lifted.

Although the foregoing methods are largely used, cams are often preferable, for they can be shaped to give any length of pause and any velocity of rise and fall. For fabrics in which one card equals two or more picks, either negative or positive cams are almost indispensable.

Fig. 112 shows the construction of a cam suitable for a fabric having 4 picks to 1 card. During the insertion of those picks the Jacquard griffe remains stationary at the top, but between picks 4 and 5 it sinks, and, after a fresh selection of hooks has been made, it rises again in time for pick 5.

Let it be assumed that a space of 3″ separates the centre of a cam stud from the smallest part of its surface, also that the lift is 3″. If the dwell is $\frac{1}{3}$ of a pick, the time for making changes is $\frac{2}{3}$ of a pick; this time may be divided into twelve parts as follows: Four for sinking the griffe, two for making changes, and six for lifting. The cam is further assumed to act on a treadle bowl 2″ in diameter.

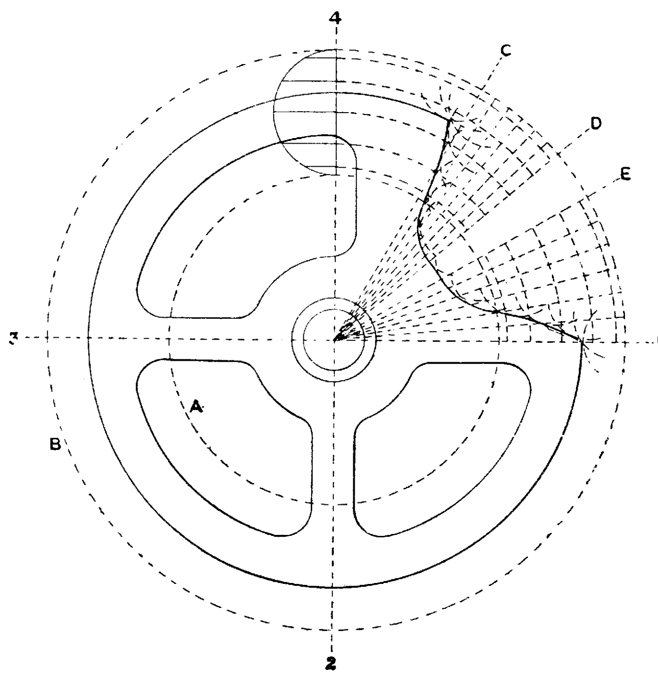

Fig. 112.

To construct such a cam, describe a circle A equal in radius to the distance between the centre of the anti-friction bowl and the centre of the cam stud when that bowl is in contact with the smallest surface of the cam, namely, $3'' + 1'' = 4''$. Add to this the lift of the cam, and

describe a circle $B = 7''$ radius. Divide the circles A, B by radial lines 1, 2, 3, 4 into four equal parts, each part to represent one pick. Next divide any space, say 4 to 1, into three equal parts, and use 4C, which equals $\frac{1}{3}$ of a pick, as dwell. Divide the remaining two-thirds into twelve equal parts, take the first four, C, D, for sinking the griffe, allow the two following parts, D, E, for making changes, and employ the remaining six, E to 1, in lifting the griffe.

Next divide A, B into any number of unequal parts, as explained in Tappet Shedding, p. 41, say six; then subdivide C D, E 1 respectively into the same number of equal parts, and use successive points of intersection as centres round which the friction bowl circles are to be described. Trace a thick line that touches the periphery of each bowl circle, and continue it round the divisions 1, 2, 3, 4C with compasses. Cams of this description are generally driven by wheelwork from one end of the crank shaft, and the cam treadle is connected to the lifting rod.

When the number of picks to each card is uniform it is customary to employ cams to move comber boards (see Figs. 125 to 128) as well as the Jacquard griffe. In case the number of picks to the weaving scheme is too large for a cam, as 18 or 24 picks to a repeat, various devices are employed to operate a harness. One is illustrated in Fig. 113. By its aid a Jacquard selects the board to rise, but a cam of 3 picks to the round is employed to lift it for an eighteen picked weave, and one of 4 to the round for a twenty-four picked weave. A is a spare hook in the Jacquard which is connected by a wire to a cranked lever B, and by a second wire to a draw rod C. This rod is attached to the tappet treadle D in the usual manner; but instead of being fast upon the jack E, it passes through a slotted bracket F, which is bolted upon the jack. C has a catch formed near the top; it is held back by a helical spring G until the hook A is lifted; then as the lever B vibrates, the catch on C is drawn over a solid part of the plate F, and retained in that position until the treadle D is next depressed, when the rod and jack lift the board. So

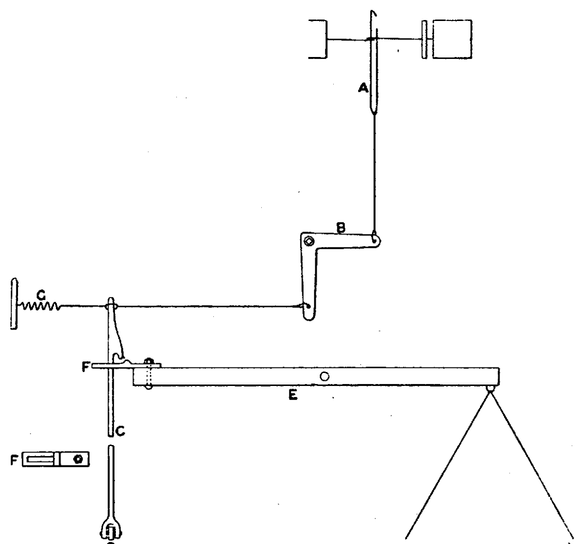

FIG. 113.

long as the hook A remains unlifted, the rod C may be drawn down by the tappet and treadle D any number of times without affecting a comber board. Similar parts are required for each board.

When there are more picks to one card than to another, the accompanying method may be adopted. A, Fig. 114, is a winged tappet fitted upon the bottom shaft of the loom and capable of acting upon an antifriction bowl B to depress

a treadle C every pick. C is fulcrumed at D, slotted at E to permit of a connecting rod F being attached, and is passed through a slot in an upright G. A cranked lever H is fulcrumed upon G, and its vertical arm is shaped to form a latch at I, while its horizontal arm is placed beneath either a tappet or a lag barrel J; the latter is moved every pick by wheel gearing or by a pawl. If free to act, the

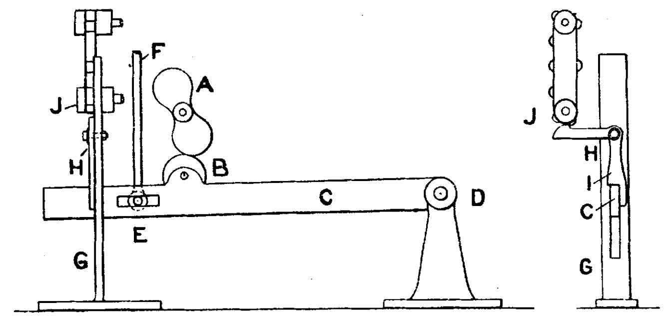

FIG. 114.

tappet A would depress the treadle C every pick, but when once lowered the upper edge of C is about $\frac{1}{8}''$ below the catch I, and is prevented by I from rising until the horizontal arm is pressed down by a peg on the barrel J. The slight movement given every pick to the treadle C, by the cam A, permits of the cranked lever H being moved with freedom. By suitably pegging the lags a Jacquard griffe can remain up for any length of time, but after each movement of H a card is changed.

PART VII

THE FIGURING HARNESS

THE Jacquard machine operates a figuring harness more economically than any plan previously used, but the harness was employed for centuries before Jacquard's birth. It consists of couplings, comber board, and mounting thread. A coupling includes a lingoe, a mail, and one loop, or two loops of linen thread; or it may be made entirely of wire.

A lingoe is a dead-weight suspended from the end of a coupling to keep the harness twine in tension. It is made from cylindrical wire or lead, flattened and punched at one end to take the lower portion of the coupling twine. Or if for wire couplings, a lingoe may be pointed at the top and bent to form a loop. A lingoe varies in length from 7″ to 19″, and in weight from 4 to 60 to the pound, but for average cotton goods 20 to 30 to the pound is usual. If a weaving room is damp, corrosion may be prevented by coating the lingoes with a vitreous enamel, or by electro-plating, galvanising, or varnishing them. The lower coupling loop connects a lingoe and a mail, and is from 6″ to 9″ long to permit the Jacquard hooks to lift without carrying lingoes amongst the warp.

Mails are made of brass, copper, steel, galvanised iron, or glass. Some have from two to five eyes for the warp, but as a rule they contain three holes, a small one near each end and a larger one in the centre. Both outer holes receive coupling twine, but the middle one is reserved for warp. An upper coupling loop varies in length to suit the position of the comber board and its place of connection

with a mounting thread. If a coupling and a mounting thread are to be united above a comber board, the loop is from $12\frac{1}{2}''$ to 16″ long. But if below a board, 6″ to 9″ will suffice. If a wire heald forms the entire coupling, it is customary to connect it below a board.

A comber board is usually made of wood and perforated to hold each mail exactly opposite the reed dent through which its warp thread has to pass, but there are several kinds:—

(*a*) A piece of wood which is $\frac{3}{4}''$ to $1\frac{1}{2}''$ thick, long enough to reach across the loom, and wide enough to take as many holes as are required in one short row. The use of such a board is optional or essential according to the class of fabric to be woven.

(*b*) Boards composed of wooden slips from $\frac{1}{4}''$ to $\frac{5}{16}''$ thick, by from 1″ to 3″ broad, and held together in a grooved frame, are most used; although earthenware, glass, and enamelled iron have been tried. For general work slips possess advantages over other comber boards, as they are capable of adjustment before tying up, and also to a slight extent afterwards. Thus, if slips are held apart with strips of wood, a harness will be suitable for a coarser and wider reed, provided the alteration does not necessitate an over-all movement of more than $1\frac{1}{2}''$. But if, after a harness has been built, the slips are opened out more than $1\frac{1}{2}''$, the outside mails will be lifted above the level of those at or near the middle of a board. Slips are of the greatest advantage for bordered fabrics which are made in various widths from the same pattern, for the number of body repeats can be increased or reduced at pleasure by adding or removing slips A plan for doing this was patented in 1880 by W. L. Ellis and S. A. Ellis. It consists in using two supplementary boards which are placed 12″ to 15″ higher than the ordinary board, and both capable of lateral adjustment. Each border twine is passed through a hole in the top and bottom boards, but the body twine only passes through holes in the lower board. In case the width of such a harness has to be altered, the required number of body repeats are removed or added, and the upper board is moved in an opposite direction to the bottom border slips until the border mails fall into the same plane as the middle mails. The same effect may be produced, without the objectionable friction caused by the foregoing, if decked mails are used for the border portions of a harness, and, after adjusting the middle repeats, the border threads are drawn through the eyes that are level with the body portion.

(*c*) Comber boards consisting of longitudinal strips of 1, 2, 3, 4, and 6 holes deep are also used; they fit into end pieces and are bolted together. When such a harness has to be reduced in fineness, the requisite number of strips, with their accompanying mounting, are removed and suspended in any convenient place until again required.

(*d*) A reed is divided into sections by stretching cords, or by laying iron rods, at right angles to the dents. Pieces of notched wood are placed at intervals across the reed and firmly secured upon it. Both ends of the rods are dropped into the notches, and the harness twines are passed between the rods and dents. A harness reed differs in count from a weaving reed in proportion as the mounting threads per dent exceed the warp threads per dent. Instead of a reed, wires may be placed longitudinally and transversely in a clamping frame so as to leave interstices for the harness threads to pass through.

A board should not be broader than is absolutely necessary, or the warp controlled by couplings in the back

rows will not be lifted high enough to allow a shuttle to pass beneath them. In most cases the number of holes in one row from back to front equals the number of needles in one vertical row of the Jacquard; but it is impossible in all cases to follow this course, for some fine fabrics require as many as twenty-four holes to each row, and yet with a large number of holes in one short row the mounting threads tend to chafe and stick as they rise and fall.

If one warp thread is passed through each mail, the number of holes in a lineal inch of the comber board must equal the number of threads in one inch of the reed. Thus, assuming a reed with 80 threads per inch, and a Jacquard with 8 needles in a row, the harness will be least crossed and will last longest if the board has 10 rows, each 8 deep, on one inch; the second row to be drilled relatively to the first as in Fig. 119. If a board with more than 80 holes is used, the surplus holes should be left at regular intervals, and for preference in full rows at every place. With 100 threads per inch in a reed, and the needles in rows of 12, a board should have 100 holes per inch, or 25 rows of 12 on three inches.

When the loom cranks are on their back centres, a comber board is fixed horizontally by brackets to the loom frame, with its front edge about $\frac{1}{2}''$ behind the slay and, if the couplings pass through holes in the board, from 9″ to 12″ above the mails, but if the mounting threads pass through the board from 12″ to 16″ should be allowed. A low board prevents the mails from swinging, but may obstruct light as well as the weaver's freedom of action.

A mounting thread is used to connect the upper coupling loops with the tail cords of a Jacquard. Linen yarn is employed for this purpose, the thickness and structure of which vary greatly, and depend upon the severity of the work to be done. From $3/60^s$ to $15/30^s$ is used for different fabrics, but 12^s, 16^s, and 20^s, in 3, 4, and 5 folds, are largely used for the ordinary run of goods. A thread containing many folds is smoother and stronger, although more expensive, than one containing few folds, but smoothness may be increased by polishing the threads before using them. From the point of view of strength, a $9/30^s$ is superior to a $4/12^s$, yet both are nearly equal in count. In the lengths of mounting thread there are also great differences, principally due to the width of loom, but also in a smaller degree to the position of the Jacquard. A narrow loom harness should be at least 4′ 6″ from a mail to the bottom of a hook, but 5′ 3″ to 5′ 6″ is to be preferred, while a loom with a reed space of 160″ requires 8′ 0″ or more from mail to hook. Excessive length, however, is as undesirable as insufficient length. At a given height, the life of a harness decreases in inverse ratio to its width. Some are worn out in less than one year, but with proper care all should last from three to upwards of six years. If the side of a Jacquard and the side of a comber board are parallel, as on 1, Fig. 117, a harness may be from 6″ to 12″ shorter than where the end of a Jacquard and the side of a comber board are parallel, as on 4, Fig. 117, because in the former the mounting threads are straight, while in the latter they are twisted and will wear rapidly.

The following methods of mounting Jacquards over looms are frequently met with :—(*a*) They are supported upon the loom framing. In that event each loom is self-contained, but requires staying from the roof or walls to avoid excessive vibration. (*b*) Jacquards are supported upon wooden or iron girders placed at right angles to the room shafts, and extending from one end of the weaving room to the other. The girders rest upon two uprights

bolted to the top rail of each loom. This plan is open to the objection that one loom, when at work, may set up a swinging motion in the harnesses of adjacent looms. (*c*) Jacquards are supported by beams suspended from the roof by long bolts. In this case the roof is subjected to vibrations which render it leaky, and then water frequently percolates into the room, to the injury of the machinery as well as the materials being manufactured. (*d*) Jacquards are supported from girders which rest in lips cast upon, or in split clamping pieces bolted to, the columns of the room. This plan is preferable to any of the foregoing, for it reduces vibration to a minimum on account of the Jacquard being free from the loom and the roof.

If wooden beams are used, supplementary appliances, such as card cradles and guide rollers, can be readily attached, and the Jacquard may be fastened in any position, but they are liable to warp and crack, and, owing to their large dimensions, to obstruct the light. I-shaped rolled-iron or steel girders are preferable. Their height from the floor varies with the height of the building in which they are erected, and also to suit the widths of the looms. The lips upon the columns are fixed to place the top of the girders from 8′ 0″ to 11′ 0″ above the floor line, 9′ 0″ being a good average. Cross girders are placed upon the longitudinal ones and should be attached by clips, for clips permit of adjustment to suit either large or small Jacquards. The latter are then either fixed to the cross girders or to stands bolted upon those girders.

A Jacquard should be capable of vertical adjustment, so that the mails may be placed on their proper level. This is usually accomplished by inserting setting-screws in the machine feet, and allowing them to abut against a solid bed.

If a machine is fixed for the cards to be suspended above the warp, as at 1, Fig. 117, where both Jacquard and comber board are shown in plan, or over the fabric, as at 2, the driving belt and wheels are not liable to injure the cards, but this course may reduce the light where light is most wanted. If the cards are suspended above one end of a loom, as in 3, 4, the harness must be twisted, and friction and wear are thereby proportionately increased. Local circumstances, however, determine the position of a machine, such as the space available for cards, light for the weaver, and the nature of the lifting tackle; but these can only be dealt with on the spot.

Before beginning to tie a harness, the exact position a machine is to occupy must be determined. Thus, if one machine only is to be used, a plummet line tied to the centre hook should hang immediately over the comber board centre, as at A, Fig. 119. If two or more machines are necessary, set them as close together as possible, with the centre of the space separating them, or the centre of the middle machine over the centre of the board.

Harness-building

Harnesses may be built at the loom or in a specially fitted room. If the work is done at the loom, a stoppage of at least one week will be necessary; but if built elsewhere, the loom need not be idle for so long a period. The following methods of building harnesses are in general use:—1. Where single mounting threads are employed to unite the couplings with the tail cords of the hooks. (*a*) At a higher level than the comber board. (*b*) At a lower level than the comber board. 2. Where a mounting thread serves instead of a top coupling loop. Single mounting threads are then employed to unite the mails with the tail cords. 3. Where double mounting threads are employed to unite each coupling with a tail cord.

If a harness is intended for a narrow loom, and for the first-named style of tying, the mounting threads are warped to the length of that thread farthest removed from the perpendicular when in the harness, plus an allowance of 3″ to 5″ to facilitate tying. But if the harness is for a broad loom, it may be advisable to warp the threads in two lengths, the shortest for those that will be least removed from the perpendicular, and the longest for those that will slope most. A frame of warping consists of four pins bolted into a wooden or iron rail A, Fig. 115; the pin E is placed in a long slot for the purpose of adjustment, and must be fixed far enough from B to give the proper length of thread. The twines are drawn from warping bobbins held horizontally in a creel and tied upon E, from whence they are taken alternately over and under D, C, round B, and back again to E, but alternately over C and under D. This order is continued until a sufficient number of mounting threads are obtained. A lease band is then passed through the openings made by the pins C, D to hold each thread in its proper place and thus avoid entanglement. They are next cut at E, loosely bunched together, and removed from the pegs. Assuming six repeats of a straight pattern to be needed in the harness, three of the doubled threads must be tied to each neck cord in the machine at a point from 6″ to 9″ in single necks, and from 9″ to 12″ in double necks, below the hooks. But since these threads will be widely separated in the comber board, the risk of falling threads hooking into rising ones when at work must be obviated by tying a knot on each bunch from $3\frac{1}{2}$″ to 5″ below the point of connection with the neck cords. The knots are tied to fall in a straight line across the harness as follows: Two pins are driven into a piece of wood $3\frac{1}{2}''$ to $5''$ apart, a knot is loosely tied upon those threads that form one set, and one pin is passed through their looped ends, the other through the centre of the knot. After a given number of knots have been made, they are slipped one by one from the pin and pulled tight; in that condition they are ready to be connected to the machine. This may be done before it is put into position, or after, as may seem most desirable. A less bulky and equally satisfactory bind-

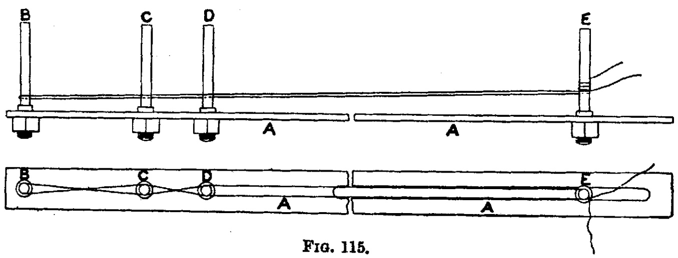

FIG. 115.

ing may be obtained by coiling a single thread round a group of mounting threads to form a band about $\frac{3}{8}''$ deep and tying the ends tightly at about $4''$ below the junction with the tail cords. Or a cross thread may be sewn into the mounting threads to form a flat neck, as at D, Fig. 90.

If the harness is to be built at a loom two building rods are employed, and each must be long enough to reach across the warp space. The rods vary from $2''$ to $6''$ in depth, and are shaped as shown in the sections in Fig. 116. The lower rod A is passed through the bottom loops of the couplings B to support them until they are tied up, and the upper rod C goes through all the top loops D. The rod C must be fixed horizontally under the comber board centre with its lower edge at such a

height that the mails F, when drawn against it, will be in the bottom shed line. The position of this line is sometimes determined by stretching a cord from the breast beam to the back rest of a loom and fixing the mail eye at from $1\frac{1}{2}''$ to $2''$ below the cord, which is approximately half the depth of a shed. For centre shedding the mails should be almost in line with the tight cord. In place of the foregoing method a flat wire may be threaded through all the mails and subsequently corded securely upon the top of the rod C, in which event the rod A is superfluous. Both rods A, C are supported upon adjustable brackets bolted on the loom ends, or in a wooden frame having two upper and two lower adjusting screws at each end. After being secured at their proper height and levelled with a spirit-level, the comber board is marked off into patterns by lead lines upon its edges, and if there are surplus holes, a pencil is drawn across them. Filling is next proceeded with. For tying above

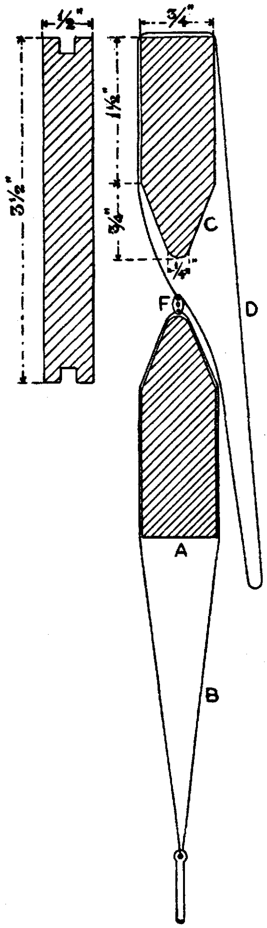

FIG. 116.

a board this consists in drawing the upper loops of the couplings D through successive holes in the comber board. Then follows the actual operation of building, or uniting the Jacquard and couplings.

If a machine is fixed for the cards to be suspended either over the warp or the fabric, all hooks in one long row are connected with couplings in one long row of the board; but if the cards are suspended over one side of a loom, the hooks in number one short row are tied to the couplings in the first short row of the board.

When facing a Jacquard cylinder, D, Fig. 117, the leading hook is number one in the back row on the left, as at B. Assuming the builder to stand in the working alley and the cylinder D to be over the warp, this hook must be connected to number one coupling in the front row on the right, as at C, No. 1. If the cylinder D is over the fabric, the leading hook B must be attached to the first coupling in the back row of holes at the left of the board, as at C, No. 2. But, as compared with the former, this will reverse the direction of any diagonal line in a pattern; still, by lacing the cards backwards, the twill will be restored to its proper direction. If the cylinder D is on the right of a loom, as at No. 3, the leading hook B must be united with the first coupling in the front row of holes at the left, as at C, No. 3; and if the cylinder D is on the left of a loom, the leading hook B must govern the first coupling in the back row on the right, as at C, No. 4.

A coupling knot is drawn to within an inch of the top, then a mounting thread is passed through the loop and its mail is pulled close against the rod C, Fig. 116; a knot is tied, and the loose end cut off. Following threads from the leading hook are tied to the first coupling in each succeeding repeat of the pattern, and the same course is

followed with the remaining hooks and mails until the harness is complete.

In Fig. 118 the knots and connections used in a harness of the foregoing description are shown; A, C are on the bottom and top loops of a coupling; B on a coupling and lingoe; D on the mounting twine and coupling; E a knot for the bunches of twine; F one for the neck cord and mounting; G one for the neck cord and hook. H shows a

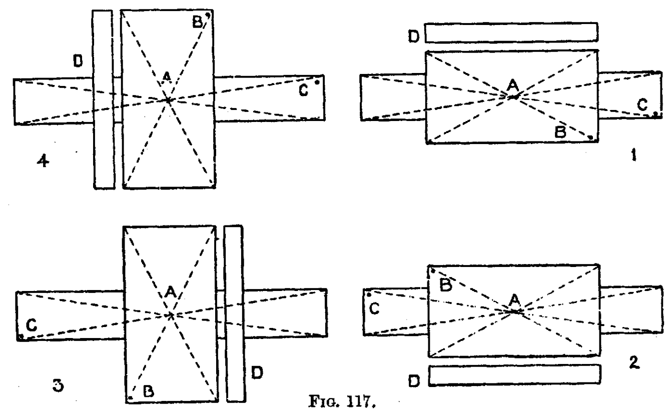

FIG. 117.

method of connecting a hook to a neck cord when it is probable one harness will have to be replaced by another: this plan provides a ready means of connecting a harness to, and disconnecting it from, the Jacquard hooks. Spring clips are also attached to neck cords to facilitate the changing of harnesses, as one may then be quickly unhooked and another hooked on.

Jacquard hooks are also specially made for this purpose, as shown at I, where a hook is bent in the usual manner at J to rest upon a rack, and again bent at K to receive a noosed neck cord L. The cord L can then be slipped off when not further required. A similar plan is shown at E in Fig. 107.

If a harness is to be tied below the comber board, the first operation is to warp, and knot, bind, or sew the

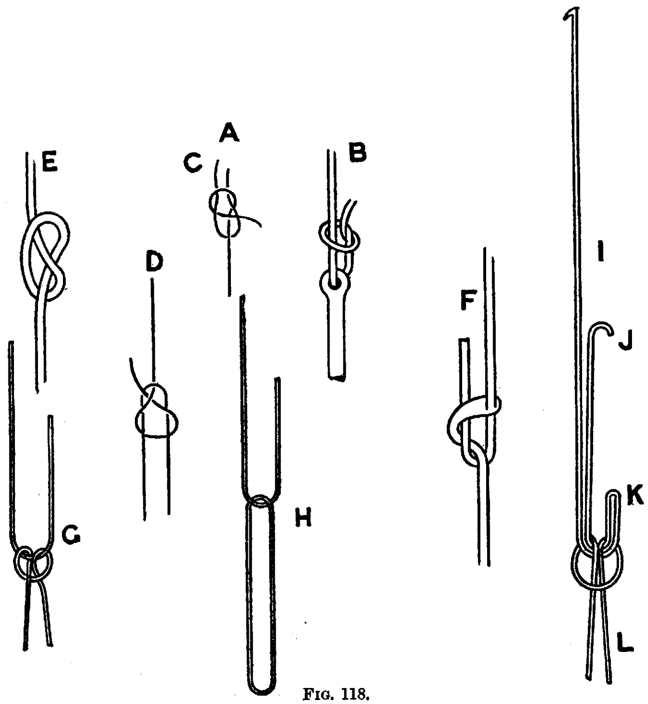

Fig. 118.

mounting threads together; they are next suspended by their loops from a rod fixed above the comber board. After dividing the board into spaces suitable for the repeats of the pattern, each twine is drawn into its proper hole in the board. The lower ends are bunched to prevent disarrangement, and the board and mounting threads are

taken to the loom, or to the building frame, where the threads are knotted in rotation to the neck cords. The comber board and levelling rods are next fixed in position. In a harness of this description there may be four or more levelling rods upon which the couplings are threaded, especially if a comber board contains many holes in one short row. Assuming one with twenty-four holes to a row to be selected, four pairs of rods may be used, or one pair adjusted four times, the back pair to be from $\frac{3}{16}''$ to $\frac{1}{4}''$ higher than the front pair, as they then assist in holding all the lifted warp threads in one line. Levelling rods, shaped as in the section on the left of Fig. 116, may be used; the grooves permit the heads of the mails to enter, and bed against the lower surface of the rod. Mounting threads from the six back rows of holes must be tied in rotation across the harness to couplings on the back pair of rods; the couplings for the following six rows of thread are on the next pair of rods, and they, with all the remaining couplings, must be similarly connected.

For fine harnesses, in which the Jacquard cylinder is over one end of a loom, it is preferable to tie below a comber board, for, when tied above, a difficulty is experienced in passing one's fingers between the threads in the last few rows of each pattern, and it becomes next to impossible to tie those threads correctly. Further, when tied below a board, the rising and falling threads are less liable to engage each other, for the knots are tied where the harness is widest. But unless the knots are from 4″ to 5″ below a board, some of them will be lifted into the holes of a board and stick there. For this reason the mails must be farther from a board when tied below than when tied above.

If a coupling consists of a lingoe, a bottom loop, and a mail, the mounting threads are warped to the required length, namely, to reach from a tail cord to a mail eye and back to a point from nine or twelve inches above the comber board. After warping they are attached to the neck cords. An open knot is next tied upon the first thread above the level of the comber board, and the end of that thread is passed down through a hole in the board; it is then threaded through the upper eye in a mail, led back again through the same hole in the board, and through the open knot. By pulling at the end of this thread the knot closes upon the return length, and finally, a second knot is tied at from six to nine inches above the board. Other threads are treated in a similar manner. In most of these harnesses the mounting threads are varnished and tied in a wet condition.

That so-called warped harnesses are in great repute with many manufacturers is partly owing to their neat appearance, and partly to the expedition with which they can be built. The system is similar to that of tying above a board in so far as marking the comber board off in sections, filling it with coupling twine, and setting up the levelling rods are concerned. But instead of warping and knotting the mounting twine as previously described, a large bobbin of thread is suspended from a skewer and placed opposite the comber board. As the thread is drawn from the bobbin it is passed through all the coupling loops that one hook is to govern, then the end is carried up and made fast to a tooth of a coarsely pitched comb, which is fitted horizontally amongst the neck cords, with its teeth in line with the points of attachment. The comb consists of stout wires driven into a wooden back, and spaced about $\frac{1}{4}''$ from centre to centre, each tooth being from 2″ to 4″ long. The

twine is then lifted between the two last coupling loops, and hooked upon a tooth adjacent to the neck cord which is to carry that thread. In a similar manner the thread between every pair of loops is taken up to the same tooth, and finally it is cut off when the starting-place is reached. These mounting threads also pass between the teeth of a similar comb fixed in the same framing, but $4\frac{1}{4}''$ below the former. The teeth of the bottom comb hold all the threads of one group close together. All the mails are drawn to the levelling rod, by pulling both ends of the thread tight, then the ends are twisted round the bunch immediately above the second comb and tied together. By this means an equivalent to a knot is obtained. The process is repeated with the remaining couplings.

On the completion of one row the bunches are taken in rotation from the comb, pulled tight to ensure evenness, and each is "knotted" to its proper neck cord.

Two mounting threads are required for every coupling, but as they are simply passed through a coupling loop the strength of a warped harness is less than twice that of a single thread harness, although double the length of material has been used. In a close harness warping has a tendency to crowd, but in medium and coarse harnesses this is of little moment. The only visible knots are coupling knots.

Dressing a Harness

Most harnesses are sized and varnished to prevent the threads from fraying and breaking. For light goods they are sometimes unvarnished, at other times dressing is only applied for 3″ to 4″ above and below the comber board. For medium goods the couplings may be sized and varnished throughout, as are the mounting threads from the tail cords to 6″ or 9″ below them. Harnesses for heavy goods are sized and varnished from the neck cords to the lingoes, and the couplings are twisted.

Numerous dressings are employed, such as boiled linseed oil, flour paste, bees'-wax and dryers, white wax dissolved in turpentine, and heald varnish. For light goods, boiled oil or white wax is usually rubbed by hand into the harness threads, but for medium and heavy goods the oil is applied with a brush. Boiled oil provides a serviceable dressing, for it leaves the twine strong, smooth, and pliant; but it takes from a week to a fortnight to dry. For heavy goods a dressing may consist of flour, or farina, fish-glue, or bees'-wax. The following sizes and varnishes are used:—

Starch . . .	10 parts by weight.
Glue . . .	1 ,, ,,
Water . . .	89 ,, ,,

These are boiled together and applied hot. Another consists of—

Starch . . .	40 parts by weight.
Glue . . .	40 ,, ,,
White soap . . .	2 ,, ,,
Carbonate of potash . .	1 ,, ,,
Water . . .	664 ,, ,,

The glue is slowly dissolved in hot water, the starch stirred into the heated mixture, and other materials added. The size is then applied with a brush to the harness, to spread it evenly and remove any excess.

Good varnish such as is used by house painters may be mixed with boiled linseed oil, in the proportion of $\frac{1}{3}$ varnish to $\frac{2}{3}$ oil, and applied hot with brushes.

A dark brown varnish is made from—

Boiled linseed oil	8 parts.
Orange lead	5 ,,
Umber ground in oil . . .	5 ,,

All the ingredients are boiled together, and constantly stirred for six hours, then used hot. This varnish will keep for months and improve by keeping.

A varnish may be prepared from—

Linseed oil . . .	7·5 parts.
Litharge	7 ,,
Gum lac	9 ,,
Lead acetate . . .	4 ,,
Spirit of turpentine . . .	0·75 ,,
Umber	1 to 2 parts.

The litharge and umber are placed in a bag, dropped into the linseed oil, and gently boiled together for from three to four hours. The gum lac is separately melted, added to the oil, and all boiled for a few minutes. When cool the turpentine and lead are stirred in, and the mixture is ready for use. If couplings are to be twisted, this is done separately, immediately the dressing is completed. If they are twisted before building takes place, from 1″ to 2″ of their upper loops should be left unsized. A dressing material that gives the smoothest, most supple, and durable thread is best for all classes of work, and a coat of varnish applied to a dressed harness should give a hard smooth surface.

Defective Shedding

Jacquard shedding is defective, because a top shed forms a curved instead of a straight line, and this is due to the mails operated by vertical mounting threads rising higher than those moved by sloping mounting threads. This can be demonstrated by assuming a harness to be 100″ wide, and when measured vertically, 96″ from a mail to a hook, 12″ from a mail to a comber board, and 12″ from a hook to the point where the threads begin to separate. The length of a vertical thread between the knot and board will then be $96-24=72''$. If two threads are attached to the same hook and one passes vertically to the centre of the comber board, the other in a sloping direction to the extreme end of the board, a space of 50″ will separate them. With the board these threads form a right-angled triangle which has a base of 50″, an altitude of 72″, and a hypothenuse of $\sqrt{72^2+50^2}=87{\cdot}66''$. If a hook lifts 4″ the altitude becomes $72+4=76''$, and the hypothenuse becomes $\sqrt{76^2+50^2}=90{\cdot}9''$. The difference between one hypothenuse and the other is $90{\cdot}9-87{\cdot}66=3{\cdot}24''$; therefore the inclined thread only lifts 3·24″, while the vertical one lifts 4″. This defect is greatest in wide, short harnesses; but it can be minimised by passing glass, steel, or wood rods between the long rows of neck cords, and stout wires between the short rows. Both sets are fixed in one frame, but one set at right angles to the other. The frame is placed below the neck cords to hold the rods against the mounting threads, and prevent them from opening as they are lifted by the hooks. By this means the angle becomes a fixed one, and a level top shed is obtained, but at a cost of increased wear and tear. Harnesses used under conditions similar to those assumed above often require heavier lingoes at the sides than at the centre, on account of increased friction at the comber board.

Tie-ups

Unless each tie-up contains some distinctive feature, no useful purpose will be served by giving a variety of them, for Jacquard ties, like drafts for healds, are made to suit special requirements. But in deciding upon a tie-up care should be taken to select, for a repeat of the pattern, a number of needles which can be divided oftenest without leaving a remainder, as this will enable a designer to introduce numerous small weaves. Thus: A 100 Jacquard contains 104 needles, yet 96 will give more divisions than the full number, for, 2, 3, 4, 6, 8, 12, 16, 24, 32, and 48 are all measures of 96, while from 104 only 2, 4, 8, 13, 26, and 52 are obtainable, and in all but special cases 96 needles to a repeat are preferable to 104. What applies to a small number of needles applies equally to a large number.

Straight-through Ties

A straight-through tie forms the basis of all ties and will produce most patterns and fabrics. It is only discarded in order to effect an economy in cards in one form or another, as by enabling a small Jacquard to weave large designs. In Fig. 119 a plan is given of a comber board containing an unbroken series of holes, but it is divided by imaginary lines into four sections, each equal to the number of warp threads in a pattern. Threads from number 1 hook go through number 1 hole in each section, and those from succeeding hooks go through succeeding holes until all are filled; the threads from the last hook will then be in the back hole of the last row of every pattern, as shown by the number 400. Diagonal marks, beginning at the same part of each section and running in the same direction throughout, indicate a straight tie.

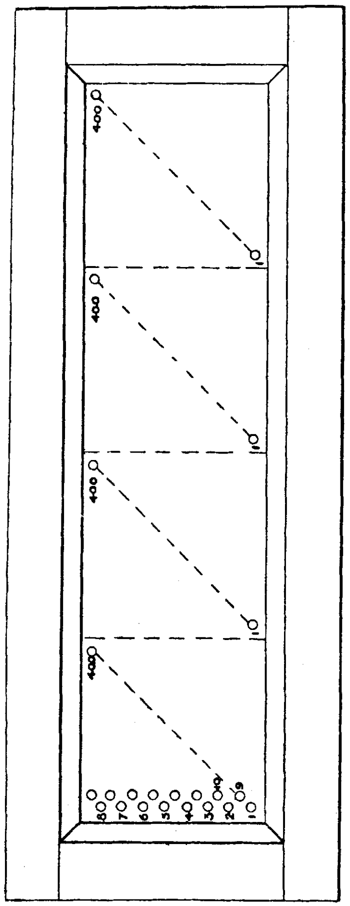

Fig. 119.

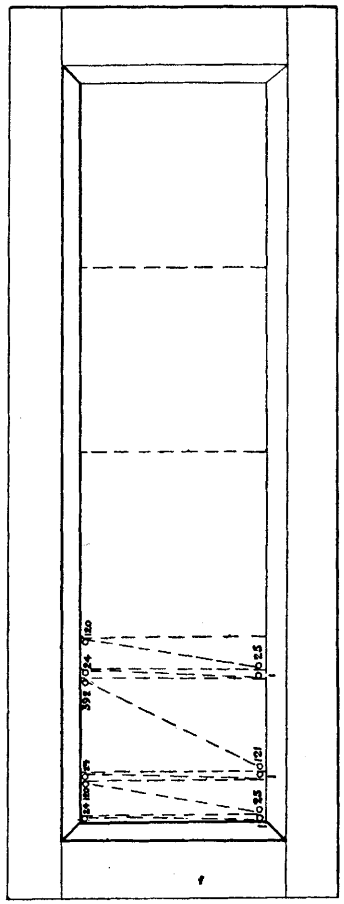

Fig. 120.

A tie may be straight in the sense that all diagonal lines shown on a plan point in the same direction, but

one section of a pattern may repeat oftener than another, as in Fig. 120, which is intended to produce longitudinal stripes of various widths and weaves. Economies are here effected by moving three threads in a pattern, namely, those numbered 1 to 24, with each needle used to weave the narrow stripes; two threads with those numbered 25 to 120, in the medium stripes; and one thread to each pattern for the wide stripe; these are numbered 121 to 392. There are thus $24+96+24+272+24+96=536$ warp threads to a pattern, but only $24+96+272=392$ needles are employed to move them.

Centred Ties

Another method of producing large effects from a small card is by centring a tie, for this doubles the width of a pattern, but the figure must necessarily possess fewer flowing lines than a straight-through tie permits of, because one half exactly corresponds with the other. Any number of repeats may be obtained, but two threads are used to each, except those governed by the first and last needles; hence to find the number of threads to a repeat, two must be deducted from twice the number of needles used, as $400\times2-2=798$. Fig. 121 is a plan of a centred tie; from 1 to 400 the tie is straight, but from 399 to 2 it is reversed, and in leasing it will be necessary to gather the threads 399 to 2 in the opposite direction to the threads 1 to 400. A harness may be leased straight if the tie is centred, as in Fig. 122, where 400 of the first half is in a back row of the board, and 399 of the last half is in the second row from the front, an empty hole being